

**Barriers to modern energy services
in low-income urban communities:
Khayelitsha energy survey, 2004**

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Energy for sustainable development: South African profile

ENERGY RESEARCH CENTRE

Phase 1 final report

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1. Energy for sustainable development: an introduction

Ogunlade Davidson

Historically, energy has been the pivot of economic development of most countries all over the world and this trend persists. It has brought great economic prosperity to nations and has been the centre for social and overall human development. Unfortunately, due to the way energy is sourced, produced and used, two major drawbacks have evolved. Firstly, the overall energy system has been very inefficient; and secondly, major local and global environmental and social problems have been associated with the energy system.

Up to about 30 years ago, the global energy system was only about 34% efficient, meaning that only a third of the energy input is converted to useful energy (Nakicenovic et al. 1998). Efforts to improve the efficiency of the entire energy chain and the decoupling of energy use from economic growth have led to this proportion increasing to about 39%. Thermodynamically, there are major irreversibilities in the system, and improving the overall efficiency of the global energy system remains a daunting problem.

The combustion, transport and disposal of energy sources as they go through the different conversion processes result in adverse emissions leading to local, regional and global environmental problems. In addition, development of most energy sources normally results in dislocation of people, and exacerbates differentials among social groups. In most cases, this leads to serious, and even fatal, health hazards. Reducing this environmental and social burden is a major concern for the energy sector.

Energy production and use have been growing throughout human history, and all signs indicate that they will continue to do so. However, this growth has gone through some great transitions that were largely dependent on needs and source availability. In general, until the industrial revolution in England, the world economy was essentially based on agriculture, energy demand was limited and could be met by biomass and animal power. Coal fueled the industrial revolution as industrial demand changed the global energy sector. Later, in the early 1900s, the use of crude petroleum was discovered, and that transformed the transport sector. Change filtered into the electricity and industrial sectors and the entire energy sector was profoundly affected. The improvement of long-distance pipeline technology to transport natural gas to markets other than the local market has been extremely useful because natural gas has proved to have more efficient systems and has recently been found to be more environmentally acceptable. The oil crises of the 1970s also deeply affected the energy system as it led to re-examination of two major aspects: the need to improve the efficiency of energy production and use became clear, and the search for alternatives to fossil fuels became a major concern globally. As a result, energy efficiency and renewable energy, as substitutes for fossil fuels, became prominent in the energy debate, leading to the concept of sustainable energy.

Sustainable energy

The term sustainable energy is now widely used in international debates, especially those relating to climate change. It does not, however, make much sense in physics, as the first law of thermodynamics states that 'energy can neither be created nor destroyed' – hence, by definition, energy is sustainable. The climate change debate, though, is based on the search for energy solutions that provide the modern energy services needed for economic and social development for the majority of the world's population while minimising adverse local and global environmental effects.

In the debate that followed, sustainable energy has meant different things to different people. It has been taken as energy related to renewable energy and energy efficiency, while others add in natural gas because of its more favourable environmental quality. Sustainable energy should, though, be seen in a broader context to cover other important factors such as resource endowment, existing energy infrastructure, and development needs. Sustainable energy can be defined as energy providing affordable, accessible and reliable energy services that meet

economic, social and environmental needs within the overall developmental context of the society for which the services are intended, while recognising equitable distribution in meeting those needs (Davidson 2002a). The term ‘sustainable development’ therefore also requires some elucidation.

Sustainable development

Past development paradigms that have been in operation since the end of the second world war have led to major social and environmental problems. During the 1950s and 1960s, nations were pre-occupied with economic growth and democratisation of major institutions and sectors, especially in industrialised countries. This led to a dramatic increase in energy demand because of the coupling of economic growth and energy consumption. In this period, economic growth was of major concern, while social and environmental issues were comparatively ignored. In the 1970s, a new realisation emerged about the social deprivation of the majority of the world’s population through the economic paths taken since the 1950s to heal the ravages of the second world war. There was then a call for development paradigms that would include social considerations along with economic growth. The rationale for this thinking was the need to close the growing gap between the 20% of the world’s population that has almost 83% of the world’s income and the 20% that has 1.4% of the income (Davidson 2002b). In the late 1970s and 1980s, the growing realisation of the deterioration in the environment, mainly as a result of the development paradigms that had been adopted, prompted a significant number of people to call for development paradigms that do not only consider economic growth and the social dimension, but also incorporate environmental issues. This thinking led to the idea of sustainable development. The late 1980s witnessed growing concerns about the global environment, particularly the perception of the climate change threat that has now increased the justification for sustainable development paradigms.

Sustainable development is defined as the development that meets the present needs and goals of the population without compromising the ability of the future generation to meet theirs. Understanding sustainable development requires defining economic development, social development and environmental development – so we must in turn define these terms. Economic development is economic progress that leads to the willingness and ability to pay for goods and services that enhanced income and efficient production. This is normally regarded as economic efficiency. Social development is the improvement in the well-being of individuals and society leading to an increase in social capital, institutional capital and organisational capital and hence in economic development. Environmental development is the management of ecological services and human beings that depend on them. A development paradigm that takes all these into consideration will help in the understanding of sustainable development. They can be represented as in Figure 1.1.

The provision of energy to satisfy the sustainable development of South Africa is the subject of this report.

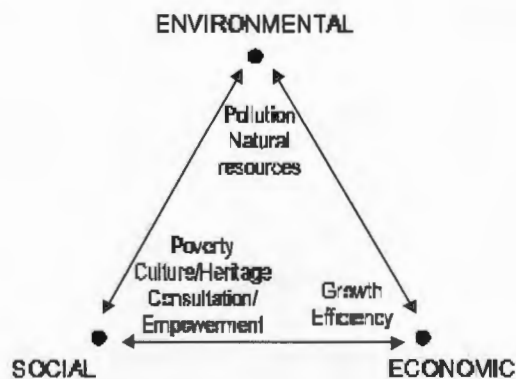


Figure 1.1 Elements of sustainable development

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2. Energy policy

Ogunlade Davidson

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2.1 The current situation

2.1.1 Introduction

Energy production has been and still is one of the main pivots of the social and economic development of South Africa. It has lent prosperity and security to the country by harnessing energy to provide heat and power for industry, transportation, and households, despite political problems. However, events in the energy sector have been largely driven by events in other sectors (mainly the economic and political), which has had a profound impact on energy policies. Recent South African energy policies can be considered in three different periods: the first is that of the apartheid regime, up to 1994; the second the period following the first democratic elections of 1994 up to 2000; and the third from 2000 onwards, after the euphoria of independence.

The energy policies in all these periods differed, but are linked because they have all contributed to the continued growth of the sector. During the first period, due to the political isolation of the country, energy policies were mostly centred on energy security. After the arrival of democracy, energy policies were directed to addressing the injustices faced by that large share of the population previously denied basic services, including energy: equity and justice were the primary goals. From 2000 to the present, energy policies have been focused on real targets and timetables in achieving the goals the government set itself after 1994. These targets and timetables relate to job creation and economic security, while recognising issues of the global agenda such as the need for development paths to proceed in a sustainable manner. Though economic development has been the cornerstone of policy, the need to protect both the local and the global environments is fully recognised. Energy is environmentally significant because of the adverse emissions from coal, the dominant fossil fuel used in the country – with, for example, nitrous oxide and sulphur dioxide from coal combustion causing serious problems for the local environment, while carbon dioxide, also emitted from combustion, promotes climate change. This is challenging because the government has to balance affordability and the huge task of providing services for the poor, and also comply with local and international obligations protecting the environment. However, it also offers opportunities, through planned management and improving the local environment. In general the country's energy policies broadly reflect this new context.

2.1.2 Historical perspectives on energy policy

Before 1994, energy policies were oriented to providing energy services based on 'separate development' of people according to their race. This translates to providing modern energy services to the whites that formed 11% of the population, and limited or no services to the rest. This had a profound impact on the energy consumption patterns of the different races, especially in the transportation, household and commercial sectors. Satisfying the needs of the industrial sector was a major aspect of the energy policy because of its contribution to both economic and political security. In general, government's policy on energy supply was largely concentrated on the electricity sector and the liquid fuel sectors as they were crucial to the economic and political interests of the country. Security was vital, and secrecy and control characterised most of the policies that prevailed.

An important government decision in the 1950s, made for political and economic reasons, was to embark on a programme of producing liquid fuel from coal through the government-owned Sasol. Security of liquid fuel supply was the main driver for developing the solid to liquid technology. The decision was also made to be involved in crude oil refining because, up to 1954, all refined products used were imported and distributed by BP, Caltex, Mobil, and Shell (Trollip 1996); the growing demand for liquid fuels justified the development of refineries.

Production of liquid fuel started at Sasol I in 1954; the Moss gas plant was developed in 1992. Both plants were heavily subsidised by the government (Trollip 1996).

Escom (the Electricity Supply Commission, forerunner of Eskom) had been producing electricity for a long time, supplying the industrial structure including the military complex, and a limited number of households. In 1987, major changes took place that now significantly affect power sector reforms. Two key power sector statutes were instituted, the Escom Act of 1987 and the Electricity Act of 1987. The Escom Act defined the responsibilities of the utility as to provide electricity in the most cost-effective manner, but not as supplying electricity to all citizens. The Electricity Act defined the structure, functions and responsibilities of the Electricity Control Board and assigned the sole right of electricity supply within municipal boundaries to local government (Eberhard & van Horen 1995). Eskom was established in terms of the Electricity Act of 1992, to be controlled by the Electricity Council whose composition was now more representative of stakeholders; the Council would appoint Eskom's management board.

2.1.3 After the 1994 elections

The government that was ushered in after the first democratic elections was not only committed to the various provisions for democratic governance in the country's constitution, but was specifically determined to provide basic services to the poor and disadvantaged that formed the majority of the population. Modern energy was one of the main components of such services, especially high quality electricity supplies. The following discussion will mainly concern electrification and the liquid fuels sector.

2.1.3.1 Accelerated electrification

After 1994, in keeping with the provisions of the constitution, the new government called many stakeholders, private companies and others researchers to submit energy policy discussion documents for consideration in forming an energy policy for the country. However, before that period, many groups were working with the party that later won the elections, the African National Congress (ANC), to formulate an energy programme reflecting the needs of the poor and disadvantaged. The basis of the current electrification programme was a national meeting on electrification in South Africa held by the Department of Economic Planning of the ANC, organised by the Energy and Development Research Centre (EDRC) of the University of Cape Town. This meeting aimed to formulate an accelerated electrification programme to serve the underdeveloped urban, peri-urban and rural areas where nearly all black South Africans live, 80% of the population. This meeting was attended by different stakeholders, universities, municipalities, and NGOs. The results of the South African Energy Policy Research and Training Project (EPRET) undertaken by EDRC provided major inputs to this meeting (ANC 1994; Marquard 1999).

During 1992 to 1994, although this was a period of political uncertainties, there were several negotiating forums between government and business, labour and opposition groups on policy-making and governance in many economic sectors including energy. During this period, the involvement between EDRC and ANC increased as EDRC researchers participated in several ANC policy committees (Marquard 1999). These and other forums led to the development of the energy section, including the electrification programme, within the ANC's Reconstruction and Development Programme (RDP) which formed the basis of all energy programmes that followed. The results of the EPRET research greatly influenced the electrification programme and its electricity targets. During this period, a number of working groups were formed on such areas as regulatory framework, structure and policy, financing and tariffs, the electricity supply industry, and end use and efficiency.

2.1.3.2 The National Electrification Programme

The National Electrification Programme was implemented between 1994 and 1999, its objective to electrify rural and urban low-income households that were deprived of access to electricity during the apartheid period. Just as the selective distribution of electricity under the previous regime meant that white households were expected to use electricity to satisfy nearly all their energy needs, so that the Electrification Programme expected that newly electrified households

would switch from using fuelwood, candles, and batteries to electricity for their household needs. Eskom had already embarked on a programme in 1991 termed 'Electricity for all'. The Government of National unity that emerged in 1994 endorsed the electrification programme. Phase 1 aimed at electrifying an additional 2.5 million households over the three million already electrified by 1993; which would increase the national proportion of households electrified to 66%. The government and Eskom funded the programme – its financing no doubt assisted by Eskom's tax-free status.

2.1.3.3 The White Paper on Energy

The process leading to the formulation of the White Paper on energy was contracted to EDRC. The process had two components: consultation and writing, then production and approval. The first involved several stakeholder forums, leading to a discussion document providing a basis for comments from the public. After a period for public comments, a National Energy Summit was held to arrive at a consensus on energy sector goals. The production and approval component of the process involved several consultation meetings that led to a draft paper in June 1996; this became public only in July 1998 due to several political and administrative problems. Under the auspices of the Parliamentary Portfolio Committee, public hearings were held and the final paper was published at the end of 1998.

The White Paper consisted of four parts: context and objectives for energy policy, demand sectors, supply sectors, and cross-cutting issues.

Context and objectives

The paper recognised national energy and economic demands, while accepting the international energy agenda and the need to identify appropriate energy supply and use. The following five policy objectives were agreed on:

1. Increasing access to affordable energy services.
2. Improving energy governance – clarification of the relative roles and functions of various energy institutions within the context of accountability, transparency and inclusive membership, particularly participation by the previously disadvantaged.
3. Stimulating economic development – encouragement of competition within energy markets.
4. Managing energy-related environmental and health effects – promotion of access to basic energy services for poor households while reducing negative health impacts arising from energy activities.
5. Securing supply through diversity – increased opportunities for energy trade, particularly within the Southern African region, and diversity of both supply sources and primary energy carriers.

Demand sectors

For households, the emphasis was on low-income and rural areas, through addressing problems of inadequate energy services, and inconvenient and unhealthy fuels. Issues such as access to fuels and their associated appliances, fuel availability and pricing were considered. Building thermally efficient low-cost housing, presenting an opportunity to promote energy efficiency and conservation, was also considered.

Providing greater energy efficiency to industry, commerce and mining for financial and environmental benefits, such as increasing international competitiveness, was a goal. It was estimated that greater energy efficiency could save between 10% and 20% of current consumption, but certain obstacles were highlighted: inappropriate economic signals; lack of awareness, information and skills; lack of efficient technologies; high economic return criteria; and high capital costs. However, government committed itself to facilitating greater energy efficiency.

The need to provide of equitable access to affordable public transport was noted, but the challenges to this goal were identified. The provision of energy for smallholder agriculture, rural schools, clinics, roads, and communication infrastructure were also addressed.

Supply sectors

Electricity: The Paper proposed restructuring the distribution industry into independent regional electricity distributors, and commitment to the goal of universal household access to electricity. Government supported gradual steps towards a competitive electricity market while they investigate the desired form of competition. Eskom would be unbundled into separate generation and transmission companies. The Southern African Power Pool would be supported.

Coal: Almost 72% of South Africa's primary energy is from coal, over half used to generate electricity and a quarter used for synfuels production. The coal industries are privately owned and since 1992 the government deregulated coal industries and there is competition in the market, leaving the role of the government as monitoring the coal industry. According to the White Paper, the coal industry will remain deregulated and government will continue to investigate options for the utilisation of coal discard streams

Liquid fuels: Minimum governmental intervention and regulation of the liquid sector was proposed, while emphasising international competitiveness and investment, appropriate environmental and safety standards, along with sustainable employment and the accommodation of local black interests. Deregulation of crude oil procurement and refining would be promoted, as well as the removal of price control. The development of the gas industry and of coalbed methane would be promoted, and there would be legislation for the transmission, storage, distribution and trading of piped gas.

Other energy sources: The future development of nuclear energy will depend on the environmental and economic merits of the various alternative energy sources. Exploration and production of oil and gas would continue under the principles of 'use it and keep it', and 'the polluter pays', with offshore rights continuing to be vested with the state. Renewable energy was realised as being advantageous for remote areas that not economically feasible for grid electricity supply. The government would facilitate the sustainable production and management of solar power and non-grid electrification systems largely targeted at rural communities. The promotion of appropriate standards, guidelines and code of practice and suitable renewable energy information systems would be considered.

Cross-cutting issues

These issues include the need for:

- integrated energy planning;
- good statistics and information;
- the promotion of energy efficiency;
- a balance between environmental, health and safety and development goals;
- energy supplies and the private sector to carry out appropriate research and development;
- development of human resources;
- capacity building, education and information dissemination;
- the facilitation of international energy trade and co-operation;
- the alignment of fiscal and pricing issues by the use of levies, tax differentials and support for more environmentally benign and sustainable energy options including energy efficiency.

2.1.3.4 Energy legislation

Several pieces of energy legislation, particularly recent ones, are of direct relevance to the future energy sector in the country. They include the following:

Escom Act 40 of 1987

Defines the responsibilities of Eskom.

Electricity Act 41 of 1987

Defines the structure, functions and responsibilities of the Electricity Control Board, and assigns the sole right of electricity supply within municipal boundaries to local government authorities.

Electricity Amendment Act 58 of 1989

Amends the Electricity Act, 1987 to provide for a levy on electricity; ensuring that a license shall not be required for the generation of electricity; and to provide for the transfer of servitudes on the transfer of undertakings; and other incidental matters.

Nuclear Energy Act 3 of 1993

To bring all nuclear activities funded by the state under the control of the atomic energy, with specified exceptions.

Electricity Amendment Act 46 of 1994

Amending the Electricity Act, 1987 by providing for the continued existence of the Electricity Control Board as the National Electricity Regulator (NER), and applying certain provisions of the Act to other institutions and bodies.

Electricity Amendment Act 60 of 1995

The Electricity Act of 1987 further amended to establish the NER as a juristic body; to make provision for the appointment, conditions of employment and functions of the chief executive officer and employees; and for the funding and accountability of the NER. The objectives of the NER are given as:

- eliminating monopolies in the generation and sales/supply sectors;
- rationalising end-use prices and tariffs;
- giving customers the right to choose their electricity supplier;
- creating an electricity market;
- introducing competition into the industry, especially in the generation sector;
- addressing the impact of generation, transmission and distribution on the environment;
- permitting open, non-discriminatory access to the transmission system;
- levelling of the playing fields between distributors of electricity.

The 1999 National Nuclear Regulation Act

The Act amended the governance of nuclear energy.

2.1.4 After 2000

In the period after 2000, the discussion on power sector reform heated up. Regulation in the context of a de-regulated market received attention, starting in the gas and electricity sectors. Concerns to extend the social benefits of electrification were reflected in the 'poverty tariff'. New policy, for example on renewable energy, continued to emerge. Many of these considerations were combined in the first official integrated energy plan (2003).

The 2001 Gas Act

Made for the orderly development of the piped gas industry and established a National Gas Regulator.

The 2001 Eskom Conversion Act

The Act changed Eskom into a public company.

The 2002 Gas Regulator Levies Act

The Act provided for the imposition of levies by the National Gas Regulator.

The 2003 Petroleum Pipelines Bill

The Bill seeks the establishment of a national regulatory framework for petroleum pipelines, and provides for the licensing of persons involved in the manufacturing or sale of petroleum products.

Merging of the energy regulators

In April 2003, the Minister of Minerals and Energy announced her intention for the NER, the Gas Regulator and the Upstream Petroleum Regulator to merge into a single entity within five years.

2.1.4.1 Integrated Energy Plan

The Department of Minerals and Energy (DME) published an integrated energy plan (IEP) at the end of 2003. The plan is essentially a framework for taking decisions on energy policy and for the development of different energy sources and energy technologies in the country. The Energy Research Institute was contracted to undertake a computerised analysis of this plan based on the energy reserves, energy demand, and consumption for up to 2020 using different scenarios of the South African economy. The scenarios do not only give future energy use based on the use of different energy sources, but also carry different exercises that help evaluating associated pollution including the emissions of greenhouse gases.

2.1.4.2 Oil and gas industry

South Africa depends heavily on imported crude oil that is refined in the country into the needed petroleum products, but about 38% of its needs are met by synthetic fuels. Historically, many government institutions are involved in the petroleum industry, covering areas of importation of crude oil, exploration activities and strategic fund development.

Liquid fuels production, import and consumption account for approximately 20% of South African TPES. Currently consumption is about 450 000 b/d, of which net imports account for about 255 000. The remaining amount is produced from synthetic fuels from coal by Sasol, and from natural gas by Mossgas.

The petroleum sector is governed by a complex system of agreements between government and the oil industries which essentially regulate the price of petrol and diesel and how it is distributed, produced, transported and sold. However, the operations are undertaken by the respective companies and, with the exception of pricing, the petroleum sector is not yet deregulated.

With regard to the petroleum price, DME introduced a new price mechanism, changing from the in bonded landed cost (IBLC) to a basic fuel price (BFP) set by the DME that will give back to motorists and the economy an amount of R1 billion over 12 months.

The DME in collaboration with the Department of Transport (DT) recommended the use of diesel fuel in minibus taxis as a means to reduce air pollution. The effectiveness of such a policy will require the use of more diesel vehicles and good collaboration between the oil industries and car manufactures.

Since 1991, the government deregulated refineries industries in South Africa, though the income of refineries is determined by import parity cost of fuels, and there is no control in respect of refinery margins. In summary:

- the government will not extend regulatory control over crude oil refining;
- there is no need for South Africa to build another refinery since the current total refinery capacity is sufficient to meet the present demand;
- the DME still sets the price of fuels;
- the DME advises the Ministries of Transport and Finance on the energy-efficiency implications of alternative transport and subsidy policies.

Natural gas is available off the country's shores, but the size of deposits is not exactly known. The reserves are estimated at 30 billion cubic metres (bcm) off the South coast and some very small discoveries of 3 bcm off the west coast.

The overall quantity of South Africa natural gas resources are yet to be fully explored. Gas plays a small role in South Africa's energy economy, accounting for less than 1% of TPES and TFC. There are possibilities to increase the use of gas, with the natural reserves in neighbouring countries (Mozambique and Namibia). At present, natural gas is produced by Mossgas from F-A field in the Mossel Bay area and accounted for about only 1.6% of total primary energy in 1997. Sasol also produces gas amounting to about 1.1% of net energy consumption; this is mostly consumed by large industries in Gauteng and Mpumalanga.

2.1.4.3 Government institutions

Soekor (Pty) Ltd was formed by the government in 1965 and is responsible for the control and coordination of petroleum exploration offshore activities in the country, including policy and regulatory functions in this area. Early on Soekor worked with several international oil companies but most of them withdrew due to international sanctions. It has the mandate to carry out joint exploration ventures and to allocate areas for exploration. Soekor operates beyond South Africa, and at present has interests in Angola and South East Asia.

Mossgas was established by the government in 1992 to be responsible for production of gas from Mossel Bay and convert it to liquid synthetic fuels. Its production capacity is 45 000 barrels per day of crude oil equivalent; the product is refined to produce petrol, diesel, kerosene and LPG from a feedstock comprising 4.9 million cubic metre day of natural gas (IEA 1996: 180).

Petroleum Oil and Gas Corporation of South Africa (PetroSA) was established in July 2000, merging Mossgas and Soekor. The goal of the PetroSA is to be a leading integrated provider of oil, gas and petrochemicals competitively in African markets and beyond. The overall production of PetroSA is 8% of the liquid fuel requirement of South Africa, and the products are produced under their own names in Southern Cape and parts of Northern and Eastern Cape. Alcohols and small quantities of transportation fuels are exported worldwide.

The Strategic Fuel Fund is a subsidiary of the Central Energy Fund, and stockpiles strategic reserves of crude oil. In 1988, it stocked up to one-and-a-half-years' supply, which was reduced to about a third by 1995. The government has approved a stock equivalent to four months supply, about 35 million barrels (Trollip 1996).

2.1.4.4 Promotion of renewable energy

The expansion of renewable energy in South Africa is mostly in the rural areas, where poor households are electrified with solar home systems (SHSs) where the national grid cannot economically penetrate. Government believes that renewable energy is able to in many cases provide the lowest cost energy to these households. A broader approach of 'energisation', combining renewable energy technologies with other sources, e.g. LPG or wind, has been also contemplated.

In August 2002 a White Paper was published by the DME for public comments. The government considers the use of renewable energy as a contribution to sustainable development. As most of the sources are indigenous and naturally available, its use will strengthen energy security as it will not be subjected to disruption by international crisis. Some of the key objectives of the White Paper were:

- To ensure that an equitable level of national resources is invested in renewable technologies, given their potential and compared to investments in other energy supply.
- To introduce suitable fiscal incentives for renewable energy.
- To make easy the creation of an investment climate for the development of renewable energy sector, which can attract foreign and local investor.

The following policies were proposed:

- To develop an appropriate legal and regulatory framework for pricing and tariff structures to support the integration of renewable energy into the energy economy and to attract investors.
- To develop an enabling legislative and regulatory framework to integrate independent power producers into existing electricity system.

- To develop an enabling legislative framework to integrate local producer of liquid fuels and gas from renewable resources into their respective systems.

Further policies are as follows:

- To promote the development and implementation of appropriate standards and guidelines and codes of practice for the appropriate use of renewable energy technologies.
- To support appropriate research and development and local manufacturing to strengthen renewable energy technology and optimise its implementation.

2.1.4.5 Electricity basic service support tariff (EBSST)

As a social responsibility measure, the government decided to provide sufficient free electricity to cover the basic needs of the poor to all connected households. 50 KWh monthly is expected to cover lighting needs, media access and some water heating. However, many municipalities across the country had already introduced free electricity since July 2001, varying from 20 KWh to 100 KWh monthly. The funding for this programme will be from government allocations to the municipalities and from cross- subsidy.

A major impact of the EBSST has been a reduction of the fee paid by the users of SHSs in the non-grid electrification programme. Households are expected to pay R58 per month, which was reduced to R18 as a result of the EBSST.

2.2 Critical issues for energy for sustainable development

Achieving the sustainable development objectives of South Africa will require a substantial increase in the supply of modern affordable services to every South African, while maintaining the environmental integrity and social cohesiveness of the country, and allowing economic development to progress. In the area of electricity, this task translates to providing electricity to the remaining 20% of urban inhabitants and 50% of rural inhabitants. Fuel for cooking is a major problem in South Africa, especially in peri-urban and rural areas where the poor and disadvantaged live. They depend largely on firewood, charcoal, coal and kerosene. To achieve sustainable development will require replacing firewood and charcoal with more modern energy sources, and introducing technological innovations to improve the efficiency and environmental problems associated with coal and kerosene. Provision of electricity and other modern fuels for the commercial and industrial sectors will promote economic competitiveness and future prosperity. The transport sector will require major attention because many people do not now have access to adequate transport. For sustainable development, the public transport system will need to be greatly enhanced in both services and technologies.

Accomplishing these tasks will raise some critical issues for energy sector policy. These issues are: energy provision to the poor and dis-advantaged, access to cleaner modern technologies, complying with both local and international environmental legislations, and energy integration and security in Southern Africa.

2.2.1 Energy provision to the poor and disadvantaged

The government has stated that it intends to achieve 100% access to electricity by 2010, but it is not clear if it will be 100% grid electricity or partly off-grid. The quantity of electricity that will be available to each household is also yet to be decided. Originally plans were made to supply households with about 350 kWh/month, but experience has shown among the new connections that households consume on an average between 75-250 kWh, mostly around 100 kWh/month (Prasad & Ranninger 2003). However, provision should be made for higher consumption as it has been shown that the provision of electricity leads to development of productive activities that use electricity. Policies will be required in the areas discussed below.

Grid and off-grid electricity supply

Despite the declining cost of new connections, as shown by Eskom (2002), the cost of connecting the remaining 20% in urban areas and 50% in rural areas will be very high. Also, unless the users can afford to pay for electricity supplied, it will be difficult to recover a meaningful share of the investments. Generally, the overall macro-economic environment will

determine the extent of electrification in the urban and rural areas. However, experience has shown that the multiplier effect of grid electricity can be significant if well planned. Supplying grid electricity to rural areas is more difficult because of remoteness and low population density, meaning that cost is prohibitive and the weak and non-cash economy makes recovery even more difficult. However, policy approaches based on 'taking electricity to the people or bringing the people to electricity' should be explored, as has been done elsewhere.

Off-grid electricity supply in South Africa is posing serious problems because of the belief that 'electricity for all' means grid electricity for all. The government is presently supporting a major off-grid system using SHSs by allocating concessions. At present it subsidises up to 70% of the capital cost and about 80% of the maintenance costs. The results of the systems installed so far are mixed and the cost to the government is high (Afrane-Okese & Muller 2003). Policy attention will be required to ensure the sustainability of the project.

Providing fuels for heating and cooking will require attention. Solar water heaters can be used to provide hot water, and the limited programme that was done at Lwande in the Western Cape shows that with policy attention, they can be viable (Lukamba & Davidson 2003). A major programme about to start with support from the Global Environment Facility will assist in providing more lessons in applying this technology.

The use of liquefied petroleum gas (LPG) is not yet widespread in South Africa, though it is increasing. There are some barriers which could be addressed by certain policies and measures (Cowan & Lloyd 2003), and South Africa can learn from successful programmes in Botswana, Senegal and Ghana (Davidson & Sokona 2003).

There are few ongoing programmes that are aimed at introducing improved cooking stoves for kerosene and coal. The Cape Technikon in Cape Town is working on improved kerosene stoves, while the government is now implementing the low smoke fuel stoves using coal. The penetration of these technologies will not only improve efficiency but reduce health hazards that are associated with the use of these fuels.

Access to high quality transport fuels

Access to high quality transport fuels for sustainable development will require improvement of petroleum fuels and the introduction of cleaner transport fuels. Also, due to the need for access to the poor and disadvantaged, the provision of public transport needs to be greatly improved to provide general transport for essential travel and especially to reduce reliance on private transport. However, such systems will require major improvements in road and communication infrastructure. Developing this infrastructure will require significant investments and energy provision is only one of the features supporting such investments.

Generally, major improvements are being made to improve the environmental qualities of petroleum products, especially petrol and diesel and South Africa has already started practising some of these. The use of unleaded petrol is growing, and the government intend to phase out the use of leaded fuel in a few years. The rehabilitation of the Natref refinery to produce low-sulphur diesel is another move by the government to improve the local environment. The government also intend to use up to 5% bio-diesel by 2006, which will also reduce local adverse emissions. Some cities, such as Gauteng and Cape Town, are planning to use compressed natural gas in public buses. Studies have been done which shows that this will result in both local and global environmental benefits (Davidson & Xhali 2003).

2.2.2 Access to cleaner modern power technologies

The cleaner technologies available to South Africa in the near and medium terms relate to cleaner fossil fuel, energy efficiency, and renewable energy

2.2.2.1 Cleaner fossil fuel technologies

Coal reserves in South Africa are huge and coal will remain a significant fuel in the energy sector of the country for sometime. However, the present technologies being employed are causing serious local and global environmental problems. In general there are a number of technologies in the public domain to address local environmental problems, but not the global problems. Natural gas contributes only about 1.5% of the country's needs, but the government

intends to increase this share to 10% by 2010. Natural gas is about 60% cleaner than coal in terms of carbon dioxide emissions, and significant progress is being made to improve technologies associated with natural gas use. Crude petroleum accounts for over 75% of the country's transport needs and nearly all is imported. Attempts are currently being made to reduce reliance on crude petroleum and improve environmental conditions in using this fuel. Possible policy interventions are discussed below.

Cleaner coal technologies

Technologies to reduce sulphur dioxide and nitrogen oxides are presently used in many industrialised countries, but they are expensive and require significant investments. Providing that the overall economy improves, then electricity consumers can be taxed to contribute to the increased investments needed.

Major technological progress is expected in coal technologies for power production, though most will be available in the medium term. These technologies include pulverised fuel combustion and integrated gasification and combustion technologies, and, in the longer term, coal-powered fuel cells. These technologies expect to reduce carbon dioxide emissions from the current 1200 kg of CO₂/MWh to about 500 kg of CO₂/MWh, while increasing efficiency from about 30% to 70%. In the longer term, technologies such as carbon capture and storage will be available as South Africa has many old coal mines where carbon dioxide can be stored in the future. Future coal power plants may include some end-of-pipe treatment, such as flue gas desulphurisation, although they add some 30% to the cost of stations (see Chapter 4).

Cleaner oil and gas technologies

Power production technologies using oil and gas are also improving and in the longer term improved oil powered technologies are expected to reduce carbon dioxide emissions by half, and similar efficiency improvements are expected with oil powered fuel cell technologies. The gas-powered technologies with improved turbine systems and fuel cells can result in similar improvements.

2.2.2.2 Energy efficiency technologies

The overall energy efficiency of the energy sector can be improved significantly, especially in the power and industrial sectors. Significant gains can also be achieved in the household sector. However, major policy changes will be needed to achieve these gains. These changes would have to be a combination of regulatory and market-based policies and institutional changes. At present, the NER along with Eskom has embarked on load management and demand-side management programmes in the residential, industrial and commercial sectors, aiming to achieve gains equivalent to between 1000-3000 MW by 2010.

2.2.2.3 Renewable energy technologies

As mentioned previously, South Africa is using renewable energy for electricity production, water heating and for cooking. However, the share of this use to the total energy used in the country it is very small, but the government intends to increase it to about 14% by 2014 (Mlambo-Ngcuka 2003). However, a government white paper on renewable energy is expected soon and it will spell out government intentions.

2.2.3 Complying with environmental regulations

Due to the extensive use of coal and petroleum fuels in South Africa, the adverse impacts on both local and global environment are significant. The country is presently drafting new, stricter air quality standards. South Africa is a signatory to the United Nations Framework Convention on Climate Change, and though the country does not have quantified targets, its status as Africa's highest emitter of greenhouse gases makes it likely that targets will be imposed as soon as developing countries are asked to take these on. Complying with such obligations, both local and global, can be expensive and, to ensure sustainable development, they should not be done at the expense of the country's socio-economic development.

2.2.4 Energy integration and security in Africa

South Africa is a member of the Southern African Power Pool (SAPP) that is made up of the different power utilities in Southern Africa, with a secretariat in Harare, Zimbabwe which started operation in mid 2002. The aim of the SAPP is to optimise the use of electricity in the region. South Africa having the biggest utility in SAPP, the future of the country can be affected by activities in SAPP. Further, Eskom is presently involved in 39 African countries, increasing South Africa's importance in continental energy integration.

South Africa has embarked on diversifying its energy supply base and reduce its reliance on the coal that now accounts for almost three quarters of its total energy supply. Substitution of coal as feedstock for transport fuel by use of natural gas from Mozambique is one such measure and full operation of this system should start in early 2004. It is also intended to use the gas to produce power from combined cycles. Working with Namibia to develop its natural gas potential is also under way. As for oil, while over 70% of current supplies of crude imports come from the Middle East, South Africa is now increasing the share from Nigeria. South Africa is also working with the Democratic Republic of Congo to develop a 100 GW hydropower plant.

2.3 Outlook: How the policy will change in the future

Previous sections have described some policies that the government has embarked on to assist the country's development in a sustainable manner; other policies which could help to improve the sustainability of its development efforts are given below in the categories of energy efficiency, renewable energy technologies, and cleaner fossil fuels.

2.3.1 Energy efficiency

A major option for future energy policy lies in the field of energy efficiency. While some progress has been made, many potential gains remain underutilised. Improving energy efficiency will have significant impact on the provision of energy to meet sustainable development goals. In the residential sector, the savings to households from energy efficiency directly contribute to alleviating energy poverty. Making current voluntary guidelines into mandatory standards for new housing (especially in middle- and upper-income housing) would enable this to happen.

Even before this happens, building codes in the commercial sector (which has greater financial capacity) should become mandatory. Government is taking the lead in some of its own buildings in this regard. Government procurement for a wider range of equipment could require energy efficiency standards. Equipment standards for a wide diversity of equipment (e.g. variable speed drives, air compression, HVAC systems) can help increase industrial energy efficiency. Appliance labelling and mandatory energy performance standards are other measures to be considered. Ultimately, industrial energy efficiency can contribute to economic development.

The transport sector is a large sector of energy consumption at municipal level, and one with rapidly growing emissions – of both local and global pollutants. Improved fuel efficiency standards would increase the energy efficiency of the national fleet. Vehicle emissions standards are being considered by the Department of Environmental Affairs and Tourism.

Implementing all of these efficiency measures requires some institutional support. The institutional framework for energy efficiency needs to be strengthened, be it within government or outside of it. A national agency championing energy efficiency could consolidate efforts, possibly working in collaboration with energy service companies. Research, development and demonstration remains of particular importance.

2.3.2 Renewable energy

At present, South Africa has limited renewable energy sources that can be exploited commercially, but the cost of renewable energy is expected to continue to decline as the technologies mature. Increased use of renewables will require the introduction of new policies. The Renewable Energy White Paper (2003) has set a target of 4% (see Chapter 4). A strategy of

implementing this target needs to be formulated, honing in on specific projects and their financing.

The government has always outlined its intention to improve the local content of renewable energy technologies used in South Africa. Hence, the most important policy is to set up policies for progressively increasing local content in the manufacture of renewable technologies used. Such a policy should be accompanied with the government supporting enabling conditions for local technology development.

Strengthening the regulatory framework for promotion of these technologies within the NER will help their development. Financial support for them in the form of subsidies and tax incentives should be considered but targeted for a limited period. Initially, it appears that Treasury will set aside funds on a once-off basis, but in the longer-term, financing schemes to be considered include:

- feed-in tariff mechanisms;
- portfolio quotas with or without tradeable certificates;
- tax incentives;
- green pricing.

2.3.3 Cleaner fossil fuels

As discussed above, technological progress is being made in developing and implementing cleaner fossil fuel technologies. However, most of these efforts are in developed countries and are in R&D and D networks. An area for policy intervention is for South Africa to become part of these networks and partnerships as this would enhance not only the knowledge basis for suitable selection, but also allow local forces to be part of their development, thus increase their chances of utilisation.

Another area of policy intervention is developing an adequate policy framework for technology development and transfer. Policies such as enhancing a national system of innovation, improved technology data base and optimisation of human and financial resources can assist to improve technology acquisition.

Improvement of beneficiation from energy-intensive industries in South Africa can not only provide macro-economic advantages but will help technology development significantly and reduce technology imports. Attempts are being made in the manufacturing sector but much more needs to be done.

2.3.4 Cross-cutting issues

Financial instruments tend to have effects across economic sectors. Particular kinds of energy efficiency – notable for low-income households – probably require subsidy. For sectors that can pay for the capital costs, government needs to invest in programmes promoting options with pay-back times short enough to attract investment by users themselves.

Pollution taxes – possibly targeted at local pollutants rather than greenhouse gases – are one cross-cutting measure that would both meet environmental objectives and also generate revenues. Care should be taken that the energy burden of poor households is not increased by such measures, but with appropriate targeting and recycling of revenue, this is possible. More generally, funding for social and environment public benefits requires attention, particularly as deregulation increases competition.

Further issues include R&D and institutions for training. Energy policy development in South Africa is done by the government which in turn contracts several institutions to undertake selected policy studies. This system works fairly well but it can be improved. The government needs a well organised structure that undertakes screening and synthesis of the many options available. This structure should also have strong international linkages. A very important role of the structure is to identify the critical areas where the government needs intellectual input for policy-making.

Government needs to fund institutions that develop highly qualified energy policy technocrats. At present this is done on an ad hoc basis, which does not give optimum results. Using different approaches of short- and long-term programmes will greatly enhance the capacity of government to make adequate policies.

Promotion of public awareness programmes around energy for sustainable development is particularly important as this is a new paradigm and needs deliberate efforts.

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3. Energy demand

Harald Winkler

3.1 Analysis of the current situation

People demand energy services rather than requiring energy for its own sake. Major energy services include heating, lighting, cooking, water heating, transport and energy for productive (including industrial) activities. In analysing energy for sustainable development, rather than simply assessing access to electricity, one might also analyse 'the cost of cooking a meal for the poor', which would reflect not just energy costs but the efficiency of the appliances and fuels available to households. Analysis of the energy system should therefore start from energy services, and work backwards through useful energy, the appliances required to deliver that energy, final energy to energy supply. A historical perspective on energy demand will help to contextualise this analysis.

3.1.1 History of energy demand

The energy sector has been a key factor in shaping South Africa's development path. Electricity supply, for example, was shaped by the demand from the mining industry as it emerged in the early twentieth century. In the 1950s, driven by concerns about energy security, the apartheid government decided to develop a synthetic fuels programme to meet demand for liquid fuels and lessen its dependence on energy imports. Massive power station projects initiated in the 1960s and 1970s (including local nuclear capacity), with the assumption of continued rapid increases in electricity demand, left the national utility with large excess capacity in the 1980s and 1990s. Excess capacity has helped to keep electricity prices low, although this excess capacity will be exhausted within the coming three to five years (Eskom 2000). This excess capacity is illustrated as the difference between total licensed capacity and peak demand in Figure 3.1. With little need for new investment in recent decades, debt has been reduced as most of the capacity has already been paid off. When new investments have to be made, costs and electricity prices are expected to rise.

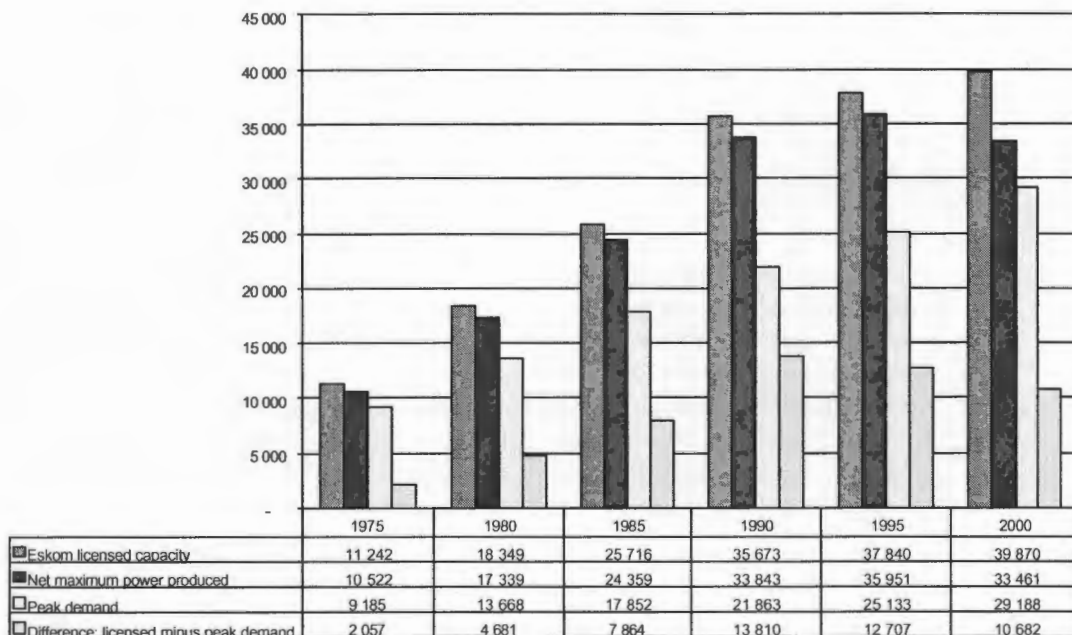


Figure 3.1: Eskom licensed capacity and peak demand (MW)

Sources: Eskom (1987, 1996); NER (2000)

The presence of low energy prices, including coal-generated electricity, has been one of South Africa's key competitive advantages and continues to drive much of new investment in

industry. After the democratic elections in 1994, the focus has shifted to residential demand, with a primary energy policy objective being universal access to electricity and making energy services more broadly available to poor households.

Energy demand historically has been dominated by heavy industry and mining, which shape the economic and energy structure of the country. Much of the manufacturing sector is also linked to mining activities through minerals beneficiation and metals production. All of these activities are energy intensive, relying on the availability of inexpensive coal and electricity. Figure 3.2 shows the dominance of industrial and transport sectors for final demand. Non-energy refers to resources such as coal, oil, gas and wood that could be used for energy but which are converted to other products like chemicals and paper (SANEA 2003).

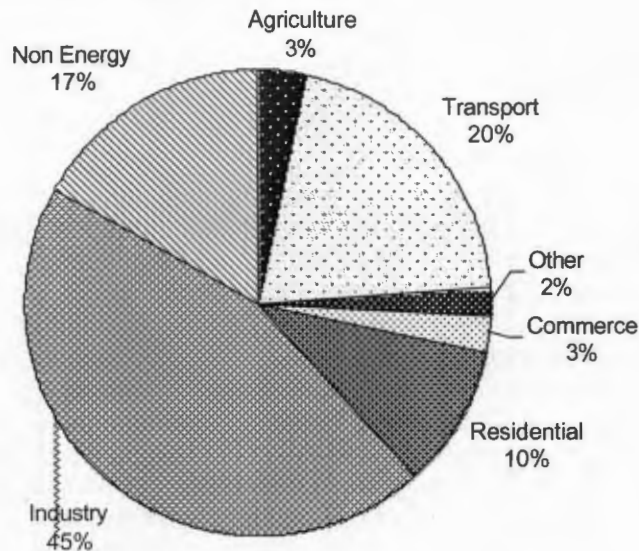
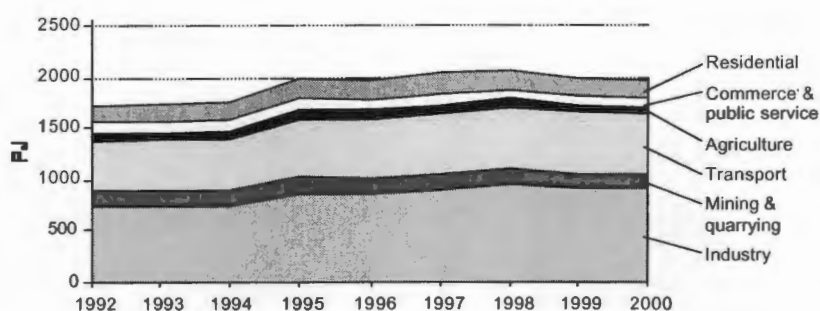


Figure 3.2: Share of final energy consumption, 2000

Source: Based on SANEA (2003)

In recent years, industrial demand has been the major source of growth across all energy carriers (see Figure 3.3). Some growth can be seen in the transport sector, while mining production declined slightly towards the end of the past decade. Comparing these patterns to international trends, we find that total final energy consumption globally has declined for coal from 627 to 546 Mtoe, while industry's share has grown from 44% to three-quarters from 1973 to 2000. Oil consumption globally has increased over the same period from 2139 to 2 950 Mtoe, with transport being the fastest growing sector, similar to South Africa. Consumption of natural gas has almost doubled from 672 to 1 115 Mtoe, but industry has declined from more than half to 44% of the share. The greatest increase has been in electricity final consumption, from 439 to 1089 Mtoe; other sectors have increased their share, with both industry and transport declining in relative terms (IEA 2002a). In terms of regional composition, the OECD continues to consume more than half of total final energy, although its relative share declined from 62% in 1973 to 52% in 1993. African energy consumption has risen from 2.8% to 5.5% over the period. The biggest growth has been in Asia (5.2% to 12%) and China (5.8% to 11.4%).



Note: does not include consumption of renewables and waste, due to uncertainties in biomass data

Figure 3.3: Energy demand, 1992-2000

Source: Based on data in energy balances (DME 2002a)

3.1.2 Energy demand in a comparative perspective

Compared to other developing countries, the total primary energy supply (TPES) per person is relatively high (see Table 3.1). Some other rapidly industrialising countries, however, such as South Korea, have higher consumption per capita. Total electricity consumption for South Africa is high, particularly in the African context. The two-thirds of South Africa's population with access to electricity consumes close to 50% of Africa's electricity with only 5% of its population. Consumption levels of energy, particularly electricity, in South Africa are significantly higher than in many other developing countries, mainly because of its strong industrial base. See Table 3.2 for an international comparison of electrification rates in 2000.

Table 3.1: Energy and electricity consumption, 2000

Source: IEA (2002a)

	Total primary energy supply /capita	Electricity consumption
	Toelcapita	TWh
South Africa	2.51	194
Africa	0.64	399
South Korea	4.10	279
Indonesia	0.69	82
Non-OECD	0.96	5 038
OECD	4.78	9 077
World	1.67	14 115

Note: TPES is shown per person, while electricity is in total consumption for whole countries or regions

Table 3.2: Electrification rates in 2000

Source: IEA (2002b)

	Electrification rate	Population without electricity	Population with electricity
	%	million	million
South Africa	66.1	14.5	28.3
Africa	34.3	522.3	272.7
South Korea			
Indonesia	53.4	98.0	112.4
Developing countries	64.2	1 34.2	2 930.7
OECD	99.2	8.5	1108.3
World	72.8	1644.5	4 390.4

3.1.3 Demand for electricity

Demand for electricity has played a particular role in the South African economy. Its importance lies both in providing access to a modern energy carrier to those who have been denied access in the past, as well as in supporting industrial development. Figure 3.4 breaks down final energy demand by carrier, and shows that liquid fuels and gas make up the largest single share, followed by coal and electricity. Electricity makes up 22% of final energy demand in South Africa, but this share understates the role that electricity plays as a high quality energy carrier and as a critical input to key economic sectors. On the industry and manufacturing side, the electricity-intensive industries are some of the largest contributors to economic growth and exports, and take up more than 60% of national electricity sales (Trollip 1996; Berger 2000; DME 2000).

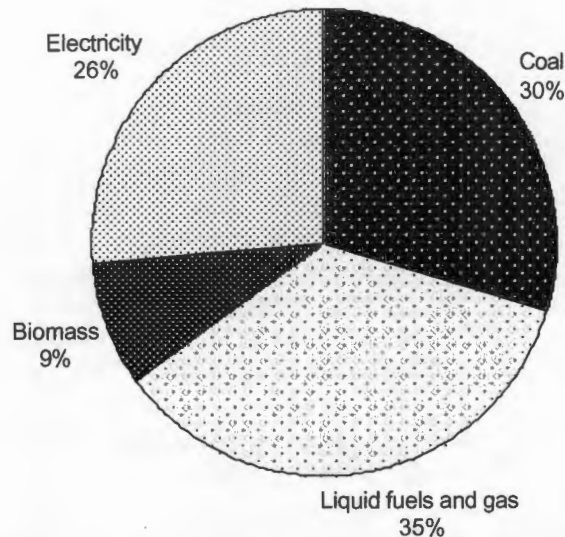


Figure 3.4: Share of final energy demand by energy carrier

Source: Based on data from DME (2002a)

Obviously the demand for electricity needs to be met by supply from power generation (see Chapter 3). The flow of electricity from production, through distribution and to end use customers is shown in Figure 3.5. Note that the percentages for different sectors in this figure are for electricity only, while those in Figure 3.2 were for all energy.

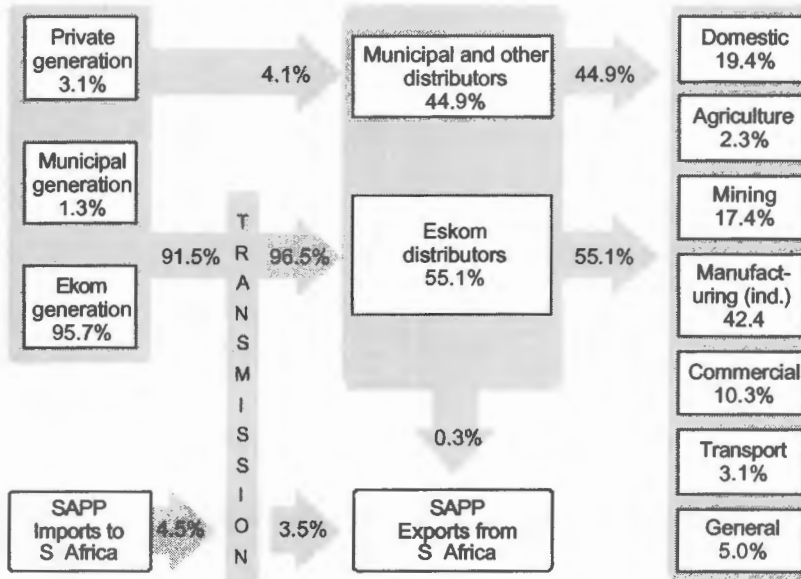


Figure 3.5: Energy flow through the electricity supply industry in South Africa¹

Source: NER (2001a)

Most electricity is consumed by the industrial sector at 44%. Mining and residential are the next two largest, with the both also showing the greatest growth in demand in the recent years.

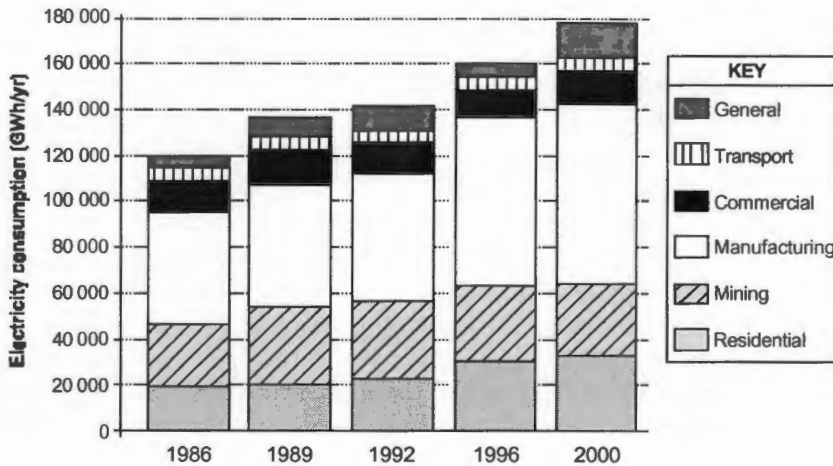


Figure 3.6: Electricity demand, 1986-2000

Source: Davis (1998), NER (2000)

The typical pattern of electricity demand during the working week shows two distinct peaks (see Figure 3.7), one in the morning and a higher one in the early evening. In winter, peak demand is more pronounced than in summer, as demand for space heating increases. Meeting peak demand means that additional capacity is required. Eskom peak demand in 2001 was 30 599 MW, almost 50% higher than average energy distributed of approximately 20 000 MW (NER 2001a).

¹ The original diagram gives no percentages for imports and exports. For 2000, however, 5294 GWh were imported from SAPP utilities and 3967 GWh exported. As a percentage of gross energy sent out of 198 206 GWh, imports constituted 2.6% and exports 2.0%. It is not exactly clear how this would change the percentages above, but the impact of 1 327 GWh difference between imports and exports is unlikely to result in changes in front of the decimal point.

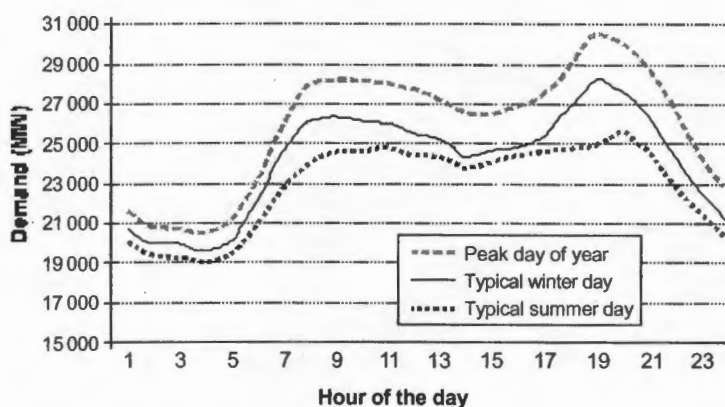


Figure 3.7: Weekday electricity demand profile (average across seasons)

Source: NER (2001a)

A key energy policy objective has been universal access to electricity. This objective formed part of the post-1994 government's Reconstruction and Development Programme. (ANC 1994) In 1998, it was included as a major objective in the White Paper on Energy Policy. (DME 1998) The National Electrification Programme in its first phase from 1994-1999 aimed to connect 2.5 million households over the period. By 1999, electrification rates had increased from about one third to two-thirds. According to the latest statistics of the NER, the overall rate of electrification was 66% in 2001 in South Africa (NER 2001b; 2001a) During 2002, a further 338 572 homes, 974 school and 49 clinics were grid-electrified, and 5 321 SHSs installed (Mlambo-Ngcuka 2003).

The total investment in the electrification programme was about R7 billion, all of which was domestically financed. Without this cross-subsidy, electrification would not be viable (Borchers et al. 2001). As electrification is taken over by government, direct government subsidies will be required. Estimates are that a capital subsidy of R840 million per year be required from government to REDs for the first five years and R560 million per year thereafter (PWC 2000: 14). This would amount to a subsidy of R2 800 per connection.

Consumption levels, however, remained low for several years after electrification at about 100-150 kWh per month, well below the planning estimate of 350 kWh. This reflects problems of affordability despite the 'low' tariffs, as shown by South African research which suggests that many electrified households continue to use traditional, highly polluting fuels (Mehlwana & Qase 1998; Thom 2000). There are also a variety of social and cultural reasons why people may still choose to use non-electric fuels (Mehlwana 1999). High cut-off rates and community protests against cut-offs epitomise the affordability problem.

3.1.4 Demand for liquid fuels

Demand for liquid fuels is dominated by petrol and diesel, as shown in Figure 3.8. The transport sector accounts for some 80% of the demand for these fuels, with most petroleum products being used in road transport (DME 2002a). Consumption of other liquid fuels is an order of magnitude smaller than those for petrol and diesel. Jet fuel is obviously consumed in aviation, while kerosene and LPG are important in the residential sector. Fuel oil is typically used by heavy industry.

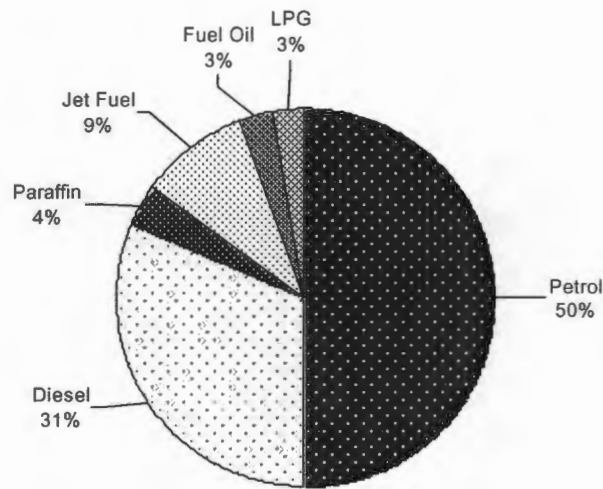


Figure 3.8: Consumption of major liquid fuels, 2001

Source: DME (2002b)

Over the period 1988-2000, two trends can be deduced (see Figure 3.9 and Table 3.3). One is that the consumption of jet fuel has been growing rapidly. The other is that the consumption of petrol has been declining in the last few years, while diesel has been increasing. Comparing 2000 to the previous year, petrol sales dropped by 4.3%, while diesel grew by 4.3%, against the back-drop of an overall decrease of 1.6% for liquid fuels (SAPIA 2001).

Table 3.3: Inland consumption of petroleum products

Source: SAPIA (2001); SANEA (2003)

Year	Petrol	Diesel	Kerosene	Jet fuel	Fuel oil	LPG
1988	7 995	5 409	641	784	524	406
1989	8 395	5 350	678	835	546	432
1990	8 612	5 273	723	866	576	434
1991	8 906	5 130	725	861	526	464
1992	9 171	4 950	743	1 009	549	465
1993	9 202	4 940	834	1 095	595	454
1994	9 630	5 110	875	1 193	633	485
1995	10 153	5 432	850	1 368	616	472
1996	10 566	5 759	917	1 601	704	450
1997	10 798	5 875	970	1 777	635	502
1998	10 883	5 959	1 052	1 877	574	523
1999	10 861	5 993	1 054	1 995	561	540
2000	10 396	6 254	857	2 020	555	567
2001	10 340	6 448	786	1 924	555	599

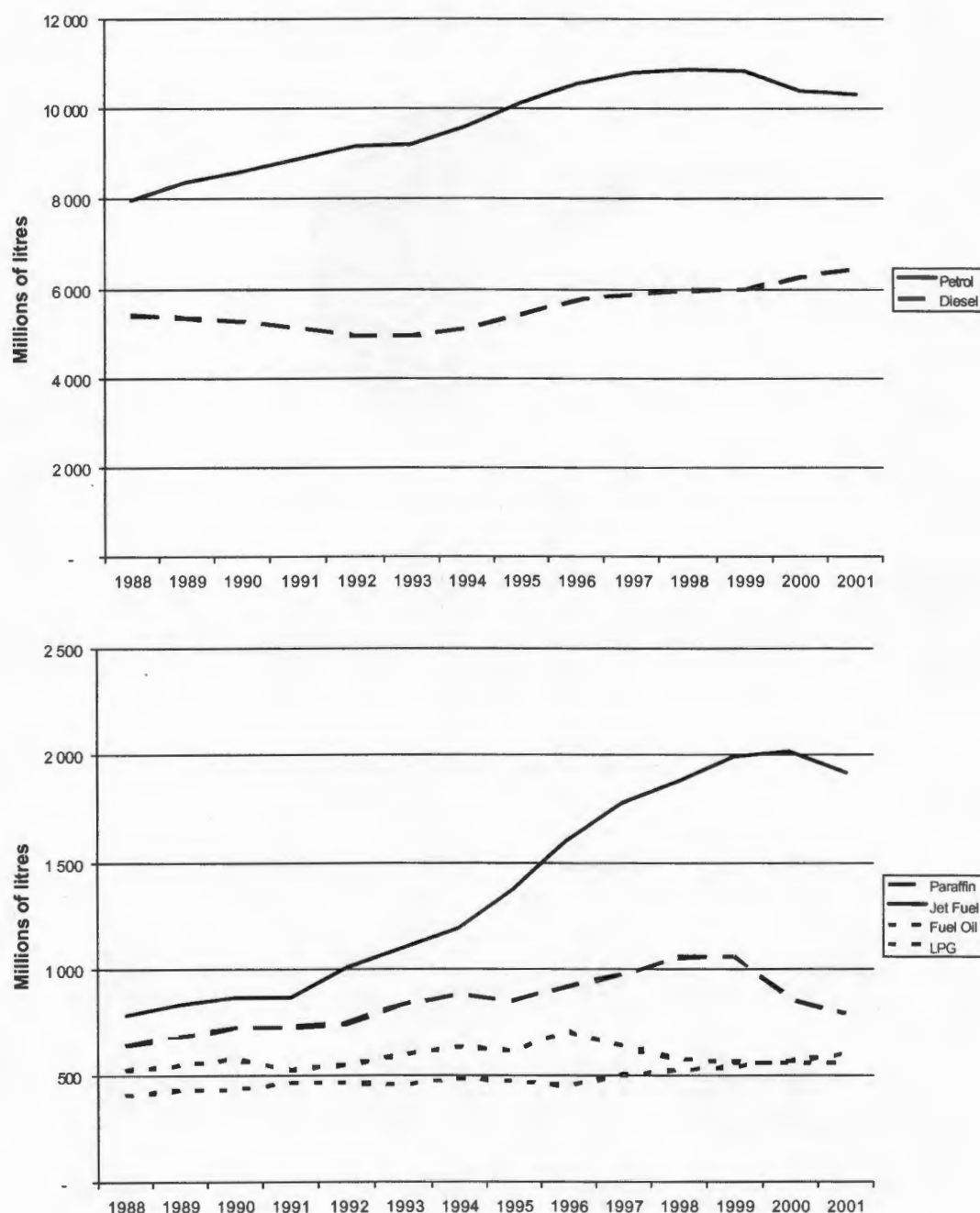


Figure 3.9: Trends in petrol and diesel (top figure) and other liquid fuel (bottom figure) consumption, 1988-2001

Source: SAPIA (2001); SANEA (2003)

3.1.5 Final energy consumption by sector

The breakdown of final energy consumption by economic sector has been described in some detail in the *Preliminary energy outlook for South Africa* (ERI 2001), a document laying the basis for an Integrated Energy Plan (IEP). The IEP itself had not yet been publicly released at the time of writing (November 2003). A more recent publication is a South African energy profile (SANEA 2003) compiled for the SA National Energy Association (SANEA, an affiliate of the World Energy Council), although most of the data is also for 2000/1. These data have been used and supplemented by unpublished modeling data from the Energy Research Centre (ERC 2003).

3.1.5.1 Industry

Industry is the largest user of energy at the national level in terms of final energy consumption (see Figure 3.3). Within the industrial sector, major sub-sectors include mining, iron and steel, pulp and paper, non-ferrous metals, chemicals and petro-chemical, food & tobacco and other (see break-down in Figure 3.10).

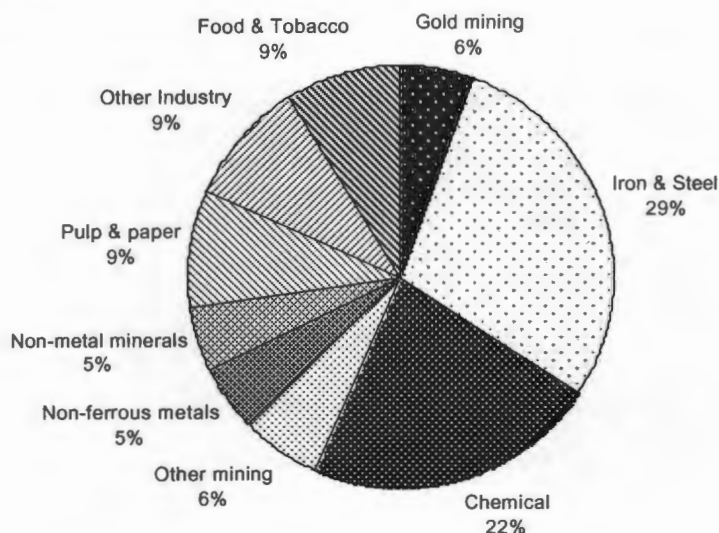


Figure 3.10: Final industrial energy consumption by sub-sector (2001 total: 1302 PJ)

Mining in particular is a large energy-consuming sector in its own right, and is sometimes shown separately from industry (e.g. electricity statistics). The chemical and iron and steel industries are also large sub-sectors. A different breakdown is shown in Figure 3.11, illustrating which energy carriers dominate consumption in this sector – coal and electricity. In the mining sector, gold mining is decreasing, but other mining growing. With about 75% of energy in this sub-sector coming from electricity, the share of that carrier is likely to increase in future. This sub-sector is expected to grow more slowly than GDP, unlike most other industries which are expected to keep pace with economic growth or even do better (ERI 2001).

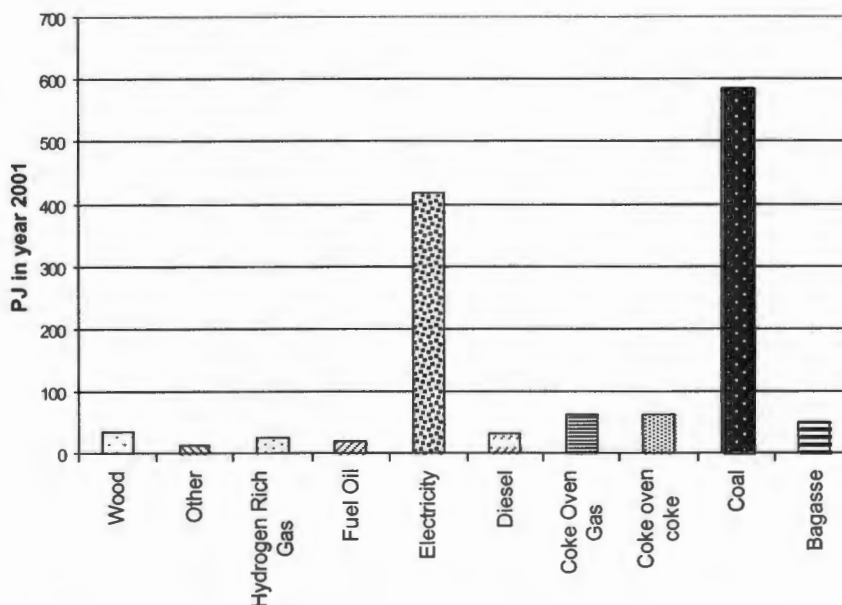


Figure 3.11: Final energy demand in industry by energy carrier (2001 total: 1302 PJ)

Source: Based on SANEA (2003); ERC (2003)

3.1.5.2 Transport

Transport energy use is dominated by liquid fuels, notably petrol and diesel (see Figure 3.12). Land passenger transport is the largest consumer of energy, followed by land freight. (SANEA 2003). Road transport dominates over rail and air modes (DME 2001). Transport energy is expected to grow more quickly than GDP (trends of petrol / diesel and jet fuel already noted in section 2.2.1).

3.1.5.3 Commercial

Electricity is the predominant form of energy carrier in the commercial sector (Figure 3.13). Government and office buildings, financial services, information technology, educational institutions and recreational sub-sectors primarily use electrical appliances, e.g. lights, air conditioning, heaters and office equipment. The sector, like transport, shows higher growth rates than other sectors and can be expected to grow faster than economic output (SANEA 2003). If energy-efficiency standards were made mandatory for commercial buildings, significant savings could be made.

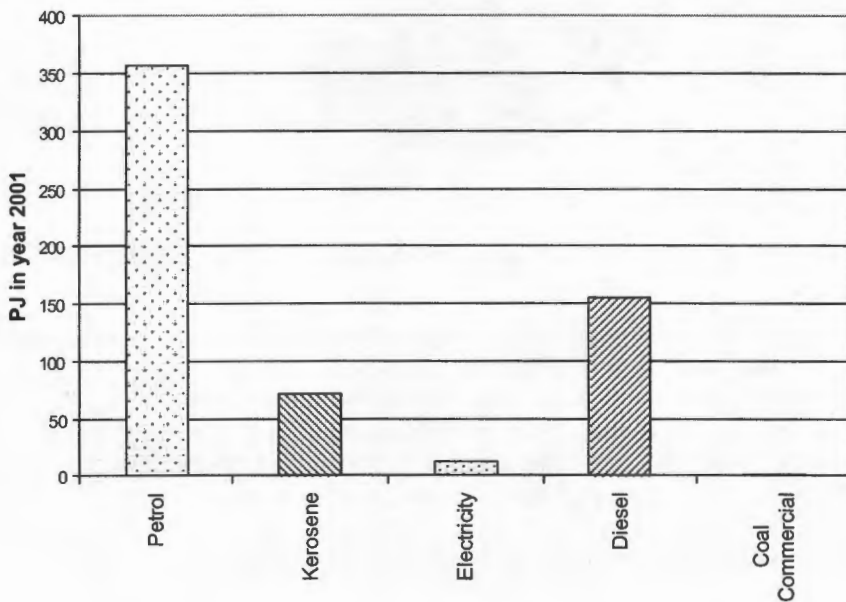


Figure 3.12: Final transport energy demand by energy carrier (2001 total: 596 PJ)

Source: Based on SANEA (2003) and ERC (2003)

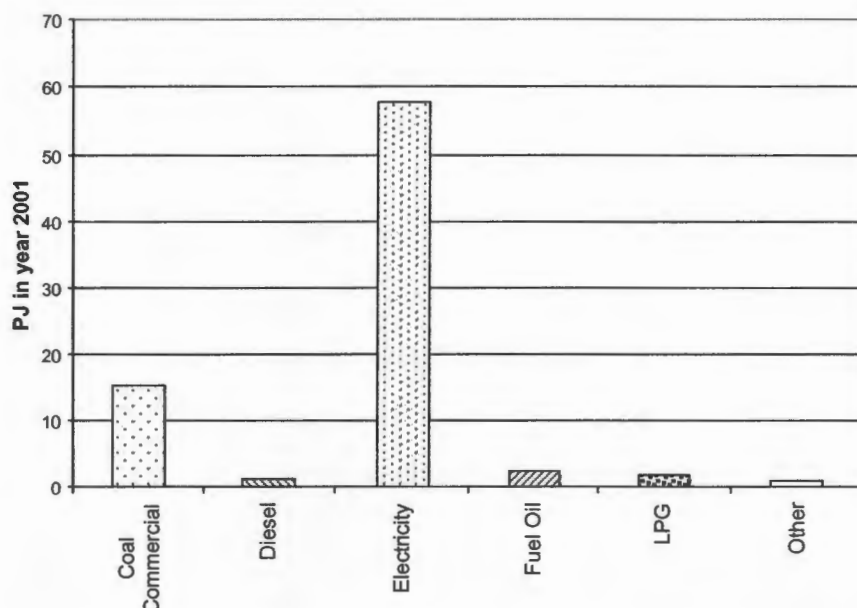


Figure 3.13: Final energy demand in the commercial sector by energy carrier (2001 total: 79 PJ)

Source: Based on SANEA (2003) and ERC (2003)

3.1.5.4 Residential

Energy use in the residential sector is characterised by a multiplicity of fuels and appliances (Figure 3.14). With increasing rates of electrification, electricity is the largest source of energy. However, many other fuels, such as kerosene, coal, fuel-wood and LPG are used as well. As with commercial buildings, there is significant potential for energy-efficiency improvements. An important distinction needs to be made, however, between low-income and other sectors. Even relatively cheap interventions (e.g. ceilings) may not be affordable for poor households and require subsidies; while middle- and upper-income households may invest upfront in return for the energy savings provided (e.g. by solar water heaters). Overall growth in residential demand is linked to population, together with increasing rates of electrification.

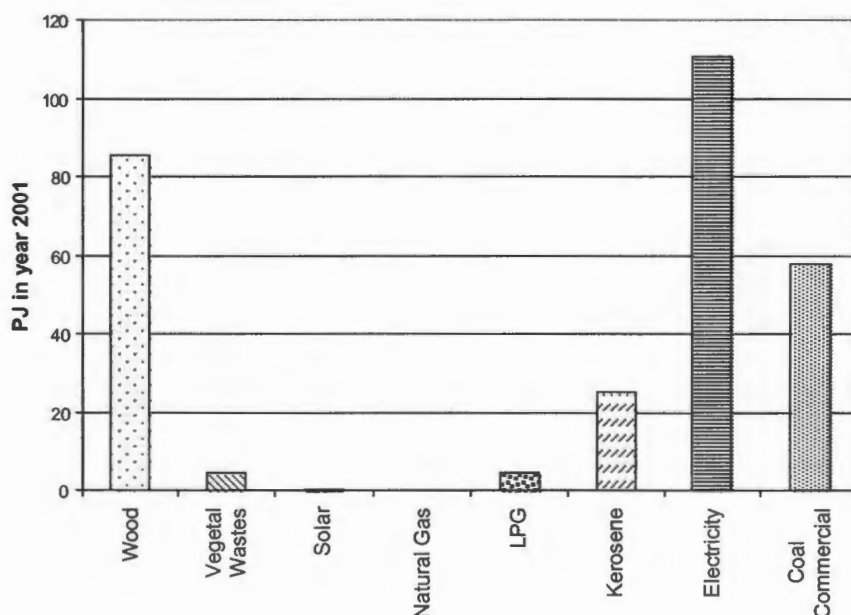


Figure 3.14: Final residential energy demand by energy carrier (2001 total: 288 PJ)

Source: Based on SANEA (2003) and ERC (2003)

Patterns of household energy demand differ significantly in rich and poor, urban and rural households (Simmonds & Mammon 1996; Mehlwana & Qase 1998; Mehlwana 1999). Electricity contributes a larger share of household energy use in urban areas than in rural, while the inverse is true for fuelwood. These differences in fuel-use patterns are discussed in more detail in Chapter 4.

3.1.5.5 Agriculture

Of South Africa's total land area of 122.3 million hectares, 13.7% (16.7 million ha) is potentially arable, 68.6% (83.9 million ha) is grazing land, 9.6% (11.8 million ha) protected by nature conservation, 1.2% (1.4 million ha) under forestry, and 6.9% used for other purposes. Of the arable portion, 2.5 million hectares is in the former homelands and 14.2 million is farmed by commercial agriculture. 9.5 million hectares are used for field crops (NDA 2000: 5-6).

Agriculture includes both commercial agriculture and subsistence farms, although the traditional peasantry was eroded by apartheid (Bundy 1979). In rural areas, there are also dense rural settlements which do not quite fit either the agricultural nor urban residential model. For both these areas and subsistence farming, there is little data on energy use, except of isolated studies (Auerbach & Gandar 1994). Land restitution and land reform under the new government is increasingly aiming at creating a new class of small black farmers. As first mining and then manufacture increased their influence in the economy, agriculture has declined in its share of economic output, contributing 9.1% of GDP in 1965, for example, but only 4.0% by 1998 (NDA 2000). This trend is expected to continue in future. With its declining share of GDP, energy demand may also grow at low rates, but growth of demand in this sector is particularly difficult to predict.

The category of 'subsistence' agriculture is questionable in the South African context, with the homeland system having created rural densities that do not even provide for subsistence. The main energy requirement in this context is for land preparation, with draft power and other energy requirements being a major constraint to the effective utilisation of land (Auerbach & Gandar 1994). Energy for water pumping is the second major use, followed by several minor ones such as crop processing, transport and lighting.

Most energy use in agriculture is from commercial farms, which are tending to increase in size but decrease in number. Energy is used primarily in the form of diesel, followed by electricity and coal (Figure 3.15).

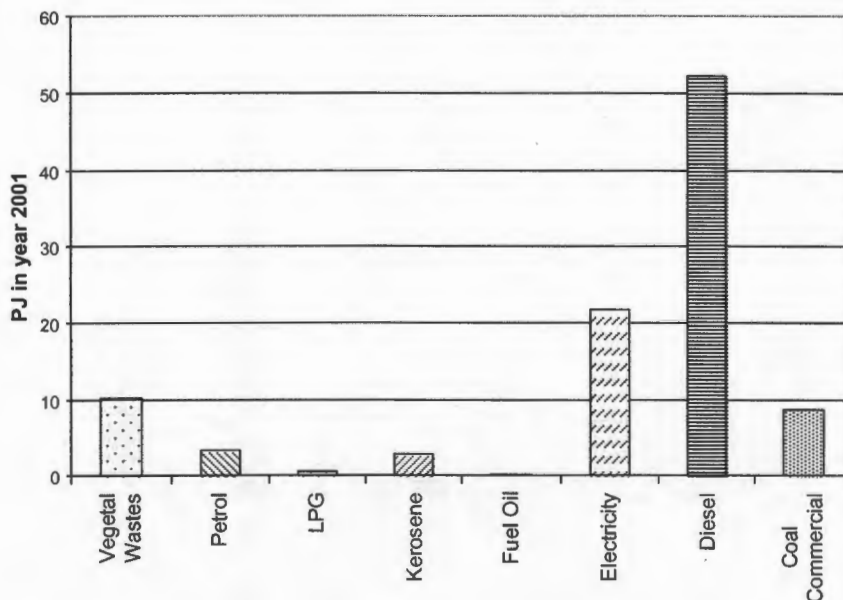


Figure 3.15: Final energy demand in agriculture by energy carrier (2001 total: 100 PJ)

Source: Based on SANEA (2003); ERC (2003)

3.2 Critical issues relating to energy for sustainable development

Energy demand relates to all dimensions of sustainable development. Energy is an essential part of human activity, not due to any inherent value, but for the services it provides in the form of heat, light and motive power (Spalding-Fecher et al. 2000). Hence energy is a critical input to economic development, consumption of energy is important to improving social conditions, and use of energy has significant environmental implications (in addition to supply-side impacts). This section focuses on South Africa's energy intensity, which is a function of both its economic structure and the its energy system. Examples of relatively inefficient use of energy are considered, but also the potential for more efficient technologies and cleaner fuels.

3.2.1 Energy intensity

South Africa's energy intensity – the amount of energy per unit of economic output, and a function of both economic structure and the energy efficiency of individual sectors – is high (see Table 3.4). This is primarily due to the large share of energy-intensive activities within the economy, based on the historical development of the economy around the 'minerals-energy complex' (Fine & Rustonjee 1996). The extent to which energy efficiency measures are implemented is in turn is influenced by relatively low energy prices, which do not provide much incentive for energy efficiency. It makes *economic* sense to use more energy if energy is cheap, but does not promote energy efficiency.² Nonetheless, South Africa has made improvements in some sectors, e.g. iron and steel, which are leading in the world.

The Integrated Energy Plan (DME 2003) acknowledged that by international standards, South Africa has a high energy intensity, that is a high energy input per unit of gross national product (GDP). This is because of low energy costs and an abundance of mineral deposits have led to an emphasis on primary extraction and processing, which is inherently energy intensive. Table 3.4 indicates South Africa's energy intensity between 1993 and 2000, where post 1995, GDP rises and final energy consumption falls resulting in a lowering of energy intensity over that period.

Table 3.4: National energy intensities between 1993 and 2000 (DME 2003)

	1993	1994	1995	1996	1997	1998	1999	2000
GDP- All industries at basic prices (R billion; constant 1995 prices)	472	486	500	521	534	538	549	571
Total Final energy consumption (renewable and waste excluded; PJ)	1 766	1 789	2 016	1 996	2 071	2 098	2 026	2 003
Energy intensity (Total energy consumption/GDP; PJ/Rbillion)	3.74	3.68	4.03	3.83	3.88	3.90	3.69	3.51

Compared to an industrialising nation like South Korea, South African energy intensity is high per GDP, but similar if adjusted for power purchasing parity; and per capita consumption of primary energy is lower. South Africa's intensity is more comparable to that of Indonesia, albeit at a higher level of primary energy and electricity consumption per capita. There is room for energy efficiency improvements, when compared to other middle-income countries (Simmonds 1995; Clark 2000). Areas for such improvements, and also requiring high amounts of energy per unit of output, include mining, iron and steel, aluminium, ferrochrome, and chemicals – the same sectors that make up a large share of South African exports. The abundance of cheap coal for generation has provided little incentive for efficient use of energy by large consumers, and the specific energy efficiency of many sectors is low by international comparison; for example,

² This section deals with energy intensity and therefore energy efficiency. Economic efficiency is a different concept, referring to the optimal allocation of resources, theoretically derived from the intersection of supply and demand (marginal cost and benefit). It may be *economically* efficient to use more energy if it is cheap, if the price of energy is correctly set by the market. The market 'optimum' often does not coincide with social or environmental optima, which might internalise environmental costs or add expenditure for social benefits.

energy intensity for iron and steel improved from 40 TJ per ton of steel in 1971 to 30 TJ/t in 1991, but in Taiwan the improvement was from 31 to 14 TJ/t. In gold mining, while annual production has been generally declining since the 1970s, the input of energy per unit (TJ/ton) has shown an increasing trend. However, effective comparison of intensity levels would require more details regarding resource endowment, type of mining and industrial processes.

Table 3.5: Energy consumption and intensity indicators, 2000

Source: IEA (2002a)

	<i>TPES/capita</i>	<i>TPES/GDP</i>	<i>TPES/GDP</i>	<i>Elec. consumption per capita (national average)</i>
	<i>Toe/capita</i>	<i>toe/000 1995 US\$</i>	<i>Toe/ 000 PPP 1995 US\$</i>	<i>kWh/capita</i>
South Africa	2.51	0.63	0.29	4 533
Africa	0.64	0.86	0.32	501
South Korea	4.10	0.31	0.30	5 901
Indonesia	0.69	0.70	0.25	390
Non-OECD	0.96	0.74	0.28	1 028
OECD	4.78	0.19	0.22	8 090
World	1.67	0.30	0.24	2 343

Key: TPES = total primary energy supply, toe = tonnes of oil equivalent, PPP = purchasing power parity (i.e. adjusted to remove distortions of exchange rates), GDP = Gross domestic product

South African industry at present depends largely on primary extraction and relatively low-grade processing, making it a heavy user of energy; but as it diversifies into higher technology manufacturing and processing, its energy intensity should reduce. However, international trends show that countries like South Africa become receptors of energy-intensive investment as developed countries shed them in favour of more service-oriented and lucrative activities – and as the labour force in developing countries becomes more skilled. Recent investments in aluminium smelters and iron and steel mills, and the SAPP strategy, suggest the trends in the country's industrial future. This at least in part – and in the short-term – balances fears among some that decreased purchases of coal by Annex I countries with emission limits may threaten South African coal exports .

3.2.2 Energy (in)efficiency

The Energy Research Institute has conducted some benchmarking studies for energy efficiency, for industrial, residential, transport and commercial sectors (Hughes et al. 2002), which forms the basis of this section. These are useful only for rough comparisons between countries, since large differences exist within South Africa due to products, raw materials and differing processes. Examples from specific sub-sectors are possibly more illuminating, although further research is needed in this area and data quality remains a problem.

Industrial production in South Africa has shifted from mining to energy-intensive manufacturing processes over time. Major industrial contributions to economic output come from the iron and steel, chemical and petrochemical, pulp and paper sub-sectors and mining. A greater shift is expected in future towards the production of technically advanced products, require low energy input but with high value-added contributions (Hughes et al. 2002). The differences in final energy demand by industrial sub-sector and shares from 1996 to 2000 are shown in Figure 3.16 below.

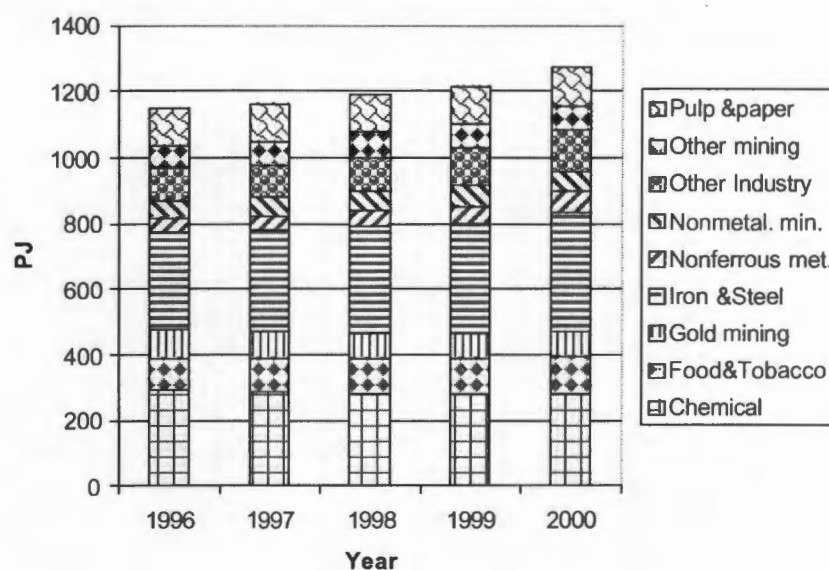


Figure 3.16: Final energy demand by industrial subsector (PJ of final energy demand)

Source: (Hughes et al. 2002)

Two examples of industrial sub-sectors which are relatively inefficient by comparison with OECD countries are pulp and paper and iron and steel. Both show relatively high energy intensities. Innovations such as the Corex and Midrex production process for steel-making are expected to lower the energy intensity of this industry significantly, but the lowering is not reflected in the data for this industry. Without such innovation, use of standard technology would not have been achieved much gain in efficiency. South Africa produces pulp at an energy intensity by gross product output higher than that of other pulp-producing countries, but paper is produced at a similar energy intensity to many countries running best practice programmes in this industry (see Table 3.6).

Table 3.6: Energy intensity in the pulp and paper sector

Source: Hughes et al. (2002)

	GJ/tonne	Pulp production Ktonne	Paper Production Ktonne
South Africa	34.13	2138	2226
USA	26.36		
UK	26	743	4824
Brazil	20		
Sweden	23.5	10215	8419
Canada	29.21	9756	25971

There is insufficient information available on most sectors to provide an accurate estimate of potential energy savings; however, an attempt has been made to identify areas where savings are possible. There are several standard energy efficiency measures that could be applied to the energy demand sectors to improve the current energy intensities. High energy intensities imply that there is (at least theoretical) potential for improvements in efficiency (Thorne 1995). Schemes with pay-back periods as short as one year can lead to significant reductions in energy demand and savings for industry (Hughes et al. 2002). Policies that would support such initiatives would be labelling schemes, energy audits and awareness & training programmes.

3.2.3 More efficient technologies and cleaner fuels

3.2.3.1 Energy efficiency and demand-side management

There is great potential for energy efficiency in South Africa, across a range of sectors from industry, commercial, transport to residential. Interventions for energy efficiency in the residential sector can contribute significantly to development for households – improved quality of life at reduced cost (Clark 1997; Simmonds 1997; Spalding-Fecher et al. 1999; Winkler et al. 2000). The largest energy savings in absolute terms, however, are found in the industrial and transport sectors.

Experience exists with innovative technologies and programmes for energy efficiency and demand-side (DSM) management. Eskom's DSM programme has focused on three key areas: load management, industrial equipment and efficient lighting. Such interventions include both load management, typically carried out by the utility, and energy efficiency improvements by end-users. The NER included estimates potential future savings in its *Integrated electricity outlook* (2002). Savings from energy efficiency are expressed as equivalent cumulative electricity generation capacity (in MW) that would be avoided by these interventions up to 2010 and 2020. Since the market penetration of energy efficiency is key to the results, estimates reflecting different assumption are shown in Table 3.7.

Table 3.7: Potential future savings from energy efficiency and demand side management (cumulative capacity equivalent in MW)

Source: NER (2002b)

	Low penetration		Moderate penetration		High penetration	
	2010	2020	2010	2020	2010	2020
Industrial and commercial energy efficiency	567	878	889	1270	890	1270
Residential energy efficiency	171	514	537	930	537	930
Industrial and commercial load management	355	444	428	535	510	535
Residential load management	222	735	443	936	669	936
Total	1315	2571	2297	3671	2607	3671

Theoretical gains are not always realised in practice, for either technical or economic reasons. Removing key barriers – informational, institutional, social, financial and market, and technical – is critical to the full realisation of energy efficiency measures (see detailed discussion of barriers in EDRC (2003)). Important success factors to implement efficiency measures include government policy (standards, incentives, recovery of programme costs), electricity pricing mechanisms that do not penalise efficiency, and the effectiveness of DSM delivery agencies (NER 2002b). Energy efficiency will also be affected by potential reforms in the power sector (Barberton 1999; Clark & Mavhungu 2000; Tyani 2000).

3.2.3.2 Demand for 'green electricity'

Renewable energy technologies for electricity generation are a supply issue, but demand for such a product is a significant factor. A small pilot project was established in supply the World Summit on Sustainable Development with 'green electricity'. Building on this initiative, the NER has indicated a commitment to regulate the development of a green electricity market (NER 2002a). Developing niche markets is an important step, e.g. large municipalities, provincial governments, national departments, environmentally conscious companies and a small group of residential customers.

Cape Town has recently agreed to buy 'green power' from the Darling wind farm, according to newspaper reports (SAPA 2003). Once the facility comes on-stream, the city would offer customers the option of buying electricity from a renewable source, at a premium. Available

electricity would be 3 GWh per year, a small contribution to the 9000 GWh consumed by the city. There would be some marketing of green power.

3.2.3.3 *Solar water heaters*

Solar water heaters (SWHs) deliver a development service, hot water, and save energy and therefore emissions, but this option has not been pursued more extensively in South Africa. The only significant project has been in Lwandle township (Thorne et al. 2000; Ward 2002; Lukamba-Muhiya & Davidson 2003), despite DME announced support from the Global Environmental Facility project on a National Solar Water Heating Programme (DME 2001a). As a result of the limited number of SWHs the South African industry is weak and rather fragmented. Most installed SWHs beyond the Lwandle project were sold by private entrepreneurs to mid-to-high-income households, primarily to avoid the additional costs of electricity. Other models that have been used to get SWHs into the market include a hot water utility/ESCO model whereby hotels purchase hot water from a supplier who finances the installation of the SWHs. SWHs have been installed using mortgage financing and, predominantly in the case of retrofits, using supplier finance.

3.2.4 **Concluding remarks on main issues**

The main issues of energy demand for South Africa include elements discussed in other chapters. Arguably the most critical issue for sustainable development on the demand side is the unequal access to affordable energy services, despite the progress with electrification. However, issues of access are considered in the social chapter. Similarly, the environmental impacts of demand are discussed in more detail in the environment chapter.

The main issues considered in this section focus on energy efficiency, intensity and demand-side measures for using cleaner energy. South Africa's energy intensity is relatively high, compared to African and other developing countries. High consumption of energy per unit of economic output, combined with the dominance of coal in the fuel mix, results in high levels of local emissions and greenhouse gases (discussed in Chapter 7). At the same time, opportunities exist for improving the efficiency of energy use. Compared to other middle-income countries, energy intensities in SA can be improved. Such interventions can assist with basic development needs in the residential sector, and provide major energy savings in the industrial and transport sectors. Two particular areas of demand for cleaner energy supply that are receiving attention are solar water heaters and 'green electricity'.

3.3 Outlook: how is this issue expected to change in future?

3.3.1 **How is demand expected to change in future?**

This section considers possible changes in future energy demand at the aggregated level. A default assumption in many scenario modeling exercises is that energy demand grows with economic output (GDP). In section 3.1.5, indications were given for sectors where this assumption might not hold for South Africa's future energy demand. Here we consider what factors might drive overall changes in energy demand.

Some of the relevant assumptions used in the Integrated Energy Plan were published are quoted below (DME 2003):³

\$1 = R8 (1 Jan 2001)

Net discount Rate: 11%

Inflation rate: 5.5% (SARB target 3-6%)

Population Growth: 2000 = 44 Million, 2010 = 50 Million (1.3% p.a.), 2020 = 57 Million (0.87% p.a.)

GDP Growth: 2.8% average annual growth over period.

³ Further assumptions are contained in the report, which was released publicly late in 2003 and can be accessed from www.dme.gov.za.

3.3.1.1 Changes in electricity demand

Overall consumption – as recorded by total sales of electricity in GWh – has grown fairly consistently from over the last 50 years. Figure 3.17 shows the percentage change from the previous year, however, were at a higher level from the 1950s to 1970s, ranging between 6 and 13%; whereas the 1980s to 1990s saw more typical figures between 1 and 4%.

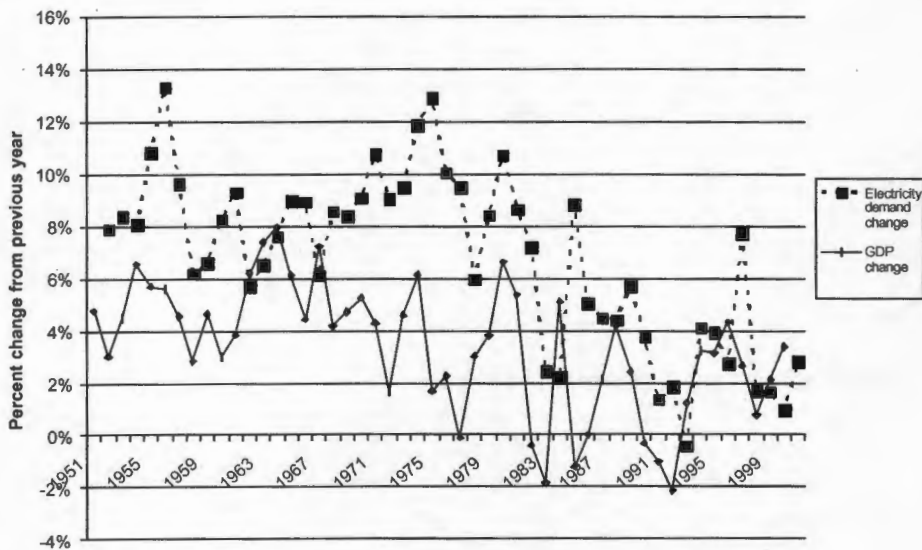
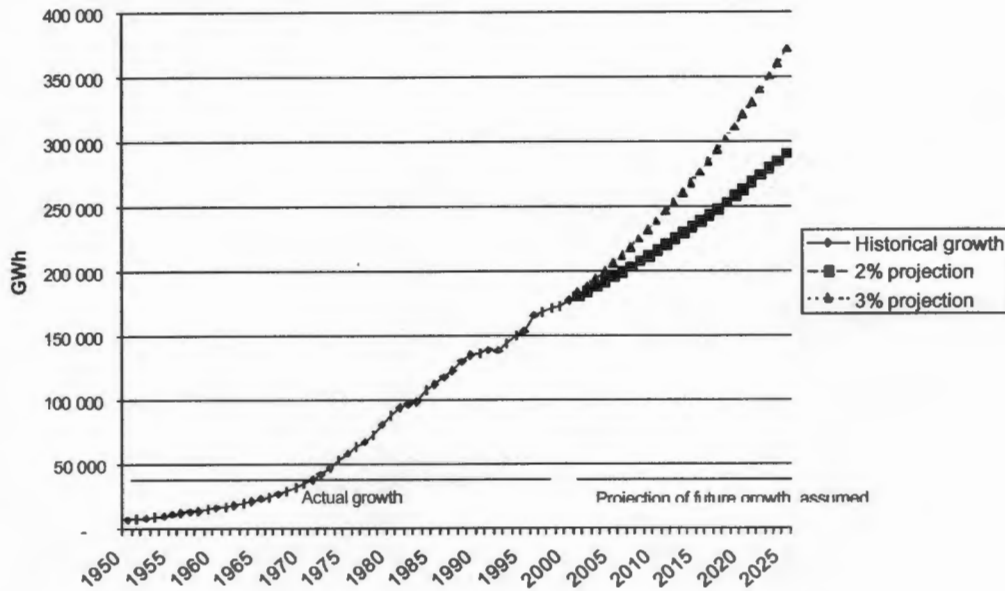


Figure 3.17: Percentage changes in Eskom electricity sales and change in real GDP at market prices

Source: Eskom (1987, 1996); NER (2000); SARB (2002)

Historical electricity sales data is combined with projections for the future based on the Integrated Resource Plan (IRP) in Figure 3.18. The IRP explored assumptions of GDP growth of 1.5, 2.8 and 4% per year, and a 'moderate outlook' on growth in electricity sales between 2 and 3% (NER 2002b: 5-6).⁴ These assumptions were used in constructing the projections in the future. While the percentage increase is in the low range of changes shown in Figure 3.17, it must be noted that earlier increases started from a much lower base.

⁴ These very broad assumptions are based on much more detailed demand modeling in Eskom's eighth Integrated Strategic Electricity Plan. The IRP, however, only publishes the broad growth figures used here. Economic growth rates 'include total national sales, as well as sales to foreign countries', including contracts between Eskom and other countries, but not imports, which are modeled as supply-side options (NER 2002b).



Note: projections follow assumptions in the IRP (NER 2002b)

Figure 3.18: Growth in electricity sales, actual historical and future projections (GWh)

Source: Historical data from Eskom (1987, 1996); NER (2000)

3.3.2 Drivers of energy demand

The fundamental drivers of energy policy have shifted from a concern with the supply-side to more focus on demand. During the apartheid years, top-down planning and concerns around energy security (amongst other factors) lead to large investments in synthetic fuels from coal, nuclear and predominantly coal-fired electricity generation. Since the first democratic elections in 1994, socio-economic development has become the key driving factor for all policy. Energy must not only supply economic development, but also improve the lives of the poor, black majority. Among many priorities, job creation stands out as the most important, given an unemployment rate of 41.6% according to the strict definition of 2001 Census, or 29.5% by the Labour Force Survey (see discussion in Chapter 5) (SSA 2003). In the energy sector, this has put more attention for demand-side management and delivering energy services, critically including cooking and productive uses for all South Africans.

Economic growth is an important driver for energy demand. GDP is the usual proxy for economic growth, but it is not without its problems. Not only does it not account adequately for some natural resources and external costs, but also focuses on overall growth. This diverts attention from the equally important consideration of the structure of the economy. Whether economic and industrial strategy emphasises primary, secondary or tertiary economic sectors (with latter being less energy intensive per rand GDP) has major implications for future energy demand.

Demographic trends are an important driver of energy demand. While the direct impact on final consumption in the residential sector is relatively small at 10% (see 3.1.5.4), indirect effects would be felt through reduced consumption of industrial goods and other factors reflected in GDP. The threat of HIV/AIDS is expected to have a major effect on population growth (ASSA 2000). For analysing the effects on energy demand, the DBSA approach of examining the uncertainty of a low or high impact of AIDS on population seems a reasonable approach (Calitz 2000b, 2000a).

The rate of technological change in the future is another important driver of energy demand. Technologies for energy efficiency are of particular importance for demand. International developments may offer opportunities for savings, but the actual 'nega-watts' delivered depend of the rate of implementation of such technologies. The NER's IRP projected a total saving of 4 784 MW over the period 2001-2025 (NER 2002b).

Plans for power sector reform include significant changes to the electricity distribution industry. This reform is driven both by local concerns and international agendas. An electricity distribution industry (EDI) holdings company has already been established, with a view to establishing six new regional electricity distributors (REDs) by mid-2005. Concerns have been raised about the impacts on social and environmental public benefits (Clark & Mavhungu 2000; Winkler & Mavhungu 2001). Investment in energy efficiency, in particular, may decline as private investors show less inclination to invest in measures that reduce revenue than utilities with a public mandate.

3.4 Emerging gaps

While much analysis tries to start from energy services, there is an emerging gap in back-casting energy scenarios more systematically from development objectives. Energy scenarios often still start from supply and resource constraints. Assuming that energy demand will increase from the current baseline and in line with government's stated objective of 100% access to modern energy services by 2012 (Mlambo-Ngcuka 2003), future energy demand needs to be met on a least-cost basis, given specified resources and technologies. Two significant changes in approach that need further development are clear identification of the energy services required, and analysing scenarios in relation to multiple objectives (cost, environment, social criteria, etc). Taking a balanced view of economic, social and environmental objectives is critical to analysis of energy for sustainable development. In Phase 2, the overall energy profile should include a chapter on 'energy and development' or 'backcasting from development'.

Other emerging gaps include:

- The understanding of drivers of energy development could be refined, based both on international and local dimensions:
 - A review of drivers identified in the World Energy Assessment (UNDP et al. 2000) and by Working Group III of the Intergovernmental Panel on Climate Change (IPCC 2001) could provide lessons for South Africa, with due care to our national circumstances.
 - A more detailed study of industrial strategy and policy would provide a more nuanced indication of areas of future development and their impact on energy demand.
- The discussion in sections **Error! Reference source not found.** and **Error! Reference source not found.** could be enriched by more detailed discussion of sectoral and process-based analysis of energy intensities.
- Searching the literature on coal and oil more thoroughly to improve the projections future demand for hydrocarbons (coal and oil). This could form part of the scenario modeling in Phase 2.

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4. Energy supply in South Africa

Andrew Kenny

The provision of energy may be considered in two parts, primary supply and energy transformation. First, energy is obtained by extraction or collection such as mining coal or uranium, drilling for oil or gas, damming rivers or collecting wood or sunshine. Second, this primary energy is converted into final energy for use. Such conversions include the burning of coal in power stations to make electricity and the refining of crude oil to make petrol and diesel. Some of the primary energy is used directly, such as coal for cooking or sunshine for heating water.

4.1 Energy reserves and primary production

South Africa has large reserves of coal, which supplies over 70% of its primary energy, large reserves of uranium, and small reserves of crude oil and natural gas. South Africa is largely arid and has very limited potential for hydropower. Biomass is an important source of energy, both for poor households and the sugar refining and pulp and paper industries. Conditions for solar power are good, especially in the Northern Cape. Conditions for wind are fairly good, mainly in the coastal regions. Figure 4.1 gives an estimate of South African energy reserves, and also indicates yearly primary energy demand to put them in perspective. These reserves are stock resources, unlike the annual flows of renewable energy sources (see sections 4.1.5 and following), and are only those found in South Africa itself. The uranium has been assumed to be used in conventional nuclear reactors. If it were to be used in fast breeders, the effective uranium reserves multiply fiftyfold. Uncertainty about the reserves is discussed in each energy section below.

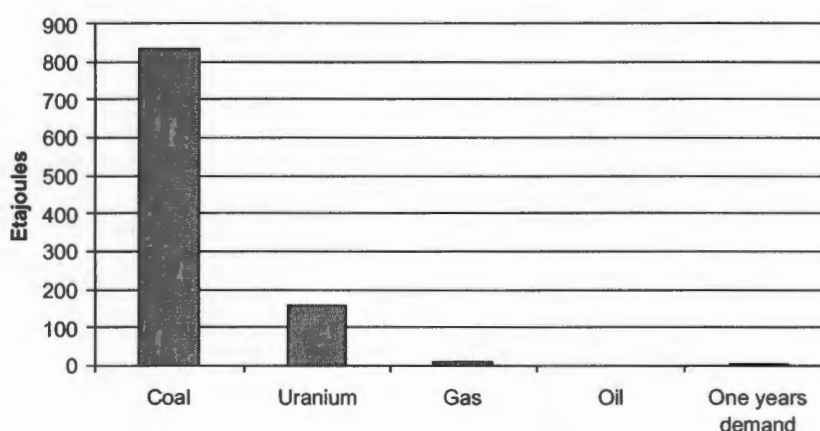


Figure 4.1: South African energy reserves excluding renewables

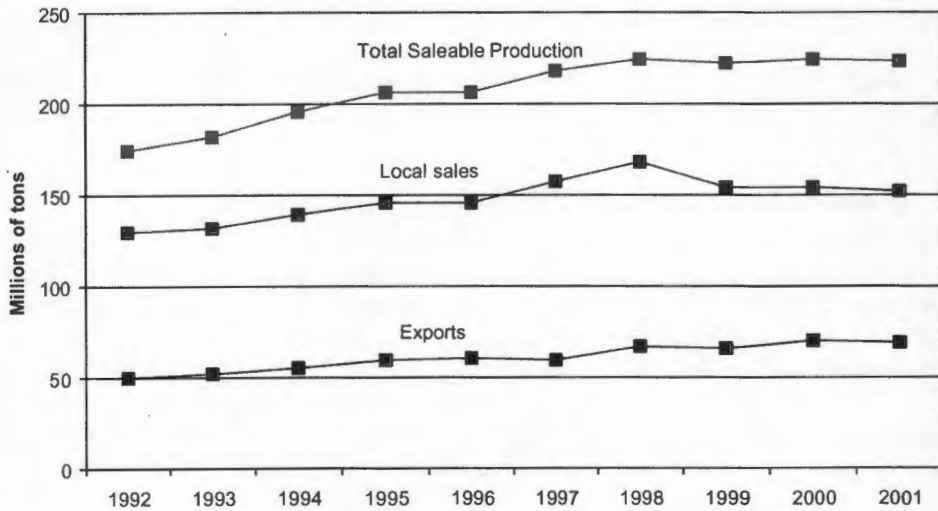
Source: Coal: Estimate from DME (2003a); uranium: WEC/IIASA (1995); Gas: estimate from Holliday (2003); Oil: PetroSA; Year's demand: estimate by DME and Energy Research institute

4.1.1 Coal

Coal from the southern hemisphere is different from that of the northern hemisphere: it is rich in durain and contains more ash and less sulphur. Most South African coal is of a bituminous thermal grade, with only about 0.8% anthracite. Typically it contains about 1% sulphur. Heating value varies from about 27 MJ/kg for export coal to between 22 and 15 MJ/kg for steam coal. Coal in Mpumalanga and Limpopo is nearly always bituminous and is laid down in thick, shallow seams relatively free of faulting, making mining cheap. Coal in KwaZulu Natal is often anthracite in relatively thin seams. Little of South African coal is suitable for coking.

For a long time the figure given for South Africa's coal reserves has been 55 billion tons, but it is not reliable. The DME is conducting a thorough study to assess the true reserves but an

interim estimation of 38 billion tons (Prevost 2003) is the best figure available now. This gives South Africa the world's sixth biggest reserves after China, the USA, India, Russia and Australia. About 44.5% of South African coal is mined by opencast methods, 44% mined underground by bord and pillar, and 10.6% by pillar recovery. 83.8% of coal is produced in Mpumalanga, 8.5% in the Free State, 6.1% in Limpopo and 0.8% in KwaZulu Natal. Mines typically produce three grades of coal: export, steam coal and discards. Many large mines



process the coal to obtain the right qualities for export and local markets (Prevost 2002). Figure 4.2 shows coal production from 1992 to 2001.

Figure 4.2: Total saleable production, local sales and exports of South African coal, 1992 to 2001

Source: DME (2003)

In 2001, South Africa mined 290 million tons of coal, of which 223.5 million tons was saleable. 152.2 millions tons went to the local market and 69.2 million to export. 66.5 million tons were discards, too low in heating value and too high in ash to have commercial value now. However, these discards might be burned in fluidised bed combustion (FBC) boilers in future.

About 62% of exports go to the European Union, 29% to the Far and Middle East and the rest to South America and Africa.

Table 4.1: Consumption of South African coal, 2001/2002

Source: DME (2003)

Sales category	Million tons
Exports	69.2
Electricity	89.0
Synthetic fuels & chemicals	48.0
Industry	6.0
Metallurgical	5.5
Merchant & domestic	3.7
Mining	0.05

4.1.2 Oil

South Africa must import most of its requirements. Local reserves are limited to small fields in the Bredasdorp Basin off the south coast: the Oribi/Oryx Fields and the Sable Field, with, in 2002, proven reserves of 49 million barrels. They are owned and operated by PetroSA, Energy

Africa and Pioneer. Production from the Oribi/Oryx Fields was 4.6 million barrels in 2002. Development drilling in the Sable Field began at the end of 2002 and production began in August 2003. It will produce 30 000 to 40 000 barrels a day and displace from 7% to 10% of South Africa’s imported oil. Figure 4.3 shows the import of oil products in 2001 and Figure 4.4 shows the country of origin of South Africa’s crude oil imports.

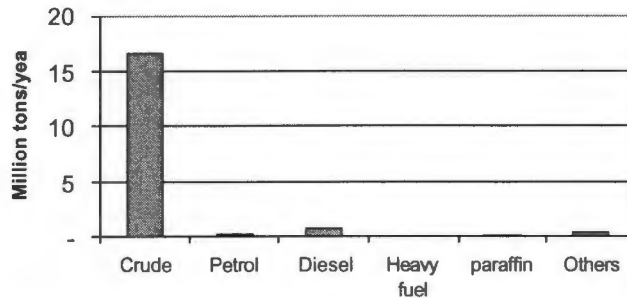


Figure 4.3: South African imports of oil products, 2001
 Source: DME (2002)

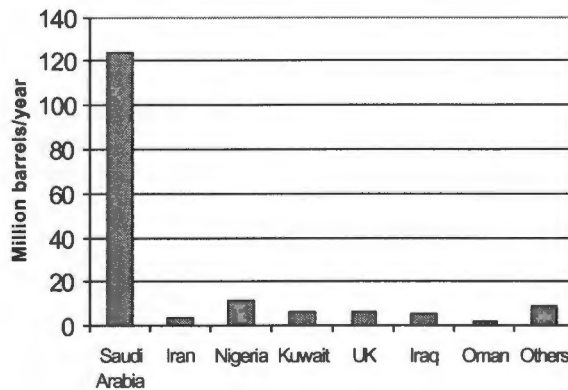


Figure 4.4: South African crude oil imports by country of origin, 2001
 Source: DME (2002)

4.1.3 Natural gas and coalbed methane

South Africa has small reserves of natural gas and coalbed methane. There are no inland gas fields but there are fields off the west and south coasts. The only South African gas field in production now is the F-A field off the south coast. This supplies the PetroSA plant at Mossel Bay, which makes liquid fuels, including petrol, diesel and kerosene, from natural gas. The F-A field is owned by PetroSA and supplies about 189 mcf of gas and 7 100 barrels of condensate daily to the synfuel plant by two 91 km pipelines. The proven reserves of the field were about 1 tcf and it is expected to run out by about 2008. PetroSA and its joint venture partners are exploring the adjacent Block 9 and Block 11a for the purpose of developing it to extend the production life of Mossgas.

The most promising new fields seem to be off the west coast. The Ihubesi Field, which is about 3 000 metres below the ocean bed, has proven reserves of 0.5 tcf but there is a possibility that they might be as high as 25 tcf. It is now being studied for development by Forest Exploration International (SA) and the Anschutz Corporation (South Africa). Drilling at the end of 2003 and into 2004 will confirm the reserves. Global Offshore Oil Exploration SA, Sasol Petroleum International and BHP Billiton Petroleum Great Britain Ltd are investigating other fields off the west coast. The total proven gas reserves of South Africa are about 2 tcf. However, this figure could rise to as high as 27 tcf after drilling and assessment.

South Africa's immediate neighbours, Namibia and Mozambique, have small gas fields. The offshore Kudu field is about 180 km west of the Namibian coast and has reserves of about 1.5 tcf. Angola has two inland fields at Pande and Temane with combined reserves are about 3 tcf. An 895 km pipeline is now being built which will bring gas from Temane to Secunda in South Africa, where it will join the existing pipeline system that links Gauteng, Durban and Secunda. The pipeline will be complete in early 2004. Angola has large gas fields and in future gas could be piped to South Africa from them.

Coalbed methane is found in varying amounts in coalfields and South Africa has about 3 tcf of it, mainly in the Waterberg and Perdekop regions. These have not yet been tapped.

4.1.4 Uranium

Nuclear energy reserves are different from those of fossil fuels in that the energy is so concentrated that transport and storage costs are negligible. Uranium is abundant in the earth's crust and there has been little commercial incentive to develop new mines. Uranium and gold are found together in mineral deposits and South Africa produces uranium as a by-product of gold mining, with an estimated 261 000 tons of uranium in 'reasonably assured resources' (205 000 tons) and 'estimated additional resources' of 56 000 tons (DME 1998). Used in conventional nuclear reactors, this is equivalent to 158 EJ of energy if it were used to generate electricity. In the apartheid era, South Africa manufactured finished fuel for the Koeberg nuclear power station near Cape Town. Today, however, the finished fuel is imported because this is cheaper.

4.1.5 Biomass

South Africa is a dry country, with about half of its area consisting of desert or semi-desert and only 1.2% under forest, so that conditions for biomass are generally poor. Nonetheless, biomass is an important source of energy in South Africa although the reserves and the extent of its use are difficult to estimate. Biomass is used both by modern industry (sugar refining and pulp and paper mills) and by poor households for domestic energy.

South Africa's sugar cane crop is about 20 million tons a year, which gives about seven million tons of bagasse (vegetable husks) with a heating value of 6.7 MJ/kg. Most of the bagasse is used in the sugar refineries for raising steam for electricity generation and process heat (although some is used to make paper). The sugar refineries have an installed generation capacity of about 245 MWe.

South Africa's annual production of commercial roundwood is about 15 million cubic metres. About 10 million cubic metres of this go to make pulp, paper and board (DWAf 1997). Bark from softwood (pine) is used to fire boilers and so is black liquor from the wood in chemical pulp mills. The steam is used to generate electricity and to provide process steam. The pulp mills have an installed generation capacity of about 170 MWe.

Wood, dung and other vegetable matter are used for heating and cooking in poor households, mainly in the rural areas. The exact amount is not known but it is estimated that about seven million tons of wood, with an energy of about 86 PJ/year, is burned for this purpose.

The South African renewable energy database considered annual biomass potential, in GJ / (ha). The data shown in Figure 4.5 reflect potential *resources* for wood (unprocessed and processed), agricultural, and grass residues, but exclude current use of residues or waste. Detailed maps of this and following figures can be downloaded from www.csir.co.za/environmentek/sarerd/contact.html, which also details the definitions of wood, grasses and agricultural crops included. They do not include some sources, such as animal wastes/dung, nor the potential of human waste.

Bio-diesel, ethanol, methanol and hydrogen can be generated from biomass. Most bio-diesel is produced from rap oilseed, sunflower oil and *Jatropha*, while bioethanol is processed from wheat, sugar beet and sweet sorghum (EDRC 2003). The main cost relates to the feedstock and cheaper sources are being sought. These cheaper feedstocks, e.g. wood, are predicted to reduce the costs of production quite considerably and help make it more competitive with fossil fuels (EC 2002). The production potential of bio-diesel without impacting negatively on food

production is large, while impressive numbers of jobs can be created in the process. Bio-fuel options have potential for generating income in rural areas through biomass plantations. However, they may also raise concerns about food supplies and impacts on biodiversity of planting monocultural crops (EDRC 2003).

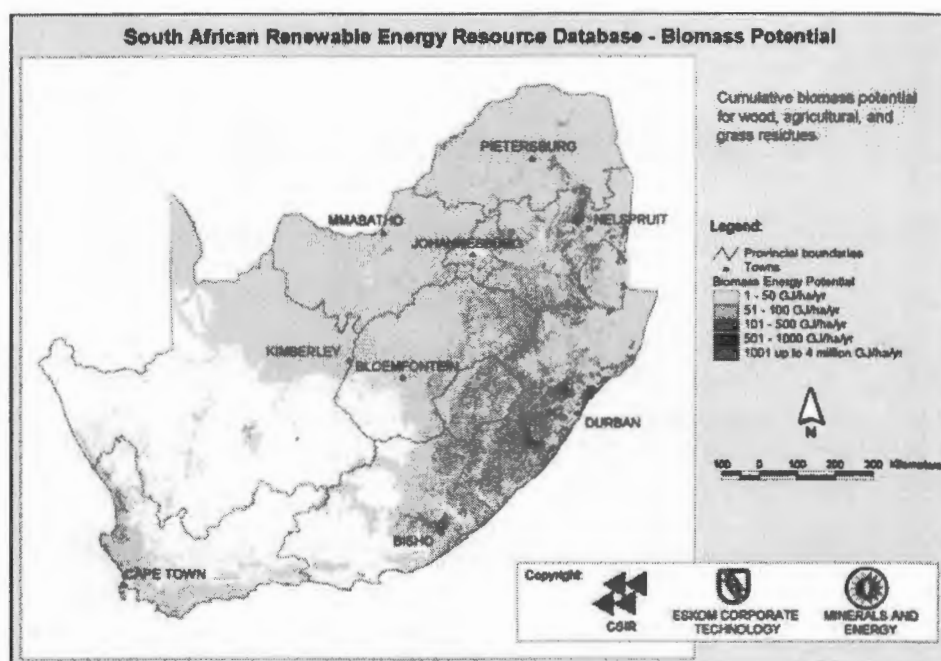


Figure 4.5: Map of biomass potential in South Africa

Source: DME et al. (2001)

4.1.6 Hydropower

South Africa has few rivers suitable for hydro-electricity and these are small. The installed capacity for hydro-electricity is 661 MWe and the potential for increasing this is limited. There are an estimated 3 500 to 5 000 potential sites for mini-hydro along the eastern escarpment. However, outside South Africa itself, central Africa has enormous potential for extra hydro-electricity, which could be exported to South Africa. Table 4.2 shows some of this. While the theoretical and economic potential is large, there are significant political constraints to developing the resource. A technical challenge would be increasing the interconnectedness of grids to distribute power within Southern Africa.

Table 4.2: Hydropower potential in southern Africa in addition to existing or planned hydropower

Source: Black & Veatch International (1996); Dale (1995); Dutkiewicz (1996); Lwindi (nd); SAD-ELEC & MEPC (1996); World Resources Institute (1996)

Location	Country	Potential (MWe)
Zambezi River Basin		
Kariba North Extension	Zambia	300
Batoka Gorge	Zambian side only	800
Devil's Gorge	Zambia / Zimbabwe	1 240 – 1 600
Mupata Gorge	Zambia / Zimbabwe	1 000 – 1 200
Cahora Bassa North Bank Extension	Mozambique	550 – 1 240
Mepanda Uncua	Mozambique	1 600 – 1 700
Total Zambezi		approx 6 000
Other sources excluding Inga		
Angola	Including Kunene Basin	16 400
Lesotho		160

Location	Country	Potential (MWe)
Malawi		250
Mozambique	Other than Zambezi	1 084 – 1 308
Namibia	Other than Kunene Basin	500
Swaziland		60
Tanzania		3 000
Zambia	Other than Zambezi	1 084 – 1 308
Total other sources excluding Inga		
Inga		36 000 – 100 000
Total southern Africa		
		70 800 – 134 800

4.1.7 Solar

Almost the whole of the interior of the country has average insolation in excess of 5 000 Wh/m²/day. Parts of the Northern Cape have average insolation of over 6 000 Wh/m²/day. The annual 24 hour solar radiation average for South Africa is 220 W/m², compared with 150 W/m² for parts of the USA and about 100 W/m² for Europe. Figure shows the amounts of solar energy falling on South Africa.

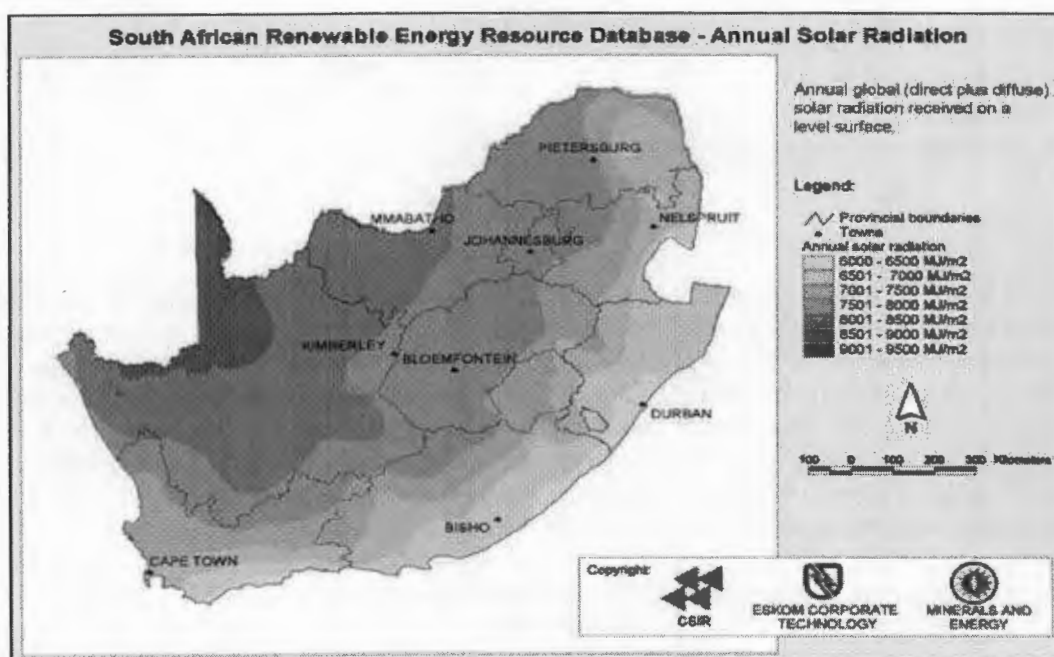


Figure 4.6: Annual solar radiation for South Africa

Source: DME et al. (2001)

4.1.8 Wind

South Africa has quite good wind resources, mainly in the coastal regions. Figure 4.7 shows wind speeds over the country.

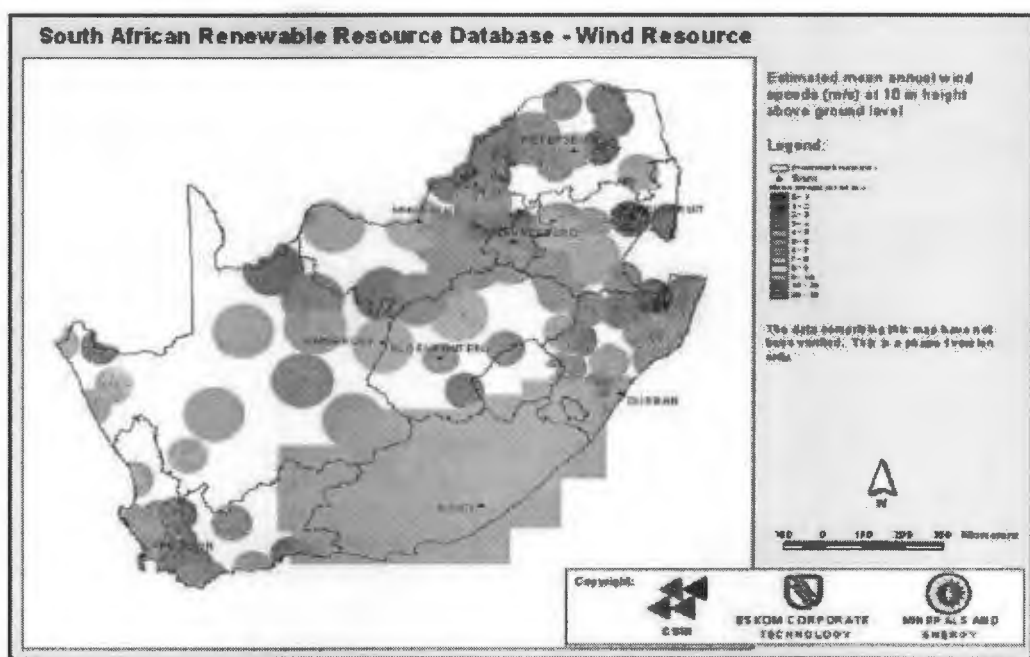
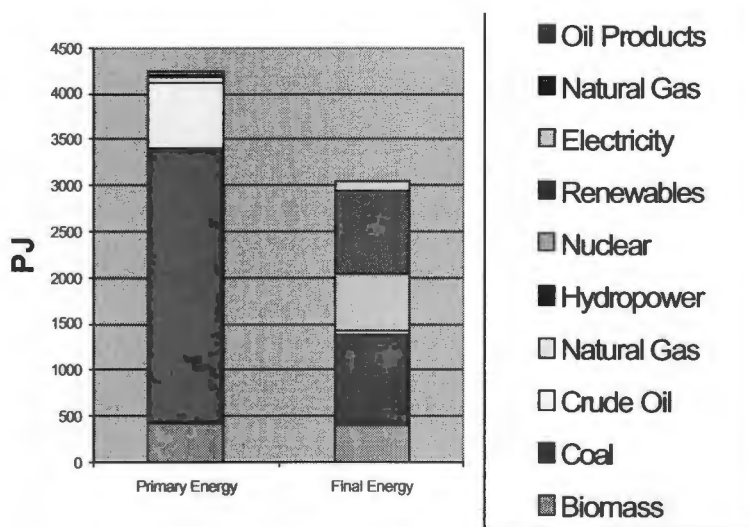


Figure 4.7: Annual average wind speeds in South Africa
 Source: DME et al. (2001)

4.2 Energy transformation

Primary energy enters the economy and is transformed into final energy, which is used in the economy. Figure 4.8 shows total primary and final energy in South Africa. The two most important conversions of primary energy into final energy are the generation of electricity and the production of liquid fuels.



Note: In this graph, final energy includes biomass, both as household fuels and as industrial energy, and marine bunkers. This gives a different total from that of Chapter 2, where these are not included.

Figure 4.8: Total primary and final energy in South Africa, 2000

4.2.1 Electricity generation

South Africa generates over half of the electricity on the African continent. Electricity provides 20% of South Africa’s final energy. It has three groups of electricity generators: the national public electricity utility – Eskom, municipal generators, and autogenerators – industries that generate electricity for their own use, including the pulp mills, sugar refineries, Sasol, Moss gas

and metallurgical industries. Eskom has 91% of the total generating capacity (93.5% of the total production), the municipalities 5.6% (2.0%) and the autogenerators 3.1% (4.5%) (NER 2001). Eskom's licensed capacity is 39 870 MWe, which includes 3 550 MWe of mothballed coal stations. This capacity comprises of 35 627 MWe of coal power stations, 1 840 of nuclear, 342 of gas turbines, 661 of hydro power and 1 400 of pumped storage. This energy mix is shown in Figure 4.9.

In 2002, South Africa consumed 203 GWh and Eskom had a peak demand (in July) of 31 621 MWe. About 67% of electricity is used by industry, 18% by households. Until now, generation and transmission have been centrally controlled by Eskom. There are about 400 distributors, including Eskom itself, large municipalities and small town councils.

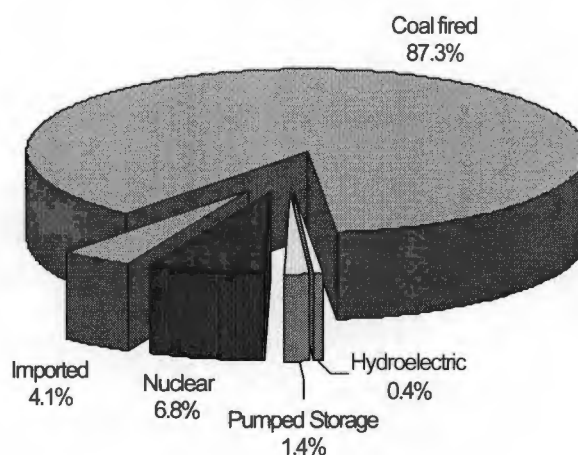


Figure 4.9 Eskom's generation mix by energy source

4.2.1.1 Coal power stations

Over 92% of the electricity now generated in South Africa is from conventional coal power stations (see Table 4.3). All of these are pulverised fuel stations without flue gas desulphurisation, although future coal power stations in South Africa are likely to have this. From 1980 on Eskom has only built power stations of capacity greater than 3000 MWe comprising of six units each. Because of their huge coal requirements, typically of about ten million tons a year, it is too costly to transport the coal over long distances and so the power stations have been built on the coal fields and the coal transported from the mines by conveyor belts. This means that all the large coal power stations are concentrated around the coalfields in Mpumalanga, Gauteng and the Northern Province.

South African coal has high ash, low sulphur and low calorific value. South Africa has become a world leader at burning poor quality coal, some with heating value lower than 16 MJ/kg. The combination of cheap coal and big, standardised coal stations without desulphurisation has allowed South Africa to produce the cheapest electricity in the world.

These stations have some disadvantages. They are polluting. Because they must be located at the coalfields, they are concentrated in the northern interior of South Africa and power has to be transmitted long distances to coastal centres such as Richards Bay, Durban and East London. This leads to problems with the quality of electricity in these places

Table 4.3: Eskom's coal-fired power stations

Source: National Electricity Regulator

	<i>Nominal capacity (Mwe)</i>	<i>First unit commissioned</i>	<i>Thermal efficiency</i>	<i>MJ / kg for coal</i>	<i>Cooling</i>	<i>Operating status</i>
Arnot	2 100	1971	33.3	22.35	Wet	Partly operating
Camden	1 600	1966			Wet	Mothballed
Duhva	3 600	1980	34.5	21.25	Wet	Operating
Grootvlei	1 200	1969			Wet	Mothballed
Hendrina	2 000	1970	32.34	21.57	Wet	Operating
Kendal	4 116	1988	34.31	19.96	Dry	Operating
Komati	1 000	1961			Wet	Mothballed
Kriel	3 000	1976	35.02	20.04	Wet	Operating
Lethabo	3 708	1985	34.89	15.27	Wet	Operating
Matimba	3 990	1987	33.52	20.77	Dry	Operating
Majuba	4 100	1996			Wet/dry	Operating
Matla	3 600	1979	35.47	20.58	Wet	Operating
Tutuka	3 654	1985	35.32	21.09	Wet	Operating

Most of the coal stations dump their heat from the condensers in conventional cooling towers, which use between 1.8 and 2.0 litres of water for every kilowatt-hour of electricity generated. However, fresh water is South Africa's most critical resource, and so two stations, Kendal and Matimba, have dry cooling, and use only 0.1 litres of water for every kilowatt-hour. As can be seen from Table 4.3, the costs in lost efficiency for dry cooling are small. Kendal and Matimba are the world's biggest air-cooled power stations by far.

The municipalities of Cape Town, Bloemfontein and Pretoria each have small coal stations, which are run at low load factors. Kelvin Power Station (600 MWe) in Johannesburg is now run as an independent power producer.

Eskom is investigating the possible future use of fluidised bed combustion coal power stations, which could burn discard coal.

4.2.1.2 Nuclear power

South Africa has one nuclear power station, Koeberg, about 30 km north of Cape Town on the west coast. It consists of two pressurised water reactor units, each with a capacity of 920 MWe. It is cooled by seawater. Its first unit was commissioned in 1984 as the only large power station in South Africa which is not located in the north east of the country – which helps with grid stability in the south west. The finished fuel for Koeberg is imported as this is more economic than manufacturing it locally.

Eskom is developing a new type of nuclear power reactor, the Pebble Bed Modular Reactor. This is a small, simple, inherently safe design using helium as the coolant and graphite as the moderator. The fuel consists of pellets of uranium surrounded by multiple barriers and embedded in graphite balls ('pebbles'). If all the necessary legal, political and commercial approvals are given, the first demonstration model (165 MWe) will go into production in about 2008.

4.2.1.3 Gas turbines

South Africa has 662 MWe capacity of gas turbine generators. Half are owned by Eskom, half by the municipalities. All of them are open cycle (single cycle) gas turbines used only for peaking or emergency power. They run on liquid fuels such as diesel or kerosene. In future these could be used to meet peak capacity.

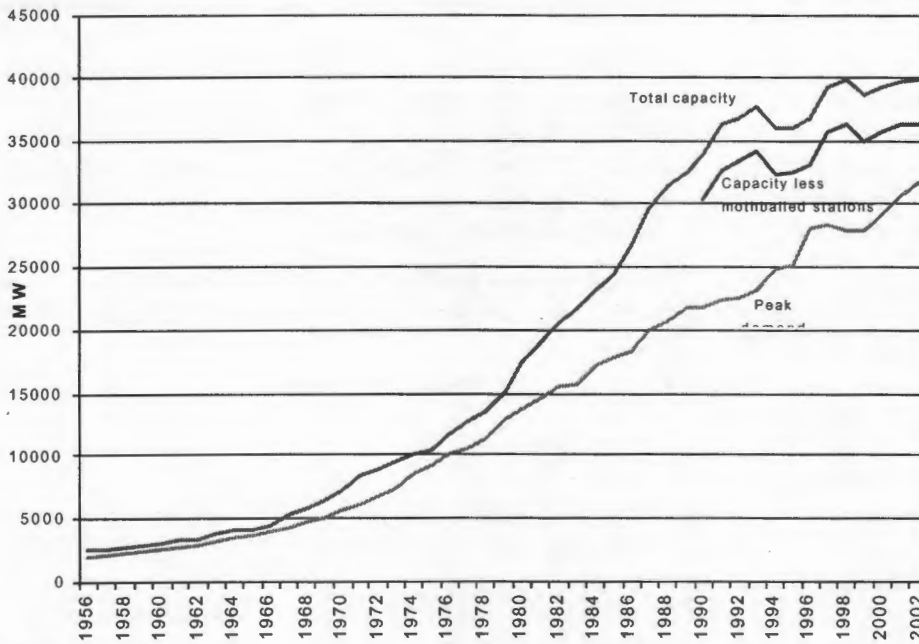
Combined cycle gas turbines, which burn gas in a gas turbine and send the exhaust gases to a steam boiler that drives a steam turbine, have the lowest capital costs per kWh of any generation technology and offer high efficiency and quick construction time. These might well be a source of new generation capacity for South Africa in future, provided gas supply and gas prices are acceptable.

4.2.1.4 Hydro power and pumped storage

There are 665 MWe of installed hydro power in South Africa, all but 4 MWe owned by Eskom. Only two stations are over 50 MWe, Gariep (360 MWe) and Vanderkloof (240 MWe). There is also 1 580 MWe capacity of pumped storage in two stations owned by Eskom, Drakensberg (1 000 MWe) and Palmiet (400 MWe), and one by the Cape Town municipality, Steenbras (180 MWe). A new pumped storage scheme is being planned for Braamhoek, on the border of the Free State and KwaZulu Natal. It will consist of three 333 MWe units initially and might be expanded to four units.

4.2.1.5 Electricity supply and demand

In the late 1960s, faced with high economic growth and high electricity demand growth, South Africa embarked on an ambitious programme of building large coal stations. In the 1980s, economic growth fell away but the momentum of the long lead times of the stations kept the programme rolling forward. The result was large over-capacity in about 1995. Figure 4.10 the gap between total generation capacity and peak demand widening from the 1970s onwards, and mothballed capacity. Since the advent of democracy in 1994, economic growth gradually



increased and the surplus electricity generation was gradually reduced. South Africa now faces a shortfall of generation in about 2007 and new stations are required.

Figure 4.10: Eskom generation capacity and peak demand, 1956 to 2002

1.2.1.6 Electricity imports and exports

South Africa’s electricity imports and exports are roughly equal. Each is equivalent to about 3% of the total electricity consumed in South Africa. Electricity is usually exported to Zimbabwe, Botswana and Namibia and imported from Zambia and Mozambique. However, depending on supply and demand, these flows may be reversed. Table 4.3 shows South Africa’s total electricity consumption, imports and exports from 1998 to 2003.

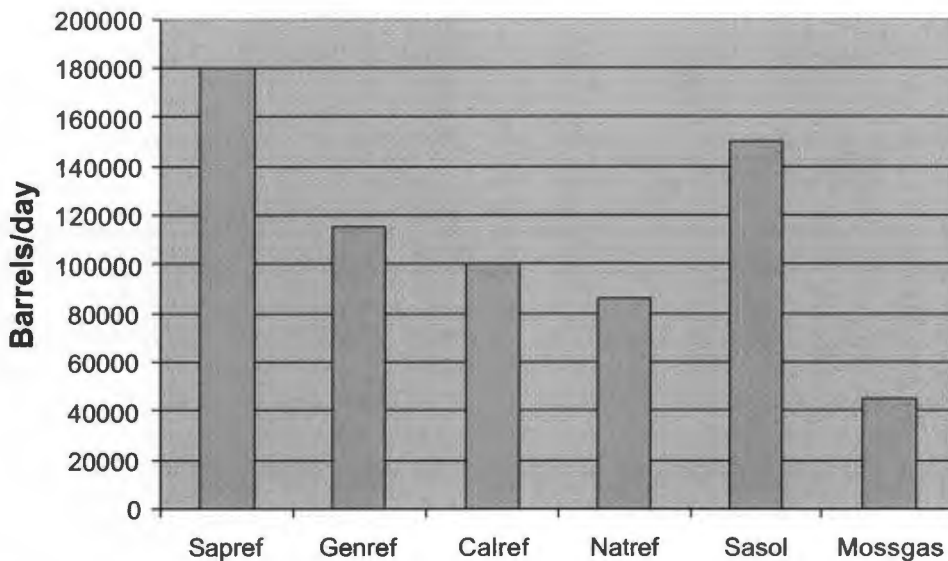
Table 4.3: South African electricity consumption, imports and exports (Gigawatt-hours)

Year	SA consumption	Imports	Exports
1998	187 516	2 375	4 532

1999	190 120	6 673	4 266
2000	195 660	4 719	4 007
2001	196 063	7 247	6 519
2002	203 348	7 873	6 950
2003	211 023	6 739	10 136

4.2.2 Production of liquid fuels

South Africa makes liquid fuels by three processes: refining of crude oil, conversion of coal and conversion of natural gas. Four oil refineries, Sapref, Genref, Calref and Natref, two coal to liquid fuels plants at Secunda and one natural gas to liquid fuels plant at Mossel Bay produce South Africa's liquid fuels. Figure 4.11 shows their capacities.



The units of production in the figure are barrels of crude equivalent per day. For the synfuel plants, the fuel production is converted into that that would have come from a conventional refinery using crude oil.

Figure 4.11: Capacities of South African liquid fuel production plants

Source: SAPIA (2003)

4.2.2.1 Oil refineries

South Africa has three oil refineries at the coast: Genref (Engen) and Sapref (BP/Shell) at Durban, and Calref (Caltex) at Cape Town, and one inland at Sasolburg (Sasol/Total). The latter does not have a market for the heavy residual oil that would be used for marine bunkers at the coast and so the process is altered to produce less of it, which somewhat increases costs.

4.2.2.2 Coal-to-liquid fuel plants

South Africa has by far the world's largest plants making liquid fuels from coal, all owned by Sasol. The first plant was built at Sasolburg in 1955 but is now used only for making chemicals. Two larger plants were built at Secunda in the 1970s and now produce about 150 000 barrels of crude oil equivalent a day. They consume 40 million tons of coal a year, which is mined from Sasol's own coal fields. The coal is first converted into 'syngas', which consists of hydrogen and carbon monoxide. Then, using the Fischer-Tropsch process, it is built up into hydrocarbons, making petrol, diesel and other fuels and chemicals. The fuels so produced are very clean and contain no sulphur.

The synfuel plant at Secunda has the world's biggest oxygen plant, which it plans to increase to a capacity of 3 550 tons of oxygen a day. A by-product of the synfuel process is methane-rich gas, which has a heating value of about 35 MJ/kg and which is sent by pipeline to industrial and

commercial markets in Gauteng, Durban and Richards Bay. The Sasolburg plant produces hydrogen-rich gas, which has a heating value of about 18 MJ/kg and is used by steel makers and other customers.

4.2.2.3 *Natural gas-to-liquid fuels*

It is cleaner, easier and more efficient to make liquid fuels from natural gas than from coal. South Africa has become a leader in this process. The PetroSA plant at Mossel Bay (Mossgas) makes liquid fuels from natural gas from the offshore F-A field. It produces about 45 000 barrels a day of crude oil equivalent. The field is expected to run out in about 2008 and new gas will have to be found to keep it in operation, either by developing the neighbouring fields or by importing gas in the form of LNG.

Sasol has developed a new process, the Sasol Slurry Phase Distillate technology, for making very clean liquid fuels from natural gas. The fact that these fuels are free of sulphur should make them attractive for the fuel markets of Europe, Japan and the USA, which have increasingly stringent legislation on emissions and air pollution. Sasol is building such production plants in Qatar in the Middle East and at Escravos in Nigeria.

4.2.2.4 *Liquid fuel consumption, imports and exports*

The tables below show South Africa's liquid fuel consumption, imports and exports.

Table 4.4: South African liquid fuel consumption, 1988 to 2001

<i>Year</i>	<i>Petrol</i>	<i>Diesel</i>	<i>Kerosene</i>	<i>Jet fuel</i>	<i>Fuel Oil</i>	<i>LPG</i>	<i>Total</i>
1988	7 995	5409	641	784	524	406	15 759
1989	8 395	5 350	678	835	546	432	16 236
1990	8 612	5 273	723	866	576	434	16 484
1991	8 906	5 130	725	861	526	464	16 612
1992	9 171	4 950	743	1 009	549	465	16 887
1993	9 202	4 940	834	1 095	595	454	17 120
1994	9 630	5 110	875	1 193	633	485	17 926
1995	10 153	5 432	850	1 368	616	472	18 891
1996	10 566	5 759	917	1 601	704	450	19 997
1997	10 798	5 875	970	1 777	635	502	20 557
1998	10 883	5 959	1 052	1 877	574	523	20 868
1999	10 861	5 993	1 054	1 995	561	540	21 004
2000	10 396	6 254	857	2 020	555	567	20 649
2001	10 340	6 488	786	1 924	555	599	20 692

Table 4.5: South African liquid fuel imports, 2001

<i>Product</i>	<i>Quantity (tons)</i>	<i>Value (R million)</i>
Crude	16 563 625	23 503
Petrol	220 361	487
Diesel	653 926	139
Heavy fuel	8 974	56
Kerosene	114 224	232
Others	347 525	873
Total	17 908 635	25 290

Table 4.6: South African liquid fuel exports, 2001

<i>Product</i>	<i>Quantity (tons)</i>	<i>Value (R million)</i>
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Crude	184 169	407
Petrol	990 989	1 075
Diesel	2 174 699	2 249
Heavy fuel	8 974	172
Aviation& kerosene	243 525	140
Others	470 094	1 027
Total	4 072 450	5 070

4.2.3 Renewable energy

4.2.3.1 Biomass

It is estimated that about 87 PJ of wood is used for household energy. This is mainly in the rural areas. The worldwide trend, which South Africa follows, is a progression from traditional fuels, such as wood and dung, through transitional fuels, such as coal, kerosene, LPG and candles, to modern fuels, such as electricity and piped gas. There is also a migration from the countryside to the urban areas. Both of these suggest a declining use of biomass for household energy in future, although widespread poverty might counter this decline.

South African pulp mills have an estimated electricity generation of 170 MWe. These mills burn sawdust and bark (in the case of softwood) in their boilers to make steam for electricity generation and process heat. In the chemical pulp mills, 'black liquor' is separated from the wood fibres after the digesters and this is burnt in recovery boilers to make steam for electricity generation and process heat. The pulp and paper industry is modern and successful, and timber yields in the forest are growing, so there are good prospects for expansion. The big pulp mills can generate more electricity than they do now and will do so and put it into the national grid if the price is right.

South Africa's sugar industry produces yearly about two million tons of sugar from about 20 million tons of cane. About seven million tons of bagasse is burnt in boiler to make steam for electricity generation and process heat. The prospects for expansion of this industry are limited.

4.2.3.2 Solar

So far no electricity in the national grid is generated from solar power. However, solar photovoltaic electricity is used widely in rural areas for own use. It is estimated that about 70 000 households, 250 clinics and 2 100 schools have had photovoltaic panels installed. Rural area supply systems companies are contracted under concession agreements to supply households in certain areas with photovoltaic units, sometimes combined with LPG. About 1 000 households a month are being added to this system. Solar water heating for households is increasing too.

Eskom is exploring the potential of grid electricity from solar and wind power. It initiated the South African Bulk Renewable Energy Generation (SABRE) programme in 1998. In 2002, Eskom installed a 25kW solar dish/stirling engine at the Development Bank of Southern Africa premises in Midrand. Eskom is studying the feasibility of a 300 MWe solar thermal power station, which would probably be built near Upington the Northern Cape, with three 100 MWe units, concentrating sunlight in reflecting troughs onto pipes carrying a coolant of molten salt; heat in the salt would be stored so that the station would be able to dispatch electricity 24 hours a day.

4.2.3.3 Wind

So far no electricity in the national grid is generated from wind but wind is used widely for water pumping on farms. There are also about 500 wind turbines on farms that generate direct current electricity, usually at 36V. In 2003, Eskom installed two 660 kWh wind turbines and a 1.7 MWe one at Klipheuvell in the Western Cape. This is part of its SABRE programme and is for demonstration and research. An independent group, Darling Independent Power Producer (Darlipp), proposes to develop the 5 MWe Darling Wind Farm, also in the Western Cape. It has been licensed by the National Electricity Regulator, but is still awaiting approval of its EIA.

4.2.3.4 *Municipal waste*

It has been estimated that South Africa's total domestic and industrial refuse disposed in landfill sites has an energy content of about 11 000 GWh per annum. This could be directly incinerated or converted into biogas and methane to produce electricity. There have been proposals for such

4.3 Summary of critical issues for future energy supply

4.3.1 Energy reserves and prices

Coal is by far South Africa's largest source of primary energy and is likely to remain so for decades. The coal reserves are now being re-assessed by the DME, and the result will be of great importance to energy planners. In view of rising demand for coal, mainly because of demand from China, coal prices are likely to rise markedly in the medium term, which will have significant effects for South Africa's energy economy, particularly in electricity generation.

The gas reserves of the Ibhubesi field of the South African west coast are now being investigated and the result should be known by mid-2004. Even in the most favourable case, however, the indigenous gas reserves are small.

4.3.2 Electricity supply

South Africa is rapidly running out of generation capacity and must build new stations soon. The problem is twofold: (i) Who is going to build and run the new stations? (ii) What energy sources are they going to use?

At the moment Eskom, the state-owned utility, is the only national supplier of electricity. The government has stated that Eskom should not build any more stations but on the other hand it has stated that Eskom has an obligation to supply. Independent power producers (IPPs) would need a return on investment of about 15%, which would require electricity prices to be much higher than now. New stations could be built on debt, with a lower return and smaller electricity price increase, but in this case it seems likely that Eskom would be asked to build new stations or at any rate build them in partnership with others.

The only two indigenous sources of energy for bulk electricity are coal and nuclear, since gas reserves are small and hydro, wind and solar power only have a small potential. Future coal stations would probably be similar to the existing pulverised fuel stations but with desulphurisation and dry cooling. Fluidised bed combustion stations using discard coal are a strong possibility too. The Pebble Bed Modular Reactor seems the most promising of the nuclear options but it will be necessary soon to commit money to the building of the full-sized commercial prototype at Koeberg to make a proper evaluation of the technology.

Importing hydro-electricity from new schemes in central Africa is a probability. The problems here are security of supply arising from present political instability in the region. South African power stations could also be run on imported natural gas, either piped from Angola or shipped in as LNG.

4.3.3 Liquid fuels

The big question of liquid fuels in future is whether South Africa will build any more production capacity, either as oil refineries or synfuel plants, or simply import finished liquid fuels in future to meet extra demand.

4.3.4 Renewables

The government's White Paper on Renewable Energy requires that from 2013 on 10 000 GWh per year of final energy demand should be met by renewable energy, of which the most important is likely to be biomass, wind, solar and small hydro. At present, biomass is by far the largest contributor of these. Increased renewable energy on a large scale is most likely to come from pulp mills, sugar refineries and solar water heating, with wind turbo-generators making a lesser contribution.

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5. Social issues

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5.1 Analysis of the current situation

5.1.1 Introduction

Social issues to do with sustainability are often interlinked with economic issues, particularly in the wealthiest and poorest countries and communities where over-consumption and poverty are both threats to sustainable development paths. In South Africa, social sustainability issues are strongly affected by local economic conditions, the national economy, and international economic relationships. All of these levels affect access to resources, employment and often social power as well. South African society is characterised by great inequalities resulting from past apartheid policies enforcing a racially divided society. The country has, similarly to Brazil, one of the highest income inequality in the world as measured by the Gini coefficient. However, taking taxes and social transfers into account, that is after accounting for the social wage, the Gini coefficient was reduced from 0.68 to 0.44 in 1997. Income inequality was further reduced in 2000, resulting in a pre-transfer pre-tax Gini of 0.57 and a post-transfer Gini of 0.35, indicating a reduction on inequality of 41% (Netshitenzhe 2003).

Access to electricity is generally seen as an important step in socio-economic development and many countries including South Africa work towards universal access. In South Africa, where people of colour were largely excluded from access to services before the democratic elections in 1994, providing such services is a way of addressing the inequalities of the past. The government has embarked on an electrification programme, which seeks to address the electrification backlog by 2014.

Adequate energy is a basic survival need in itself, while suitable energy provision can be required to meet other basic needs (e.g. water supply). The common fuels which the poor use for cooking and heating (biomass, kerosene, coal, etc) can each meet these immediate basic energy needs. The direct effects of extreme energy poverty (inability to obtain sufficient energy for meeting basic human needs) are likely to be malnutrition and exposure to disease and death. These impacts would be difficult to quantify in South Africa; they are tied up with other factors threatening the survival of poorest people (food shortages, inadequate water supplies, less access to healthcare, etc). However, energy researchers have little doubt that extreme energy poverty contributes to the plight of most vulnerable households and, within them, the most vulnerable family members such as the elderly, the infirm and the very young. Economic inequities are clearly a main cause of cases of extreme energy poverty in South Africa. Overall, there are no shortages in energy supply capability.

5.1.2 Household energy access

In the early 1990s, when Eskom planners were preparing a suite of electrification options to reach as many people as possible in the country – ‘Electricity for All’ – there was already a realisation that some sections of the population would probably not gain access to grid electricity in the foreseeable future. For households in remote rural areas, or in very sparsely settled localities, the high costs of grid supply (coupled with low average income levels) suggested that the electrification programme would have to resort to non-grid alternatives in these circumstances. There was an acceptance that such households would have to continue using non-electric fuels for their thermal energy needs, particularly their largest energy need, cooking. Among poorer households, which depend on non-commercial fuels such as wood, dung and crop residues for much of their cooking energy, this dependence was expected to continue.

5.1.2.1 *Electrification programme of the last 10 years*

The National Electrification Programme (NEP) Phase 1 (1994-1999) provided 2.5 million electricity connections at a total cost of about R7 billion. Previously disadvantaged and rural

areas as well as schools and clinics without electricity were connected to the national grid. Phase 2 of the National Electrification programme was started in 2000 and the target to provide 300 000 additional households with electricity every year has to date been achieved. The ambitious Phase 1 was an outstanding success and was implemented by the national utility Eskom (1.75 million connections) and municipalities (750 000 connections). The electrification rates during Phase 1 were among the highest in the world and this was achieved without external funding (Borchers et al. 2001). Eskom funded the NEP out of its own resources and the municipalities' subsidies derived from Eskom revenues through the electrification fund. Valuable lessons were learned and innovative approaches and technologies were pioneered.

Pre-payment meters were one of the innovations widely installed under the electrification programme. Paying before consuming gives households better control over electricity expenditure and avoids the accumulation of debts. The utility also avoids the many problems associated with non-payment.

Table 5.1 shows that from 1997 to 2001 more urban than rural houses were electrified because rural settlements are generally further from the grid and more dispersed, making rural electrification more expensive than urban electrification.

Table 5.1: Urban and rural electrification information from 1997 to 2001

Source: Based on figures from SSA 2003

Year	Type of Area	Population	Houses	Houses electrified	Houses not electrified	% Electrified	% not electrified
2001	Rural	20 832 416	4 267 548	2 095 229	2 172 319	49.10	50.90
	Urban	23 723 327	6 503 427	5 023 186	1 480 241	77.20	22.80
	Total	44 560 743	10 770 975	7 118 415	3 652 560	66.10	33.90
2000	Rural	19 967 564	4 267 548	1 952 494	2 315 054	45.75	54.25
	Urban	23 357 452	6 503 427	4 828 103	1 675 324	74.24	25.76
	Total	43 325 016	10 770 975	6 780 597	3 990 378	62.95	37.05
1999	Rural	20 009 245	3 873 990	1 793 193	2 080 797	46.29	53.71
	Urban	23 045 062	5 745 180	4 585 185	1 159 995	79.81	20.19
	Total	43 054 307	9 619 170	6 378 378	3 240 792	66.31	33.69
1998	Rural	19 550 322	3 785 454	1 612 168	2 173 286	42.59	57.41
	Urban	22 580 078	5 636 392	4 322 820	1 313 572	76.69	23.31
	Total	42 130 400	9 421 846	5 934 988	3 486 858	62.99	37.01
1997	Rural	19 111 522	3 700 494	1 409 681	2 290 813	38.09	61.91
	Urban	22 115 078	5 520 200	4 097 981	1 422 219	74.24	25.76
	Total	41 226 600	9 220 694	5 507 662	3 713 032	59.73	40.27

It was found that in most cases electrification is not financially viable and electricity consumption, contrary to expectations, is so low that revenues in many areas do not cover operation costs (Borchers et al. 2001). Case studies show that 56% of households in South Africa connected to the national grid in Eskom-licensed areas consume less than 50kWh of electricity per month (Prasad & Ranninger 2003). The electrification of poor and rural areas is not financially sustainable because of the low consumption of the electrification customers. A consumption level of 350kWh was initially anticipated, but the consumption for the year 2000 was 132 kWh/month/household (Borchers et al 2001). The financial loss has to be weighed against the social and developmental gains in the long term. The NER (1998) stated that:

[I]t was understood from the beginning that the primary motivation for the massive electrification of disadvantaged communities was not to achieve economic benefits. For socio-political reasons it made sense at the time, as it still does, to improve the quality of life of millions of South Africans while at the same time creating opportunities for jobs and prosperity.

The programme contributed to the welfare of the communities by providing improved health care in clinics and evening adult education in schools. Computers and photocopiers where schools could afford them benefited education. Fires in homes were reduced because kerosene for lighting and candles were substituted by electricity (Borchers et al 2001). The benefits from cooking and heating with electricity were lower than expected because many poor can only afford to pay for electricity for lighting and media (see Figure 5.1). For economic development to take off, electricity is insufficient; finance has to be made available and access to markets has to be facilitated amongst other support structures. However, small enterprises benefited, with retailers and workshops able to open for longer hours in the evening.

The experience gained showed two major limitations in the national electrification programme. Although extremely successful and creditable in terms of expanding the numbers of South African households connected to the national grid,

- even after electrification a majority of lower-income households (both rural and to a somewhat lesser extent urban) continued to use non-electric fuels for their larger-quantity energy needs;
- the wider socio-economic development benefits of electrification seemed disappointing, partly because this improved energy supply was not integrated with other necessary improvements in infrastructure, services and economic development initiatives;
- some groups of poor people like backyard dwellers and people living on land not approved for settlement are excluded from electrification.

As a result, there was a growing awareness that

- an energy development strategy which seeks to benefit the poor must not be restricted to electrification, but needs to improve access to complementary non-electric fuels, appliances and safe/efficient practices – and that this is applicable in both grid-electrified and non-grid areas of the country;
- electrification investments could achieve greater development benefits if they are not solely driven by numerical connection targets, but instead are integrated in more detailed, cross-sectoral local development plans and implementation.

5.1.2.2 Non-grid electrification programme

Since some remote rural areas will not be connected to the national grid in the near future the DME looked at non-grid options. In 1999 it adopted a concessionaire model to deliver non-grid electricity to rural communities. It is expected that 350 000 households will get access to solar home systems (SHSs). Designated remote rural areas were allocated to approved utilities to provide non-grid electricity services for an agreed fee to be paid by the customer – the fee-for-service model. The concessionaires own the SHSs they have installed, and service them regularly for a monthly fee of R58.

Small photo-voltaic systems with 50 Wp panels were provided to households who applied for them. Approximately 7000 SHSs have been installed in four concession areas so far. A capital subsidy of R3500 for each installed and certified system was paid by the government directly to the service provider. A monthly service subsidy of R48, the equivalent of the basic electricity support service tariff (BESST) for grid-connected poor customers (see below) has been promised by government payable directly to the service provider. This is a new initiative and implementation has been slow. Experience is gathered as the project is rolled out. Initial evaluation of the concessionaire model indicates that the very poor households are excluded because they cannot afford to participate. In one of the concessions they do not meet the selection criteria, which is proof of employment, and they often cannot make regular monthly payments of R58. The promise of the monthly subsidy would help the poor because they would then have to pay a monthly service fee of R10 only.

A solar panel provides on average 62 kWh/year, so that even after the capital subsidy and the poverty tariff, customers are paying 193c/kWh. This is five times the amount a grid-connected customer pays without any subsidy (Spalding-Fecher 2002).

It was initially intended that fuels like kerosene and gas for cooking, space and water heating would be made available by the concessionaires in remote rural areas, but this has only been partially implemented.

5.1.3 Household energy use

5.1.3.1 Provision of electricity and multiple fuel use

Worldwide, multiple fuel use is quite normal, both in industrialised and developing countries, in industrial and residential sectors, and among richer and poorer households. Households do choose different cooking fuels for convenience, tradition, taste and preparation method of food even when they can afford to cook with electricity. However, households in the low income groups do not choose wood or kerosene for these reasons but because they can neither afford the electric appliances nor high monthly electricity bills.

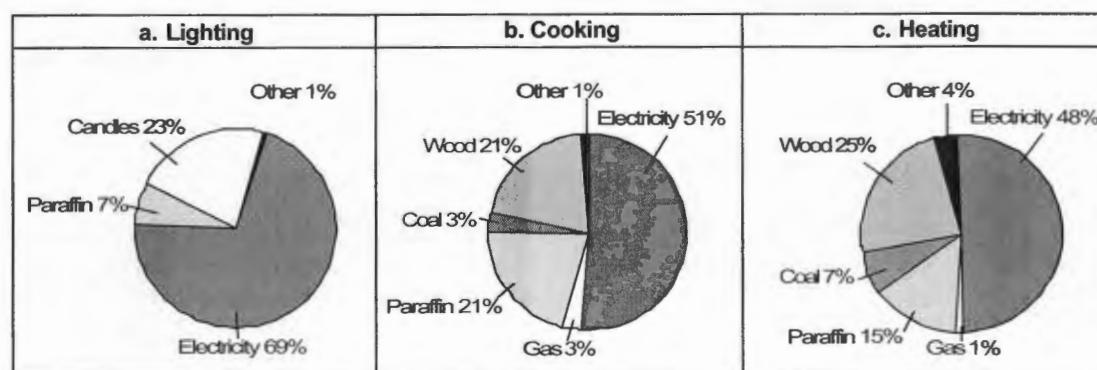
Seven years after the electrification programme started, the 2001 census data showed that many households are still using multiple fuels. Comparing energy sources used for cooking in 1996 and 2001 (Table 5.2) households using electricity have increased by 4.3%. The use of gas has slightly declined, kerosene has remained approximately the same, and the use of wood has declined by 2.4% (Table 5.2).

Table 5.2: Comparing energy sources for cooking in 1996 and 2001

Source: Base on Census 1996 and 2001 data from SSA (2003)

Fuel	1996	2001
Electricity	47.1	51.4
Gas	3.2	2.5
Kerosene	21.5	21.4
Wood	22.8	20.5
Coal	3.5	2.8
Other	1.9	1.4
Total	100%	100%

Of households, 69% have access to electricity and use it for lighting (Figure 5.1a). 23% light their homes with candles and 7% use kerosene. Comparing electricity use for lighting and cooking (Figure 5.1a and b) it becomes clear that 18% of households although connected to electricity cannot afford to use it for cooking. Wood and kerosene substitute the more convenient electricity. The difference between electricity used for lighting and cooking is thus an indicator of poverty affecting energy use.⁵



⁵ The census data probably over-represent the extent to which electricity is used for cooking. Numerous studies have shown that lower-income households using electricity for cooking only use electricity for a part of their cooking activities.

Figure 5.1: Distribution of South African households by main energy source used for lighting, cooking and heating

Source: Based on Census 2001 figures from SSA (2003)

Electricity used for heating (Figure 5.1c) follows the trend of electricity used for cooking. Wood, coal and kerosene are quite widely used instead of electricity. Both these fuels can be used with inexpensive or no appliances, another reason why poor households use them. Analysing the difference between electricity use for lighting and cooking by province and income (Figure 5.2) shows that in poor provinces (Limpopo, Mpumalanga and others) the differences are higher than in provinces with relatively high incomes (Gauteng, Western Cape) supporting the findings from case studies that poor households cannot afford to use electricity for cooking and the cost of electrical appliances (UCT 2002). These studies revealed that poor households can afford to use electricity for lighting and media only and in very poor households there is frequently not enough money to buy electricity for the whole month and towards the end of the month people either remain in darkness or use candles (Prasad & Ranninger 2003).

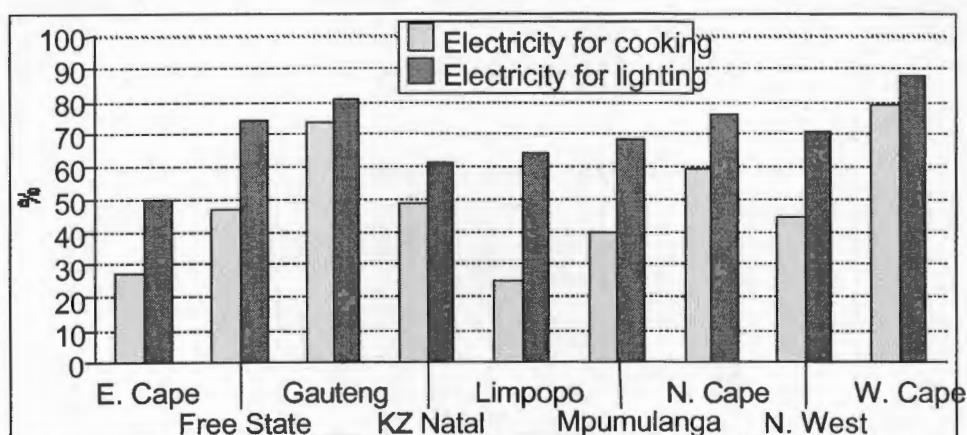


Figure 2: Households using electricity for cooking and lighting by province in percentages

Source: Based on census 2001 figures from SSA (2003)

Case studies in urban areas (Mehlwana & Qase 1998) showed that electricity was considered the most desirable fuel but households could neither afford the monthly electricity bill nor the most basic electric appliances. The study further revealed that sharing of energy and appliances was part of poor people's social relations; these include the credit system between households and local shops and wider kin networks. Women keep these relationships active as part of their many risk strategies.

Comparing income and fuel source for cooking (Table 5.3) just over 30% of the two poorest income groups cook with electricity at the same time they are the highest kerosene (25–31.4%) and wood (31–33%). Rich households in the income group R1153 601 – R307 200, cook most with electricity while the very rich use multiple fuels more widely.

Table 5.3 Annual household income in rands by energy source for cooking in percentages

Source: Based on census 2001 figures from SSA (2003)

Income group	Electricity	Gas	Kerosene	Wood	Coal	Others	Total
0 – R4 800	30.0%	2.3%	31.4%	31.0%	3.3%	2.0%	100%
R4 801 – R9 600	33.8%	2.3%	25.0%	33.0%	3.8%	2.0%	100%
R9 601 – R19 200	47.7%	2.8%	25.2%	19.4%	3.4%	1.4%	100%
R19 201 – R38 400	67.1%	3.2%	17.0%	9.3%	2.6%	0.8%	100%

R38 401 – R 76 800	85.8%	3.0%	6.1%	3.3%	1.2%	0.5%	100%
R76 801 – R153 600	93.3%	2.2%	1.9%	1.7%	0.5%	0.5%	100%
R153 601 – R307 200	95.9%	1.9%	0.8%	0.8%	0.2%	0.4%	100%
R307 201 – R614 400	94.7%	2.2%	1.1%	1.3%	0.3%	0.5%	100%
R614 400 – R1 228 800	92.3%	3.0%	1.7%	2.1%	0.4%	0.5%	100%
R1 228 801 – R2 457 600	76.2%	2.8%	7.7%	10.6%	1.4%	1.2%	100%
R2 457 601 and more	85.7%	2.7%	3.6%	6.5%	0.8%	0.7%	100%
Total	51.4%	2.5%	21.4%	20.5%	2.8%	1.4%	100%

Use of electricity in South Africa is to some extent exceptional. Because of relatively low electricity prices, middle-income and higher income households are more likely to use electricity for most of their domestic energy needs, compared with many other countries. As a result, multiple fuel use in the domestic sector presently has greatest significance for lower-income households (both in electrified and unelectrified communities).

Non-commercial fuels

An important distinction here is between commercial and non-commercial fuel-use. Much of the biomass used as fuel by low-income households is collected by householders rather than purchased. If the fuel is gathered 'free of charge' this has important money-saving benefits for the poor. There are urgent competing demands for any money that is available, so very poor households depending on non-commercial fuel sources are less likely to shift willingly to other (commercial) cooking fuels, unless their economic predicament improves. This underpins one of the most intractable energy problems in the country: enforced dependence on non-commercial fuels, which brings with it a number of sustainability issues – including health impacts, environmental degradation, decreased productivity and energy poverty.

In some parts of the country there is an increasing commercialisation of biomass fuels, firewood in particular. Sometimes households purchase firewood because they can afford this. However, *enforced* purchasing of wood often results from local scarcities, or inability to collect sufficient quantities (e.g. as a result of infirmity or shortage of able people in the household – which is compounded by the HIV/Aids pandemic). When this is the case, the commercialisation of firewood is usually associated with increased energy poverty, and deteriorating livelihoods.

Factors affecting the use of commercial fuels among low-income households

Among poorer households, the most important criteria affecting people's choices amongst commercial fuels are probably the cost and availability of different energy options (both the fuels and the appliances needed to use them). Particularly in rural areas, transport is an important intervening factor, which affects both costs and availability. Rural householders often have to travel significant distances to purchase fuels like kerosene, which adds to the cost of obtaining the fuel; or else they may buy small quantities from local traders, at a higher cost per litre. In general, where there are several steps in the distribution chain (as is usually the case with kerosene and LPG) the mark-ups at each step raise the final price, making energy expenditures a larger burden for households in this situation. Transport costs also have a major impact on the use of coal and commercial wood. Close to mining areas, coal is a 'cheap' fuel, but it becomes relatively expensive when long transport routes are involved. Thus coal is widely used by low-income households only in some areas of the country.⁶

⁶ These unfortunately include areas with high settlement densities, cold winters, and adverse climatic conditions for dissipating the pollutants from coal fires and stoves, leading to extremely unhealthy local indoor and outdoor pollution levels.

A number of other factors impact on the use of commercial non-electric fuels. One is the cost and availability of suitable appliances. Very cheap kerosene wick stoves are widely available, unfortunately with poor safety, performance and durability characteristics. Kerosene pressure stoves, with a somewhat higher efficiency are less common, can also be of low quality, and are as expensive as a two-plate electric stove. LPG appliances tend to be expensive for poor families. Appliance costs (and also their durability) constrain people's fuel choices, and their flexibility in switching between fuels. Among households with low and irregular income streams, the ability to switch between 'superior' and 'inferior' energy practices, according to their level of resources at a given time, is an important technique for improving their quality of life, or surviving periods of destitution. The cost of owning several appliances for multiple fuel use can be an obstacle here.

5.1.3.2 Urban-rural divide

Very poor households (quintile 1) in rural areas have the lowest electrification rates (see Table 5.1) in the country. Only 41% of these households have access to electricity. The largest difference between rural and urban is found among the poor households (quintile 2), 45% of rural q2 households have electricity while 78% of urban q2 households have access to electricity.

Table 5.5: Estimated electrification levels of rural and urban household by income quintile

Source: UCT (2002); data from October Household Survey (1999)

Rural households					Urban households				
Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
41%	45%	59%	68%	76%	63%	78%	87%	91%	98%

5.2 Critical issues for sustainability for energy development

5.2.1 Access, affordability and acceptability

The energy burden is the percentage of the total household budget spent on energy. The average energy burden of poor households in remote rural villages is 18%⁷ (see Table 5.6) (Prasad & Ranninger 2003). After an allocation of 50 kWh free basic electricity the energy burden reduced to 12% of the total household budget.

Table 5.6: Mean household expenditure on electricity and other fuels and energy as a percentage of total household expenditure

Expenditure on	Before subsidy	After subsidy	Difference	
Electricity (R/month)	38	31	7	18%
Fuels excluding electricity (R/month)	70	59	11	16%
Energy as % of household expenditure	18%	12%	6%	

5.2.2 Subsidies

Since poor households cannot afford much electricity and do not have the resources to start economic enterprises, they cannot make full use of the opportunities an electric connection could provide. A subsidy is needed to achieve a social benefit from the investment in the electrification networks (Gaunt 2003). The DME introduced a policy on electricity subsidy, the electricity basic support services tariff (EBSST), in order to reduce the worst effects of poverty

⁷ In the USA the energy burden for low income households was 14% twice the energy burden for all households which was 7% in 2001 (EIA 2003).

on communities. The policy provides for 50 kWh free basic electricity to be given to all poor households. The policy has been piloted and some municipalities have rolled out the subsidies. The amount of basic free electricity varied from 20 kWh to 100 kWh. Negotiations are under way to allocate a uniform amount of 50 kWh free of charge to all grid-connected poor household in the country.

Some economists believe that subsidies have a negative effect on economic efficiency. For example, to remove value added tax on illuminating kerosene is a measure designed specifically to give some relief to low-income households using kerosene as a domestic fuel. It is unlikely to lead to increased efficiency in the economy. Some economists argue that reducing taxes and levies on commercial and industrial fuels such as diesel and gasoline might lead to more efficient economic production (since the high taxes and levies constitute a price distortion). However this is debatable because of the massive uncosted social and environmental externalities in the South African economy.

5.2.3 Energy and job creation/losses

The employment rate starkly reflects the inequality of apartheid history. South Africa has high levels of joblessness – the official rate of unemployment in 2001 was 41.6%, (SSA 2003), significantly higher than previous estimates of 29.5% (SSA 2001).⁸ According to the 2001 Census, unemployment⁹ among Black African men was 43.3%, for white men 6.1%; with an even greater gap among women – 57.8% for black women and 6.6% for white females. For those employed, 1.2 million black Africans were in ‘elementary occupations’ and only 106 000 as ‘professionals’¹⁰, of total of 2.5 million; while there were more white professionals (138 000) and far fewer doing elementary jobs (20 000) of a total of 819 000 (SSA 2001).

Over the last 10 to 15 years jobs have been lost in the energy and energy-related industries (Figure 5.3). From 1993 to 2002 Eskom reduced its workforce from 40 128 to 29 359 (Eskom 2002). In the energy-related coalmining industry 100 000 people were employed in 1986 compared with 49 000 in 2001 (SANEA 2003). Production of electricity and coal increased in the respective industries at the same time as the workforce decreased, indicating increasing mechanisation

⁸ Among those who are included in the expanded but not the official definition of unemployment will be discouraged job seekers (those who said they were unemployed but had not taken active steps to find work in the four weeks prior to the interview). The official definition is that ‘unemployed are those people within the economically active population who: (a) did not work during the seven days prior to the interview, (b) want to work and are available to start work within a week of the interview, and (c) have taken active steps to look for work or to start some form of self-employment in the four weeks prior to the interview’ (SSA 2001). The expanded unemployment rate excludes criterion (c).

⁹ Unemployment rate (strict definition) among those aged 15-65, i.e. as a share of the economically active population.

¹⁰ These are only two of ten occupational categories.

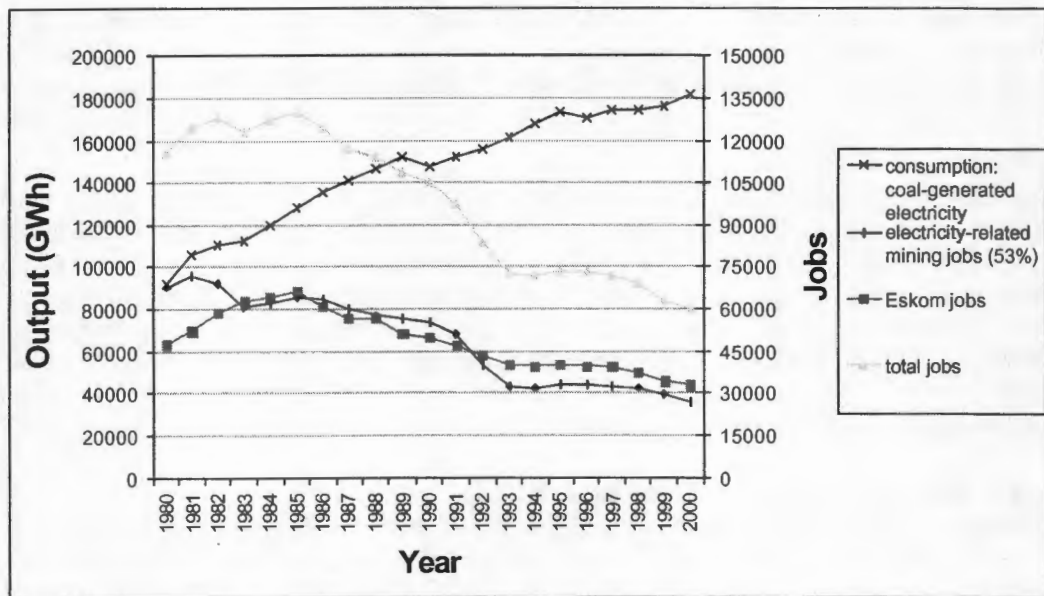


Figure 5.3: Employment in coal-based electricity generation in South Africa
Source: AGAMA (2003)

5.2.4 Economic empowerment of historically disadvantaged population groups

The government has a commitment to redress race and gender inequalities of the past. Eskom employed 54.6% black staff and 24.5% women on managerial level, slightly exceeding the target for 2002. Black staff is 68.8% and women are 19.7% on all levels. As part of its procurement policy Eskom supports black economic empowerment. In 2002 a policy framework for the empowerment of women was implemented (Eskom 2003).

5.2.5 The need to inform and educate the poor on energy issues

The use of electricity and appliances is relatively new to most poor households. Research conducted at two EBSST pilot sites demonstrated that poor people did not benefit optimally from this tariff because of a lack of energy education and information. Vilakazi (2003) notes that a lack of education and information was a major barrier to the successful implementation of the EBSST programme. The White Paper on Energy (DME 1998: 110) also acknowledges that South African energy consumers, from low-income households to business and industry, are poorly informed about good energy-use practices and options. A lack of energy information contributes to conditions of unsustainability and community underdevelopment (Visagie 2002). An energy-literate public is needed to make well-reasoned decisions about energy options and to use the natural resources more wisely – which is the key to sustainable development

5.2.6 Gender and energy

In most households women do the cooking and in most poor rural households women and children are responsible for collecting the firewood which few households can afford to buy. This exposes them to dangers from wild animals and human attacks. The heavy headloads up to 50 kg carried over many years have a negative impact on health. There is a definite need to replace fuel wood for cooking by less harmful fuels. A detailed description of the effects of indoor air pollution on human health is presented in the environmental chapter.

Women, gender and energy in South Africa is the focus of *Energia News*, October issue 2003 edited by Wendy Annecke and Tieho Makhabane. It highlights gender and energy work which really began in 1994 following the national mandate for equity. The appointment in 1999 of Ms Phumzile Mlambo-Ngcuka as Minister of Minerals and Energy was a turning point for women in energy (Annecke 2003). The minister actively supports the participation of women by encouraging training and allocation of resources.

5.3 Outlook: how is this issue expected to change in future?

5.3.1 Future energy generation and job creation

Unemployment is one of the greatest problems in South Africa, where about 41.6% of the population is without a job. The need to generate more electricity to fulfil future demand could therefore be considered an opportunity to create more jobs. The greatest impact on poverty lies in the employment potential in the energy sector itself, in the energy-related coal mining industry or other industries consuming large amounts of electricity. South Africa has one of the lowest energy tariffs in the world and this attracts direct foreign investment in energy-intensive industries. The aluminium smelter at Hillside in Richards Bay and the planned development at Coega an industrial development zone near Port Elizabeth are two examples of recent developments.

A recent study (AGAMA 2003) evaluated the role renewable energy could play in the creation of new jobs. The projected electricity demand for the year 2020 is expected to be 267 TWh increasing from the 2000 electricity generation of 181 573 GWh. Figure 5.4 indicates that if an additional 62 TWh is to be generated by RETs and new coal capacity around 52 000 jobs will be created, compared to 43 000 jobs if the additional capacity be created by coal-fired plants. The largest number of jobs would be created if RETs alone would generate the demand. It would result in 57 000 jobs (AGAMA 2003).

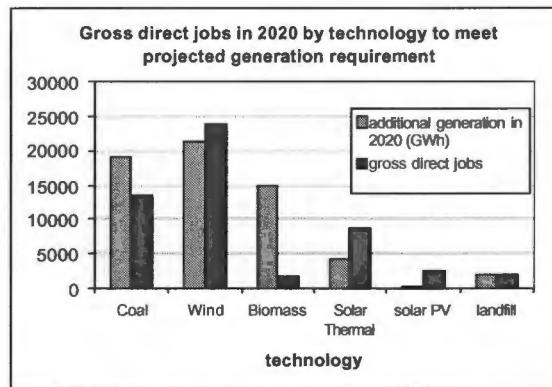


Figure 5.4: Summary of jobs against electricity generation for coal and RETs in 2020

Source: AGAMA (2003)

5.3.2 Increase in electricity prices and subsidies

Electricity prices are expected to rise in future because electricity demand will outstrip the baseload capacity of the existing power stations by 2007 and new power stations will have to be built. In this case the unusual use of electricity for thermal domestic energy needs (cooking, water heating, space heating) may give way to wider multi-fuel use by richer South African households.

Poorer households in South Africa tend not to use electricity for their main thermal energy needs. One reason – mainly in rural and peri-urban areas – is the use of non-commercial fuels for these purposes. In addition, half of rural households do not have access to grid electricity, and therefore do not have the option. However the non-use of electricity among electrified low-income households (for cooking, etc) is quite surprising, at current costs. Further, if the EBSST is successfully implemented, whereby electricity will be a cheaper cooking option than other commercial fuels, it will make financial sense for low-income electrified households to cut down on their use of other commercial fuels and use electricity for their basic energy requirements. This would be a profound change, requiring wide customer education/information campaigns and ongoing careful policy assessment.

If, however, the national subsidies for electrification (i.e. widened access to electricity) and electricity itself for poorer households are sufficiently large, could this picture change? That remains to be seen. There are of course also questions about whether such a large national subsidisation of electricity can be sustainable. Even if subsidised grid electricity becomes an affordable cooking option for larger numbers of households, it is likely that among the very

poor, there will be a continuing use of non-commercial energy options, where these are obtainable. Such people are well aware of the burdens, inconvenience and health effects of cooking over smoky fires but for economic reasons their scope for making better choices is very limited.

5.3.3 Energisation approaches and integrated energy development

The term 'energisation' has become popular in South Africa over recent years. It usually refers to the improved provision of a combination of different fuels, rather than a single energy carrier (such as electricity). Another term which is often used in this context is 'integrated energy' provision – again referring to combinations of various fuels. In either case, these terms reflect a switch in thinking away from an almost exclusive focus on electrification. 'Energisation' has also developed some other connotations in South Africa. It is sometimes associated with a more political notion of empowerment and local community activism around energy and development issues (with resonance to LA 21 precepts).

5.3.3.1 Agencies and actors

Since energisation implies a range of fuel supplies, there can be numerous agencies and companies involved on the supply side. In addition, other actors and agencies can be involved in supporting community empowerment and organisational development around energy issues. Policy-makers and planners are also involved.

A list of participants could include:

- National government (primarily the DME) Planning, policy, support, regulatory oversight, subsidies and taxes, etc.
- Local government Responsibility for securing the delivery of basic services (including energy) in their municipal areas, and for many aspects of Integrated Development Planning. Possibly also for routing national government subsidies directed towards energy provision.
- Eskom and other electricity suppliers and distributors Mainly responsible for grid electricity supplies. A rationalisation between Eskom and municipal electricity distribution is pending.
- Oil companies and distribution networks for petroleum products Sourcing/producing and distributing petroleum-based fuels – sometimes with further diversification.
- Industry associations E.g. safety associations within the petroleum sector – geared more towards public interest and market-support activities.
- Solar energy companies, and other energy companies/utilities involved in the 'concessionaires programme' for non-grid service provision Supply and maintenance of non-grid electricity services plus improved provision of complementary thermal fuels.
- Retail outlets, large and small, dealing in fuels and appliances For example, retail chains selling appliances (and concerned with safety standards), or the multitude of small traders involved in the distribution of fuels like kerosene.
- Community organisations For example, consumer co-operatives, community-managed 'energy centres', civic environmental and safety groups, local development forums, etc.
- NGOs and government/multilateral development support agencies Generally assisting local development initiatives, organisational development, capacity building, etc.

The above is not intended to be a complete list, but it does indicate how the aims of 'energisation' can lead to more complex involvements by many agencies, compared with an energy supply approach which focuses on electrification and where a large part of the responsibilities, planning, financing and implementation were formerly assigned to Eskom.

The combinations of different fuels and appliances in an energisation approach mean that different types of distribution and trading easily come in. For example, candles are traded and distributed much like other household consumables. Kerosene is widely available, both as a household consumable which can be purchased almost anywhere in the country from shops, and also from petrol stations and other 'bulk' outlets. However, its refinery-gate price is regulated, retail price mark-ups are regulated (though ineffectively), and it is exempt from VAT (also with uncertain effectiveness, in terms of final prices paid by low-income households). Kerosene distribution and trading therefore combine elements of a free market commodity and government regulation. LPG poses further complexities in South Africa, since there is supposed government regulation of refinery-gate prices, but presently no control over retail margins, and consumer LPG prices are unusually high in many areas. Grid electricity is a different kind of commodity, as it involves network infrastructure, seen by some as a necessary social investment and repair for past injustices in the country. For households the commodity of *electricity use* may be compared with the expense of buying alternative fuels, but for electrification planners the income from selling electricity units is small compared with the scale of electrification subsidies required to extend this infrastructure, and current operational subsidies proposed. Electrification planners tend to see electrification as a social rather than commercial programme. Thus 'energisation' can imply a very mixed bag of commercial conditions, in order to deliver a combination of energy services.

Three 'energisation' examples will be given below to illustrate different possibilities.

A weak grid approach, to extend the range of rural electrification

The costs of rural electrification tend to rise as the network is extended into increasingly remote and sparsely settled parts of the country. Cost-saving can be achieved through the use of lower-capacity medium voltage transmission and distribution lines, smaller transformers, and lower cabling costs for local reticulation. Observing that typical electricity demand levels in poor rural areas tend to be very low, electrification projects can be designed for a very low ADMD ('after diversity maximum demand'),¹¹ reducing the electrification supply costs, and increasing the number of communities and households that can be reached within the available electrification budgets.

If such electrification projects are not designed to cover community-wide cooking energy requirements, a corollary is that most people will need other fuels for cooking and heating. The picture is that households depending primarily on non-commercial fuels like wood and dung are likely to continue this cost-saving path, although it is hoped there will be some fuel-switching to cleaner fuels even among this group. Households using fuels like kerosene may also continue to do so. Again, however, there is hope that the use of LPG may become more widespread, through improvements in LPG supply and pricing, and appreciation of its greater convenience, cleanliness and safety compared with kerosene.

A paradox may become apparent, if grid electricity is cheaper than kerosene or LPG for cooking. This is already believed to be the case – a view endorsed by members of the LPG Safety Association of Southern Africa – and would become much more clearly the case for households adopting the proposed EBSST. The demand to use electricity for cooking could then

¹¹ Electricity demand is used here in the technical sense, where maximum demand is the maximum power consumed by customers. Individual consumers may require peak power at different times of day, so this 'diversity' effect can bring down the average peak power requirement for a community of consumers. Unfortunately, if a major electricity use occurs at the same time of day for many of the consumers (for instance, cooking meals) there is less demand diversity, and the average peak power requirement rises. The load factor then falls, indicating that the supply capacity required to cover the *peak* demand is severely under-utilised at other times of day, or seasonally. This is a familiar problem in rural electrification, and is bad for economics.

rise substantially, especially among those households presently using kerosene and LPG. The strategy of reducing electrification supply costs through a weak grid approach could then be at odds with a subsidy policy which promotes higher levels of electricity demand and use.

Non-grid concessionaires: solar systems plus other energy services

In the non-grid 'concessionaires' programme, the primary responsibility of the concessionaire companies is to supply, install and maintain solar home systems. However, they are also expected to improve the supply of other fuels, needed for purposes such as cooking and heating. A typical high-quality 'energisation' approach along these lines would be the provision of a SHS for electric lighting and media/communications appliances, coupled with improved distribution of affordable LPG and appliances, for thermal energy needs.

The first large SHS project in Eastern Cape operated by an Eskom-Shell Joint Venture has so far not become significantly involved in improved supplies of other fuels, finding that the challenges of SHS supply were arduous enough. However there are other examples where lower-cost LPG is being supplied alongside solar electrification (e.g. the NuRa utility operating in northern KwaZulu-Natal), reportedly with success. A central strategy for NuRa – a strategy that has also been considered by other groups concerned with off-grid electrification in deep rural areas – is the establishment of multi-purpose one-stop rural energy stores. These can provide a base for the marketing, supply, maintenance and billing for solar systems, as well as provide a range of other fuels and appliances, possibly also conducting public awareness activities. This approach has many similarities with the idea of 'integrated energy centres' outlined below. It differs in having a distinctly commercial basis, which in turn depends on the government-subsidised programme for non-grid SHS electrification. However, apart from the government subsidy-stream for SHS supply, NuRa reports a significant income-stream from LPG sales, a positive indication which shows better matching between rural energy demand and energy supplies, following an 'integrated energy' approach.

3.2.4. Integrated energy centres

Community-managed rural energy centres were piloted in the Rural SEED (Sustainable Energy, Environment and Development) project of 1998-2003 (Van Sleight et al 2003). A number of village clusters in Eastern Cape and Limpopo province formed local energy committees, and subsequently energy and development co-operatives. One of these co-operatives went on to establish a multi-purpose energy centre, which provides a range of fuels and appliances as well as public service activities (awareness and safety campaigns, etc) to surrounding communities.

This successful example has been supportive for the government's plans to 'roll out' a number of integrated energy centres across the country, in areas with high needs and poor service provision. These will not only be in rural areas, but they have a special relevance in low-income rural areas, and form an important component of the government's Integrated Sustainable Rural Development programme. The government-initiated integrated energy centres are designed to be public-private-community partnerships, with funding assistance particularly from Sasol and hopefully a high level of participation by local government and community groups. Two have so far been established, and a number more are at various stages of planning and organisation.¹²

Through bulk-buying, such centres can obtain fuels at a lower cost and reduce the cost overheads associated with transport and multiple steps in distribution chains. In addition to bringing energy services 'closer to the people' in this way, it is also intended that the integrated energy centres will stimulate active local participation, both around energy issues and also the integration of improved energy supplies and practices in economic development initiatives and social services.

¹² In the lead-up to national elections in 2004, it seems that there has been swing towards establishing integrated energy centres in peri-urban locations, serving poorly serviced communities living around towns. They have a higher voter density.

5.3.4 Energy and integrated development approaches

Energy has come to be viewed as a central cross-cutting component in government policies and programmes to promote integrated development in South Africa. Important elements here include a stress on inter-sectoral linkages (rather than single-sector planning and implementation), the process of 'integrated development planning', and in the case of rural areas, the government's Integrated Sustainable Rural Development programme.

5.3.5 The challenge of intersectoral linkages

The idea here is that energy planning and provision should take careful consideration of the links between improvements in energy supply and improvements in other services and economic activities where energy is required. This is easiest to illustrate by giving some examples:

- Rural grid and non-grid electrification can contribute to improved facilities for social services like education (schools), health (clinics, hospitals) and administration – so it should be co-ordinated with planning in such sectors.
- Household energy supplies (electricity and other forms of energy) often take precedence in rural energisation programmes, but the links with opportunities for increased economic activity (whether in commerce, services, agriculture or manufacturing) need to be stressed. Income opportunities have to be created for the poor so that they are enabled to pay for the energy services.
- There are links between energy and water supplies, particularly in areas where there are critical water-pumping requirements – so joint planning should be encouraged.
- The transport and energy sectors are obviously closely linked, because transport requires energy, and some forms of energy distribution require transport.
- More generally, infrastructure such as roads should be taken into account when planning energy developments; an inter-sectoral planning approach can encourage greater synergy and gains – however there can be drawbacks as well (for example, greater complexity and possibly dilution of purpose, compared with a single-sector supply programme).
- Special attention may be warranted for the close links between electricity and improved information and communications technology (ICT) – without access to affordable ICT facilities, disadvantaged communities may be increasingly separated from national and world development..

5.4 Emerging gaps

Intersectoral linkages need to be strengthened to make investments in electrification more effective so that poor people can use electricity and other fuels for the development of small businesses and other enterprises. Co-ordination between sectors can imply

- national and provincial level coordination, among government departments;
- practical co-ordination between implementing agencies;
- local-level assessment and planning of co-ordinated development approaches which suit the prioritised local needs and opportunities (as in 'integrated development planning' discussed below).

Each of these is challenging and, while it is easy to make arguments in favour of an integrated inter-sectoral approach, there are demanding requirements, for example for thorough communications among different agencies, some synchronisation of purpose and implementation, and securing suitable combinations of funding/investment that allow such synchronisation. Further complexities arise when different sectors are served by different tiers of government (e.g. national energy policies/programmes engaging with provincial departments of education) or where there are mixtures of responsibility between government, private sector and NGOs/CBOs (as in the development of integrated energy centres).

Electrification planning is now meant to be conducted in consultation with the integrated development planning process. It is generally less clear how the provision of non-electric fuels would be subject to local-level planning to the same extent, since non-electric fuels are usually supplied through a variety of private sector activities (in the case of commercial fuels) or through informal collection of non-commercial fuels. However, initiatives to establish integrated energy centres, supplying a range of fuels, have been formulated in consultation with local government and may be incorporated as specific projects within a local integrated development plan.

In terms of energy provision, there are many schools experiencing energy constraints. These impede some aspects of education and can also contribute to sickness among pupils (through, for example, no heating in winter, or no energy to prepare cooked meals in school feeding schemes).

Inadequate energy supplies can contribute to reduced agricultural productivity (for example, a lack of suitable energy for ploughing, irrigation, food processing and preservation, warmth and light for poultry-keeping, etc). However, improved rural agricultural productivity among the poor generally requires several further inputs, such as finance and investment facilities for small-scale farmers, intensive state support for rural agriculturists, and major measures to counter inequities in access to resources, like land resettlement programmes.

The electrification programme redressed one of the important aspects of inequality. Future social sustainability will, however, require further redistribution combining economic growth and job creation with effective social programmes.

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6. Energy and economic development

J C Nkomo

6.1 Analysis of current situation

6.1.1 Situational analysis of the energy sector

The energy sector is characterised by several outstanding features fundamental to social and economic development, including the following:

- A strong natural resource base and a variety of energy options. Coal reserves are vast, with estimates of their size varying considerably. Reserve estimates are a function of the resource price, the price of its substitutes, improvement in technology, exploration, development of alternatives and so forth, and change as these variables change. South Africa burns low-quality coal, allowing it to be one of the world's lowest-cost producers of electricity.
- A well developed energy and transport and grid infrastructure.
- An electrification drive to increase access to disadvantaged communities. Most of those without access are low-income households.

The economy is largely dependent for its electricity consumption on coal. Low-income households with access to electricity use electricity selectively and rely on wood and other inefficient fuel types for reasons associated with fuel availability, affordability, and cultural preferences. The generation and production of coal is polluting, and has a significant environmental impact.

The level of competition in the sector is low with reasons ranging from entry barriers to the issue of regulation. This, however, is not necessarily bad for now, especially if trying to finance expansion. Apart from the high cost of capital required to enter the industry, available information is imperfect, there is lack of technology and technology transfer available to entrants, and the existing structure and regulation is not conducive to entry. The government seems to be in the doldrums in restructuring the energy sector, and there is lack of legislation to stimulate competition and efficiency. All these issues are critical as the economy develops, with important social and environmental implications. They have, for example, an important bearing on the quality of life, job creation, rural development, equity improvement, improved pollution levels and technology transfer opportunities, as well as investment-led strategies promoting investment in renewables and energy efficiency as a centre of South Africa's development.

6.1.2 Energy and energy economy linkages

The relationship between energy use and economic growth is complex and important. Changes in energy demand are affected by factors such as volume effects, which reflect changes in economic activity; structural change resulting in changes in energy technology used; and energy conservation, mainly through substitution of old appliances.

The South African economy produces and uses large amount of energy, is highly energy-intensive, and is heavily dominated by extraction of raw material and primary processing (see Chapter 2). The energy sector contributes 15% to GDP and employs a labour force of over 250 000. Energy provision and use are crucial to South Africa's overall development, especially given the desire to attract foreign investment in the industrial sector. The demand for energy is expected to grow, with the energy sector remaining of central importance to the country's economic growth.

6.1.2.1 Economic performance

Figure 6.1 shows fluctuations in economic growth rates over time. The economy experienced high growth rates in the 1960s, with high growth rates coming from mining and raw materials, and from a tightly controlled economy. Factors such as the world oil crises and the changing gold prices (notice the spike in 1980) added to economic slowdown of the 1970s. From then on until 1993, increased public spending, economic sanctions and the effects of political instability stifled the economy. The period was characterised by poor growth performance, low levels of

investments, rising unemployment, political instability, currency instability, widening deficits, falling living standards and growing inequalities. Growth rates have been relatively low since 1994.

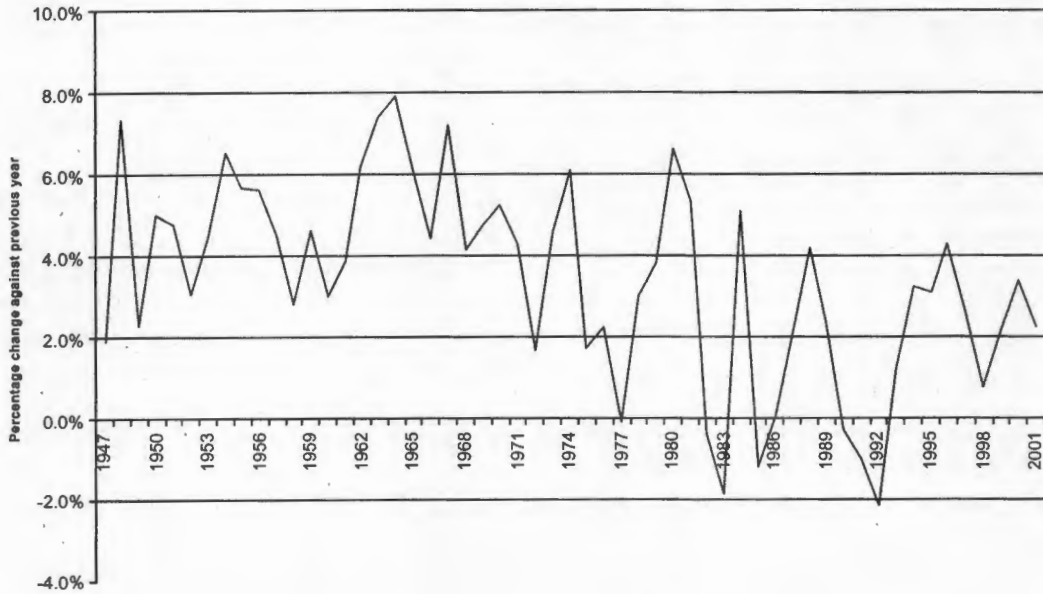


Figure 6.1: Annual real economic growth from 1947 to 2002

Source: Based on SA data, SA Reserve Bank, various years

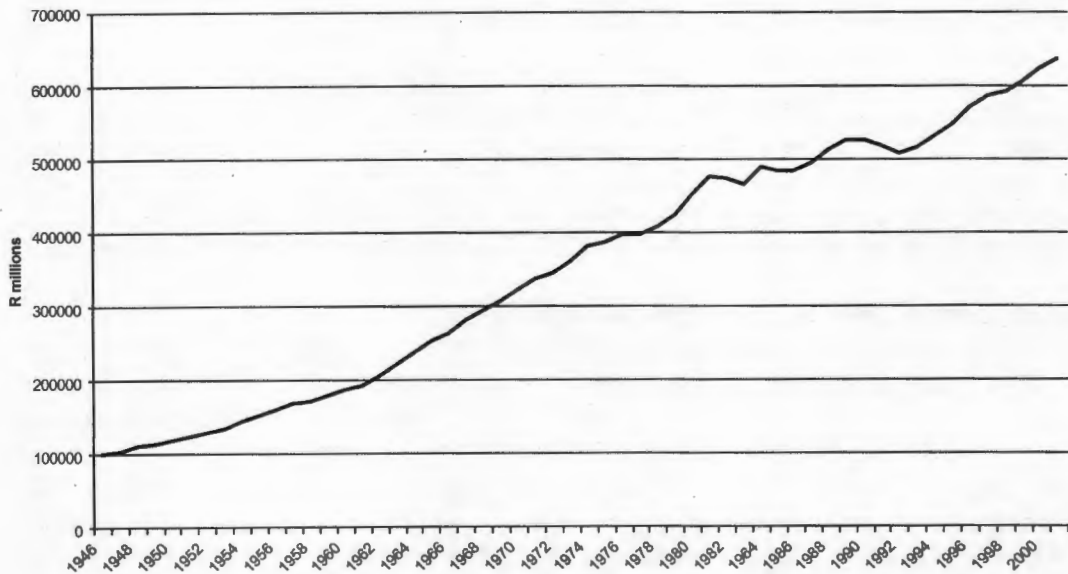


Figure 6.2: Gross domestic product at market prices (constant 1995 prices)

Source: Based on SA data, SA Reserve Bank, various years.

Since 1994, the government has been adamant about getting the macroeconomic balance right, to attract investors, to reduce the budget deficit, and to fight inflation through high interest rates. Expected economic objectives could be achieved by economic growth creating employment, and with growth leading to less inequality and poverty through employment creation. Despite the GEAR strategy to promote positive trends, the economy has not achieved higher rates of economic growth as predicted (Table 6.1). Employment performance has contracted substantially, and private sector investment (a driving force behind growth) grew by 2.7%

instead of the predicted average of 12%. Measured by the Gini coefficient, South Africa is ranked as the third most unequal society in the world, surpassed only by Brazil and Guatemala.

Despite the above problems, the government has met its key fiscal and monetary targets, and has been successful in reducing the fiscal deficit, inflation, and interest rates. Notwithstanding, economic growth has been less than expected. GDP growth (Figure 6.2) averaged 2.5 between 1996 and 2000 against the predicted average of 4.2% (see Table 6.1).

Some studies show that, even given the sluggish growth over time, there has been rapid substitution of unskilled and low-skilled labour by capital equipment in almost all sectors (Bhorat et al 1998). This is a major source of productivity movements. Increase in capital intensity influences production methods and accounts for an increased demand for energy. On average, then, the economy has become more capital-intensive and less labour-intensive. It is more unequal, as exhibited by increasing job losses and increased labour productivity, with no 'trickle-down effect' experienced by the poor. Because energy is cheap, the economy has also become highly energy-intensive, with more energy used to produce economic output than in most countries in the world. It is therefore not surprising that Makgetla and Meelis (2002) argue that 'the trajectory of growth must shift towards labour intensive industries, and away from current emphasis on mining and refining and relatively high class consumer durables', ensuring that the poor have access to productive assets. While this may be true at a small enterprise level, as general trend, the move from high value added industries will have low profit and so low investment potential.

Table 6.1: GEAR's predictions and actual outcomes for key indicators

Source: Naledi (2000)

	<i>GEAR predicted average</i>	<i>Actual average 1996 – 2000</i>
GDP growth (real)	4.2	2.5
Inflation	8.2	6.6
Fiscal deficit	-3.7	-2.9
Employment growth	2.9	-2.0
Private sector investment growth	11.7	2.7

6.1.2.2 Energy supply

Coal dominates the energy picture in South Africa, providing approximately 70% of the primary energy. The country has large reserves of low-grade and low-cost extractable coal. Most of the coal is used for electricity generation (coal dominates electricity generation with a share of 92%), and for the production of synthetic liquid fuel with Sasol and PetroSA as major players in the market. Imported crude oil accounts for 20% of primary energy used – mainly by the transport sector. Nuclear, natural gas, renewables including biomass account for the rest of the energy needs. Eskom accounts for over 90% of South Africa's electricity, and it owns and operates the generation and transmission system. Eight municipalities generate the rest of the electricity for their own use.

6.1.2.3 Energy consumption

The industrial sector (industry and mining) accounts for the largest proportion, 45%, of energy consumed (SANEA 2003). Industries can be assumed to choose energy inputs to minimise the total cost of energy subject to energy-burning appliances. Technologies differ across industries and so is the nature of their energy demand. Energy consumption levels and energy intensity, particularly of electricity, are high compared to all of Africa and of the world average. (See section 2.1 for an extensive discussion of intensity.) Large industrial consumers of electricity are gold production, because of declining ore grades and mines therefore going deeper, and non-ferrous metals. Coal is the main energy source for the following industries: iron and steel, chemicals (it is used as feedstock), non-metallic minerals (where coal is mainly burnt in clamp kilns), pulp and paper (which rely heavily on the black liquor to produce most of their energy

requirements), food, tobacco, and beverages. Coal-based industries have low energy conversion efficiencies compared with oil, gas and hydro plants (Eberhard & van Horen, 1995).

Residential energy demand is complex and is often explained in terms of both the 'transition' and 'ladder' concepts, representing the positions of households and their transition from low-cost high-emission non-commercial forms of energy (for example, wood and coal) to modern or less polluting commercial fuels like electricity. Some argue that energy choice is a function of variables such as educational levels, the degree of mobility and the length of time urbanised (Viljoen (1990), others contending that the main determinants of energy choice are the relative availability (or access) of fuels, income and affordability of energy resources (Eberhard & van Horen (1995). The phenomenon of multi-fuel use, however, is widespread, with households selecting fuels for different end-uses, as well as using more than a single fuel for the same end-use. Primary sources for low-income households are kerosene and candles, and to a lesser extent LPG and woodfuel. Their consumption of electricity is low, although it is preferred for reasons of convenience, cleanliness and better light quality.

6.1.2.4 Investment

Massive investment in coal-fired power plants overtime has led to excess capacity, with licensed capacity exceeding peak demand for at least the last 25 years. Figure 6.3 shows the degree of excess capacity (in MW) as well as exports and imports (GWh) between 1996 and 2000. Overinvestment was based on the assumption of rapid and continued electricity demand, and this has left Eskom with a large surplus of generation capacity. With little need for new investment in recent decades, debt has been reduced as most of the capacity has already been paid off. Growing electricity demand and economic growth points imply that more capacity, however, will be needed before long.

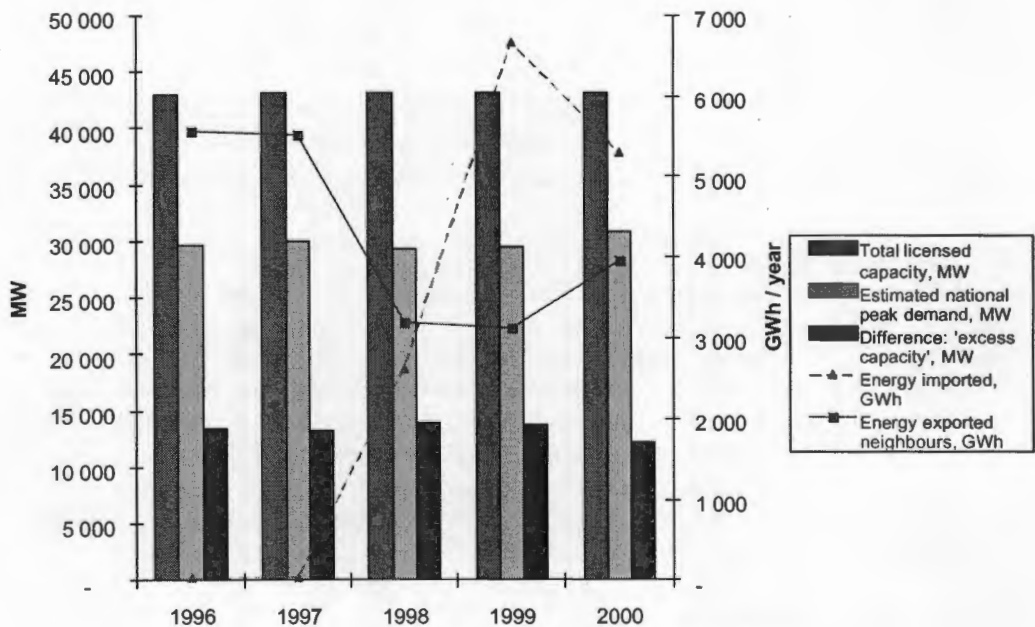


Figure 6.3: Excess capacity for all power stations 1996-2000

Source: NER (2004)

6.1.2.5 Electricity tariffs

Eskom sells electricity to distributors who then resell to residential consumers, commerce and industry. The average price, per kilowatt-hour, is among the cheapest in the world. This is attributable to several factors, such as:

- Access to large resources of low-grade coal and use of technologies that maximise economies of scale. To add to this, power stations are located near coal mines and enjoy the benefits of long-term contracts.
- Overcapacity from power stations, which are already paid for. This reduces Eskom's finance costs and enables it to peg electricity prices at a low marginal cost.
- Environmental costs are not included in the price of electricity.
- Eskom's investment has been subsidised through the Reserve Bank forward cover thus protecting Eskom against exchange rate fluctuations. Further financial benefits are that Eskom is exempted from taxation and dividends.

Ultimately, the price of electricity does not reflect economic costs, the long-term costs of increasing capacity, and excludes the externality costs.

Undoubtedly, the low tariffs give the local industries competitive advantage and drive much of new investment in industry. For example, the manufacturing and mining sectors are linked through beneficiation and metals production (Spalding-Fecher 2002). These activities are energy-intensive, and rely on low prices for coal and electricity, which, in turn, have contributed to the development of an energy-intensive primary sector.

Electricity price increases have remained below those of inflation, providing sound reasons for Eskom to allow prices to rise in real terms so as to earn an acceptable rate of return on capital invested and ensure sufficient generation of dividends and interest. But this raises the problem of affordability by poorer households, especially given the government's commitment to making electricity accessible to all its citizens. Although the price of electricity is low compared to that of other countries, providing a good foundation for economic growth, it has not had a significant impact in promoting poor households' access to affordable electricity services.

6.1.3 Externality costs

Reliance on wood, coal and kerosene as energy sources by low-income households contributes to high levels of indoor pollution. Of serious concern are particulates, carbon monoxide, respiratory illness (second highest cause of death after gastric illness), and fires. These problems persist despite the GEAR strategy that aims to bring low-income households into the modern economy through economic growth. Quantified impacts of external cost of household fuels reveal that greater damages are from candles, kerosene and the use of wood as fuel (Table 6.1). The estimates are based on the assumption that the use of electricity does not have significant negative externalities at the household level.

South Africa's best quality coal is exported and earns the country its third-largest export revenues after gold and platinum. But the use of low quality coal also leads to GHG emissions and other environmental problems (such as the ash produced and emitted and the pollution of water sources). South Africa's carbon emissions are higher than those of most developed countries partly because of the energy-intensive sectors (such as mining, iron and steel, aluminium, ferrochrome, and chemicals) which rely heavily on low quality coal. This illustrates a classical conflict in resource use. Just as the exploitation of cheap and low quality coal is seen to fuel growth (accompanied by arguments that this ultimately leads to social upliftment), there are also environmental reasons to minimise the negative effects of this energy use, especially in terms of pollution and climate change.

Consider externality cost estimates associated with coal generation. Blignaut and King (2002) estimate potential GHG damage costs across all industries. According to their findings, two major consumers of coal, Eskom and Sasol, are responsible for approximately 90% of all coal combusted, contributing 65% (approximately R7.2 billion) and 24% (R2.8 billion), respectively to the costs. Van Horen (1996) and Spalding-Fecher and Matibe (2003) evaluate potential external costs of coal-fired power generation on health and climate change damages caused by GHG emissions for the South African economy.

Findings expressed in Table 6.3 indicate that the estimated damages resulting from GHG emissions and climate change are significantly higher than those from local air pollution. The negative values are estimated benefits, and are total avoided health costs for 1999 for all low-

income households electrified. They relate to health costs of the fuels displaced by electricity use in 1999. The damage costs from GHG emissions range from R1.6 to R16.3 billion, that the global warming externality of coal based electricity production may be of the order of R0.01 and R0.095, with the total global damage per tonne of coal ranging from R18 to R186. These estimates are not plant specific because of lack of data. Furthermore, the estimates do not include coal-fired power stations owned by municipalities. If these are taken into account, the impact on human health will be greater given that the power stations are older, are used during the peak period, have lower stack heights and are in major urban areas.

Table 6.2: Summary of external costs of households fuels (1999 rands/GJ)

Source: Spalding-Fecher and Matibe (2003)

Energy type	Low	Central	High
Coal	2.37	5.32	9.51
Kerosene ¹	10.31	60.84	151.48
Candles ²	12.04	93.16	174.68
Wood ³	10.46	38.20	92.60

Notes

1. Includes kerosene poisoning and 30% of costs of fires and burns.
2. Includes 70% of the costs of fires and burns.
3. Includes indoor air pollution and the social cost of fuel wood scarcity.

**Table 6.3: Summary of external costs of Eskom electricity generation, 1999
(Per unit of coal-fired power produced/delivered, c/kWh)**

Source: Spalding-Fecher and Matibe (2003).

(1999R m)	Low	Central	High
Air pollution and health	852 (0.5/0.5)	1 177 (0.7/0.7)	1 450 (0.9/0.8)
Electrification	-173 (-0.1/-0.1)	-958 (-0.6/-0.5)	-2 324 (-1.4/-1.3)
Climate change	1 625 (1.0/0.9)	7 043 (4.3/4.1)	16 258 (9.8/9.4)

6.2 Critical issues relating to energy for sustainable development

In Table 6.4 we summarise key issues for energy development spelled out in the 1998 White Paper on Energy, categorising them by sustainable development dimension and showing the progress made, then discussing these issues in no particular order. The objectives show a clear shift from a pre-1994 policy dominated by the need to secure energy supplies (a period dominated by international boycotts and oil sanctions), to post-1994 policies that strive for social equity and economic efficiency within the context of sustainable development.

Table 6.4: Sustainable energy development priorities and progress

Sustainable development dimension	Energy objectives (White Paper on Energy 1998)	Priorities (DACS Foresight, Energy 1999)	Progress (Spalding-Fecher 2002)
Economic	Secure supply through diversity	Develop Southern African Power Pool Develop gas markets Stimulate use of new and renewable energy sources Stimulate energy research	SAPP regional co-ordination centre established Mozambique gas to Sasol and Namibia under discussion Renewable Energy White Paper in 2002 Declining research fund

Social	Increase access to affordable energy	<p>Electrification policy and implementation</p> <p>Addressing off-grid electrification</p> <p>Facilitate management of woodlands for rural households</p> <p>Establishing thermal housing guidelines</p>	<p>Initiate second phase of electrification programme, including renewables</p> <p>Initiate pilots of free electricity</p> <p>No progress</p> <p>Voluntary guidelines only</p>
Environmental	Managing energy related environmental impacts	<p>Improve residential air quality</p> <p>Monitor reduction of candle/kerosene resulting from electrification</p> <p>Introduce safety standards for kerosene stoves</p> <p>Develop policy on nuclear waste management</p> <p>Investigate environmental levy</p>	<p>Proposal of ambient air quality standards under debate</p> <p>Hazards still significant</p> <p>Under discussion</p> <p>Under discussion</p> <p>Not investigated</p>
Interlinkages	Improve energy governance	<p>Promulgate electricity regulatory bill</p> <p>Manage deregulation of oil industry</p> <p>Implement new regulation of nuclear</p> <p>Restructuring of state assets</p> <p>Establish information systems and research strategy</p>	<p>No petroleum regulator, petroleum Products and Pipelines Bills in 2002</p> <p>Nuclear regulator established</p> <p>Eskom conversion bill passed</p> <p>PetroSA formed</p> <p>iGas formed</p> <p>Limited activity</p>

Crucial issues for sustainability stand out as follows:

- The one key issue that seems missing here is *added value*. This relates to the structure of the economy. Growth in economic output, measured by GDP, is a necessary but not sufficient condition for improvements in the welfare of South Africans. The more the economy is structured towards value-added sectors, rather than exporting raw materials, the greater the local benefits. Clearly this involves changes that go far beyond the energy sector, but there are important implications for energy. One example is whether the country attracts facilities like aluminium smelters, which process raw material for export at Coega, or goes a step further in manufacturing products from aluminium. Another case is building up local manufacturing capacity in the energy sector is only a small part of this.
- Increasing access to affordable energy services (see Chapter 5). Residential energy use is characterised by poor access and inefficient and hazardous energy sources. The electrification programme is central to the development of the country and is increasing the number of people connected to the national grid. Estimates show that households with grid electricity increased from 45% in 1995 to 66% in 2001, and the number of people using electricity (including non-grid electricity) increased from 58% in 1996 to 70% in 2001 (SANEA 2003). The main problems are that poorer households cannot afford enough electricity to render connection economic, and cannot afford to pay for electrical appliances. Davidson et al (2003) argue that the existing system of electricity financing and implementation, while successful in meeting RDP targets, is not sustainable. Lack of access makes fighting poverty and promoting greater inclusivity in growth difficult as it hampers individual efforts to advance social and economic development goals.
- The economy exhibits high carbon-intensity due to the energy-intensive economy and heavy use of coal. Plentiful supplies of inexpensive coal have supported the development of large-scale coal-fired power stations. Emissions per unit of economic output are high because the specific energy efficiencies of many sectors are lower than average, making emissions control a viable option.

- Energy efficiency standards are generally lacking. Even given benefits of energy efficiency, most of the standards have not been implemented because of low-cost energy supply in coal, lack of public awareness, the unaffordability of appliances, and the inadequate long-term policies and absence of codes and standards.
- Energy pricing, particularly electricity pricing, deserves more attention. Electricity is generated from coal of low quality, and its price does not account for the environmental externality of this resource. The full cost of producing electricity is higher than that borne by Eskom, and the external costs are borne by society. However, low prices benefit the poor, give South Africa a comparative advantage, are an incentive for energy-intensive mainly exports oriented industries, and provide a subsidy to foreign markets. But the low price of coal has not promoted incentives for investments in both energy efficient technologies and renewable energy.
- Another major contributor to air pollution is the country's four refineries. These contribute to high levels of pollution and emit high levels of sulphur dioxide and other harmful chemicals that cause health problems. There are no legally binding air pollution regulations, but only non-binding guidelines with no enforcement authority.
- Energy governance should be improved by clarifying the roles of various government institutions, and making them accountable, transparent, and representative of the population – particularly of the previously disadvantaged groups. Economic and social losses from poor energy sector governance manifest themselves in/through: misdirection of growth (through subsidies) and losses of growth; continued economic, social and gender inequalities; negative environmental impacts and high direct consumption subsidies.
- Maintaining security of supply through diversity. There is still a challenge for an integrated planning for future supply options. While coal remains an important energy source, the following activities also deserve serious consideration: introducing other primary energy carriers; encouraging research and development partnerships; and facilitating regional co-operation on energy
- Managing the energy-related environmental and health effects by promoting access to cleaner energy so as to minimise the negative health effects arising from the use of certain types of fuels.
- Macroeconomic stability is a prerequisite for sustainable growth. Sustainable development can not be expected when the economy is exposed to macroeconomic shocks stemming from energy price increases and supply disruptions. Fortunately, this has not happened to South Africa. While it may be argued that subsidies promote economic activity in rural areas, subsidies are often poorly targeted and usually benefit a small segment of the population.

6.3 Outlook: how is this expected to change in the future?

The government is expected to continue to pursue the critical issues in the previous section, and to address the issue of externality associated with the energy supply and use. As the economy develops, energy supply and use should not only be sustainable but should also lead to the standard of living rising for all South Africans. With increasing commercialisation and competitiveness, more attention has to be given to internalising the adverse impacts of energy usage as well as how energy can better serve development, continue to promote growth through exports and investments, and create jobs.

6.3.1 Some issues on energy demand

The Energy White Paper (1998) commits the government to improve the plight of the low-income and rural populations by addressing issues of inadequate energy services and less convenient and less healthy fuels. Success of this drive will depend on the responses such as pricing and financing on affordability, appropriate appliance/fuel combinations, availability of efficient appliances. Potential benefits can, for example, be illustrated by the retrofit housing project in Kuyasa, Cape Town. This project entails installation of solar water heaters, ceiling and ceiling insulation, and compact fluorescent light bulbs in existing RDP houses. Expected

benefits are in terms of reduction in CO₂ emissions, contributing toward health and energy cost benefits and savings in the cost of energy services of approximately R685 and R626, respectively, per household per annum. Building thermally efficient low-cost housing can therefore be expected to promote energy efficiency and conservation.

Greater energy efficiency will also yield potential financial and environmental benefits to industry, commerce and mining sectors, with industry becoming more internationally competitive. Although cheap energy results in foreign exchange earnings, the harmful environmental and health factors are not included in energy pricing, thereby raising need to balance energy pricing with sustainable environmental standards. South Africa's relatively high energy intensity has negative effects on the environment because of combustion of more coal and the greenhouse gases burden. Sanea (2003) estimates that greater energy efficiency could save between 10% and 20% of current consumption. This, in turn, would lead to an increase of between 1.5% and 3% in the GDP. But to achieve this, a solution has to be sought to critical barriers to the uptake of such technologies such as inappropriate economic signals, lack of awareness, and the high capital costs.

6.3.2 Restructuring and energy diversification

The electricity industry is to be restructured into independent regional distributors, and Eskom restructured into separate generation and transmission companies. Expected policy goals are to promote universal household access to electricity and to move the industry towards competitive electricity. The coal industry, on the other hand, will remain deregulated, with coal remaining a dominant energy source and least expensive option in the planning horizon. Pursuing clean coal technologies thus become important. The restructuring of electricity generation is likely to result in some of Eskom's power stations being sold, as well as in allowing independent power producers to enter the generation market. The current price of electricity, however, is too low and is a deterrent in attracting new competitors to the market. Proper regulation is therefore important

Regardless of coal's dominance, it is important to diversify energy resources to other energy forms such as natural gas and renewable energies. This will be in line with the policy objectives of improving both supply security and environmental performance. Power stations in future will depend on the following energy sources: coal, nuclear, gas and hydro-power. Nuclear energy as a viable future source of electricity generation depends much on the environmental and economic merits of other energy sources, and is likely to come from the next generation of simpler and safer reactors. The main concern with gas is its price, given the limited reserves in the country. Importation of gas from other countries is therefore a strong possibility. South Africa's limited potential for hydropower implies that there will be some reliance on the imported hydropower. Liquid fuels are to be met with minimum government intervention and regulation, with emphasis on environmental and safety standards, investment and promotion of black economic empowerment.

6.3.3 Realising potential benefits of energy efficiency

Low energy costs have not induced industry and households to adopt energy efficiency measures and the growing GHG emissions are a source of growing concern about promoting energy efficiency standards. Demand-side management can be used to limit residential demand growth or mitigate the impacts through the provision of incentives for industry/commerce to move load out of the peak periods. Benefits of this include avoiding high price increases through the deferment or avoidance of certain generation capacity construction.

The residential electrification programme, with a final target of five million additional connections by 2007, raises various issues of public policy interest. Electrification connection of poor households (where coal, wood, kerosene and LPG were the primary household energy sources), promotes the use of a clean, versatile and convenient form of energy that connects them to the modern economy. This raises the proportion of energy sales, leading to a rise in peak demand, with the residential sector contributing more than 30% because of the peaky nature of the load (Africa 2003), and implies that Eskom has to construct a new plant to meet this load type. For the residential sector, necessary interventions to defer building a new plant

and to achieve energy efficiency include energy efficiency lighting, thermal insulation, energy management and energy saving appliances.

There is substantial scope for energy savings for the commercial and industrial sectors. For the commercial sector the opportunity is through better design of buildings and improved management of energy use. A relatively high potential for energy savings exists in the industrial sector, with focal areas being as follows: energy management and good housekeeping, providing incentives to adopt specific technologies, conducting energy assessments to identify areas for energy savings, and implementation or adoption of standards for electrical equipment. The main challenge rests with the adoption and promotion of economically efficient energy measures. This, in turn, would guarantee achievement of market transformation and demand-side management sustainability.

6.3 Emerging gaps: challenges

Challenges facing the energy sector and crucial to economic development are as follows:

- Dealing with the problem of negative externalities associated with energy production and consumption. South Africa relies on low-grade coals for generating electricity, and the poor communities depend on inefficient sources of energy. Use of low quality coals is the main contributor of GHG emission. The energy-intensive sectors of the economy emit carbon emissions that are higher than those of most developed economies. Eskom is thus vulnerable to impacts of international response measures that may be taken to reduce GHG emissions (Davidson et al 2002), for which South Africa has no commitments. The biggest problem is that poor communities use inefficient energy sources that contribute to high levels of indoor air pollution with negative health effects.
- Adoption and promotion of energy efficient measures. While such measures are being pursued in the residential sector, there is also a high potential for energy savings in the industrial and commercial sectors.
- Achieving social equity and economic efficiency within the context of sustainable development within the energy sector. The White Paper on Energy (1998) focuses on the security of supply through diversity, increasing access to affordable energy, managing the energy related environmental impacts and improving energy governance.
- Choosing an appropriate policy instruments to minimise the negative impact of externalities. Such an instrument should incentivise carbon intensity reduction, encourage investment in energy saving measures and generate revenue for the economy. A most effective way is to encourage adoption of improved technologies, which may be much more efficient and more economically accessible than technology switching, and to improve society's well-being.

While linkages between these challenges may seem clear, all endeavouring to contribute to economic development and to improve social well-being, there are sharp conflicts over the understanding of sustainable development and its implications for policy. If, for example, economic efficiency is the prime objective, then energy subsidisation to help poverty alleviation will receive limited attention. This, on the other hand, would limit the role of energy as an essential precursor to both social and economic development and redress challenges, especially given the social and economic inequities that exist. It is reasonable that 'trade-offs' should take into account the need to improve social equity by addressing the energy requirements of the poor; and promoting both efficiency and competitiveness of the economy by providing low-cost and high-quality energy inputs (Eberhard & van Horne 1995). Obviously, the economy will not be able to develop without the abundant, easily mined and low-cost coal. When we include the environmental equation, then, apart from addressing short-term environmental problems, there has to be serious planning for a long-term transition towards renewable energy sources that have less negative externalities.

We are not aware of any comprehensive policy position on environmental taxes in South Africa. Data limitation, on the other hand, poses a serious problem for assessment of instruments. Lack of meaningful data limits effective decision-making on the location of subsidies, the number of

qualifying households, and assessing the cost and impact of the subsidies to the economy. Furthermore, there is no established network for the delivery of information on the consequences of industrial pollution and available technological options, nor are there awareness programmes for industrial managers on the consequences of pollution.

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7. Energy and the environment

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7.1 Analysis of the current situation

7.1.1 Broad overview

South Africa has recently placed itself firmly on the environmental world map with the hosting of the World Summit on Sustainable Development (WSSD) in Johannesburg in August/September 2002, whose primary outcome was a global Plan of Implementation. The summit also helped to put sustainable development as a focal point on the international agenda, and encouraged world leaders to recommit themselves to sustainable development goals (Bigg 2003).

Local environmental energy issues in South Africa relate largely to the household, bulk energy supply, and transport sectors. For households, the primary concern is indoor air pollution and health implications associated with burning coal and woodfuel. In the bulk energy supply sector, the long-term feasibility of the resource base is the main concern (Spalding-Fecher et al. 2000). Environmental concerns in the transport sector are largely related to the emissions of noxious gases.

South Africa is party to a number of international conventions and protocols, a few of which are particularly relevant to the sustainable use of our energy environment. The United Nations Framework Convention on Climate Change (UNFCCC), ratified by the South African government in 1997, addresses the climate change threat, advocating governments to reduce and control their sources of GHG emissions (primarily related to the burning of fossil fuels). Linked to this is the Kyoto Protocol. South Africa has also ratified (in 1990) the Montreal Protocol on substances that deplete the ozone layer, designed to restrict the use of chlorofluorocarbons and halons.

Energy demand in South Africa is dominated by coal, liquid fuels and electricity (see Chapter 3). With these different energies come various environmental advantages and disadvantages which need to be weighed in the context of economic growth and development. Between 1990 and 1997, the proportion of the population with electricity access increased from 35% to 63%. The government initiative to increase electrification was largely socially driven, but environmental considerations also played a part, through a focus on the provision of cleaner and safer energy to low-income households (EDRC 2003). Today South Africa is the biggest producer and consumer of electricity in Africa.

7.1.2 Legislation and policy

Some of the environmental impacts of energy in South Africa are governed by legislation. Important acts in this regard are the National Environmental Management Act (NEMA) (No. 107 of 1998), and the Atmospheric Pollution Prevention Act (No. 45 of 1965). NEMA should be seen as a framework for integrating good environmental management practice into government activities (DEAT 1998). Some of the principles of NEMA have been open to interpretation and hence obligations are hard to determine unambiguously, but some have implications in terms of the energy sector, especially with respect to renewable energy and energy efficiency. Provinces, and to an extent national government, have been required to prepare environmental implementation plans or management plans (EDRC 2003). The Atmospheric Pollution Prevention Act is managed by the Department of Environmental Affairs and Tourism (DEAT) and is responsible for the control of noxious gases, smoke, dust, vehicle emissions etc. Noxious or offensive gases are controlled by the granting of registration certificates to seventy-two listed processes, which include power generation processes and gas, charcoal and coke processes (DEAT 1965). This act, being promulgated in 1965, does not focus on contemporary issues (such as energy efficiency and renewable energy), so that government has recognised the importance of modernising legislation to control air quality, as provided by

the new National Environmental Management Air Quality Bill, currently in draft format (DEAT 2003).

Two policies guide the government's environmental management framework, the White Paper on an Environmental Management Policy for South Africa (1997), and the White Paper on Integrated Pollution and Waste Management (2000). The former is a policy based on sustainable development (as required by the Constitution), and shows a movement towards international trends. The latter's primary aim is to develop an integrated pollution and waste management system which takes account of sustainable social and economic development with respect to air, water and land resources protection (EDRC 2003).

7.2 Critical local issues relating to energy for sustainable development

7.2.1 Petroleum

Environmental issues related to petroleum pertain to production, refining, distribution, storage and use. All four of these aspects are pertinent to the South African situation. Different initiatives to ensure environmental conformity have been undertaken by stakeholders in the country, including the formation of the South African Oil Industry Environmental Committee (OIEC) more than 20 years ago. The OIEC was formed with the task of managing potential environmental impacts that may arise from the four areas mentioned, and issues to be addressed have included the following (SAPIA, 2002):

- oil spills at sea during importation;
- air and water emissions and waste management at refineries;
- spillage of product during transport to depots;
- leaks from underground storage;
- inappropriate disposal of used petroleum products.

7.2.1.1 Upstream petroleum activities

The relatively active oil exploration, development and production in the South African marine environment creates a need to evaluate the environmental effects of these activities. Measures have to be set up to ensure that from time to time environmental monitoring is undertaken, sampling techniques that will present a picture of the changing contaminant profiles are set up, and reliable measurements of pollutant concentration levels are provided. Samples need to be drawn from areas suspected of having, or expected to have, elevated levels of contaminants, and compared with areas that are expected to have no contamination. Major issues to be addressed may include seismic noises, levels of hydrocarbons and metals in the water, impacts on breeding habitats, movement of species, and economic impacts and costs. The potential effects of offshore petroleum activities have to be monitored in the context of the marine environment and other areas of indirect impacts. Social aspects would include effects on people living in coastal communities.

Decommissioning of offshore production facilities also calls for appropriate planning to avoid environmental and safety problems. Options should be considered well in advance for the removal and disposal of redundant facilities, and the government needs to have a clear regulatory framework on decommissioning of the facilities, even though the responsibility of removing the facilities lies with the companies concerned. Depending on circumstances, decommissioning may be complete removal, partial removal or alternative use.

Refining of petroleum is another area raising environmental issues, including emissions, spills, discharges and sludge handling. Currently South Africa has four crude oil refineries, located in Durban, Cape Town and Sasolburg. Two additional refineries produce liquid fuel from gas and are located in Mossel Bay and Secunda. Some of the gaps in refinery-related environmental aspects in the past have been, for example, a lack of nationally regulated ambient air quality standards. The general feeling is that while the Atmospheric Pollution Prevention Act (1965) sets out guidelines and some standards on air quality, this is on a rather arbitrary basis and with

specific given objectives, like community health issues. To address such gaps in the refinery sector, oil companies in South Africa, through the Refinery Managers' Environmental Forum, have taken the initiative to tackle some of these issues. It has been reported that the Forum is in the process of drawing up and entering into an Environmental Management Cooperation Agreement with the government (SAPIA 2003).

Some of the areas covered in the atmospheric prevention Act of 1965 include guidelines and standards for sulphur dioxide emission levels for refinery plants, average sulphur content in fuels used by refineries, efficiency standards for sulphur recovery units, particulate emissions and control of oxides of nitrogen (NO_x). The guidelines also cover, among others, issues of incineration, odours, spills and fugitive emissions.

7.2.1.2 Oil spills

Environmental safety is an important issue for oil drilling and transportation. During offshore drilling, uncontrolled oil spillage into the ocean is a potential hazard. Within the vicinity of our ports (e.g. Saldanha Bay) oil spills may result from the damaging or loss of a shipping vessel at sea, navigation into the port, or transfer of oil from oil tankers (CSIR 1997). Most oil spills are of the latter type, generally being small (mostly less than seven tonnes) and are part of routine oil transfer operations. Larger oil spills pose a particular threat to the physical and socio-economic environments in the vicinity of the spill, through damage to beaches, mariculture, sea birds etc. A recent oil spill off the Western Cape coast was that from the *Treasure* in 2000, which will be particularly remembered for its affect on the African penguin colonies, and the resultant volunteer-driven effort to clean oil off thousands of penguins.

There are two international compensation mechanisms which cover damage and recovery costs associated with a marine oil spill:

- the International Convention on Civil Liability for Oil Pollution (1969), which makes provision for compensation from damages associated with oil spills; and
- the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (1971), which subsidises the International Convention on Civil Liability for Oil Pollution on the basis that there has been compliance with the convention.

Within South Africa, the oil industry has equipment such as booms and skimmers lodged in Cape Town, Mossel Bay, Port Elizabeth, East London, Durban and Richard's Bay to respond to oil spills in the marine environment. Land-based oil spills are dealt with via forty-two trailers (which clean up road and rail tanker accidents) along major transport routes (World Energy Council 2003).

7.2.2 Transport pollution

The transport sector has a notable effect on the environment, primarily due to brown haze (especially in Cape Town and Pretoria), with road transport being the main emissions source. The sector also contributes to global warming through GHG emissions, and emissions of sulphur dioxide, carbon dioxide, nitrous oxides, carbon monoxide, suspended particulate matter and volatile organic carbons and their associated toxicity or carcinogenic effects all contribute to deteriorating air quality (Xhali 2002). Transport oriented to private cars contributes to this pollution, as do the high emissions from the extensive bus and taxi commuter networks (Xhali 2002). Some of the typical transport-related environmental problems are summarised in Table 1.

As a result of the brown haze in the Cape Metropolitan Region, the City of Cape Town has initiated a Brown Haze Action Plan in an attempt to improve the situation (CCT n.d.). There are also government initiatives that will help curb brown haze by phasing out lead in petrol and reducing sulphur in diesel. The Cabinet has, in fact, approved a phasing out of leaded petrol and a sulphur reduction to 0.05% in diesel by 2006 (World Energy Council 2003). Xhali (2002) suggests the use of alternative fuels such as natural gas and electricity in addition to petrol- and diesel-burning vehicles for public road transport in the longer term.

Table 7.1: Transport-related environmental problems

Source: Davidson (1993)

Scope	Environmental issue	Impacts
Global	Global warming (GHG emissions)	Impacts on: - ecosystems - hydrology and water - food and fibre production - coastal systems - human health
Regional	Air pollution (emissions of NO _x etc.) Marine pollution (emissions of NO _x , SO _x etc.)	May affect nearby nations Run-off to water resource
National	Air pollution (emissions of CO, HCs, NO _x , SO ₂ , SPM etc) Water pollution Land disturbance Solid waste Noise and vibrations Accidents Socio-cultural	Health Surface and groundwater runoff Land destruction and waste disposal Waste disposal from vehicles and machinery Acoustic pollution and vibration effects Injury and death from damage to property transporting waste Social and cultural disturbance

7.2.3 Impacts of kerosene as a fuel

Kerosene is a primary energy source used to meet the cooking, lighting and heating needs of some six million households. It is also one of the main causes of death and injury in the 0-4 age group in South Africa (Pasasa n.d.), with children often subject to kerosene burns and poisoning. Since informal housing is often high in density, a kerosene-related fire in one unit may spread easily, multiplying the consequences. Residential fires accounted for 75% of the deaths of children between 1990 and 1996 recorded at the Salt River State Mortuary in Cape Town (van Horen 1994). Ingestion by children frequently leads to hospitalisation and/or death. Kerosene is also emerging as a health problem as a result of indoor air pollution, causing respiratory-related diseases, especially in poorly ventilated government-subsidised houses or informal settlements (Sparks *et al.* 2002). Carbon monoxide emissions are a major concern. A non-electric fuel which has emerged as a good alternative to kerosene is LPG, with health and safety risks an order of magnitude lower than for either kerosene or coal (Lloyd & Rukarto 2001). Presently costs of the fuel and appliances are the main hindrances preventing widespread use of LPG. A government directive promoting LPG use could help stimulate mass production to reduce appliance costs and a reduction the fiscal burden could help with on-the-ground fuel costs (Lloyd and Rukarto 2001).

7.2.4 Coal production and use

7.2.4.1 Water consumption from coal-based electricity production

There are three primary concerns about water use by power stations: degradation of the quality of the water of associated water sources (e.g. coal mining could affect ground water in coal fields), the amount of water required by power stations, and the price paid by Eskom for water and whether this reflects the actual opportunity cost of water. Eskom has, in fact, paid for water infrastructure construction in a number of cases, rather than the Department of Water Affairs and Forestry, as one would expect, and hence the cost calculations are somewhat complex (Spalding-Fecher & Matibe 2000).

Water consumption will also depend on various factors such as the age of the power plant (water-cooled plants, a newer variety, improve efficiency), weather conditions (evapotranspiration losses are greater under hot and windy conditions), and water quality (wet-cooled power stations require more water if their water is of a poorer quality) (Eberhard 2000). A large proportion of the generation of coal-fired power is provided by water from three river systems.

With the push towards a change in water pricing (DWAF 1998) it is likely that the costs of water supply to power stations will increase over the coming years. However, based on modelling done by Eberhard (2000), it is unlikely that this will significantly affect the cost of electricity. However, sustainable use of water resources should nonetheless be encouraged.

7.2.4.2 Air pollution and health

Coal combustion is an important contributor to air pollution (van Horen 1994). Electricity generation is the major contributor to outdoor air pollution. The majority of the coal production for electricity generation is confined to Mpumalanga, with about 90% of the scheduled emissions of dust, nitrous oxide and sulphur dioxide being accounted for by eastern Mpumalanga (Held et al. 1996). Climatological conditions in this region are unfavourable for low-level dispersion because of stable atmospheric conditions (Preston-Whyte & Tyson 1993).

Coal used in South Africa is of a poor quality, as most higher-grade coal is exported, and its energy content (and hence economic value) is low (van Horen 1996a, 1996b). Eskom has therefore invested in particulate matter control rather than reduction of sulphur dioxide and nitrous oxide emissions (Sparks et al. 2002). Bag filters or electrostatic precipitators have been fitted to coal-fired power stations in the Mpumalanga region, removing the smaller remaining particles (van Horen 1994). Precipitator performance is being improved further by installing flue gas conditioning plants at some power stations (Eskom, 2003). Between 1994 and 1998 particulate emissions reduced by approximately 50%, while power increased by almost 10% (Eskom 2003). Figure 7.1 shows ash emitted per kWh of power, and displays a marked decrease between 1992 and 2001. In addition, chimney stacks (up to 220m) have been fitted in areas where low-level dispersal conditions are unfavourable, and have proved to be a beneficial means of penetrating the lower inversion layer (van Horen 1994). Data show that air pollution has reduced over the last 20 years due to these and other measures. Work subsequent to van Horen (1994) has shown that, in fact, low-level sources (burning waste dumps and domestic coal use) are one of the major sources of air pollution (Held et al. 1996). Environmentally, the mining process itself has had important consequences, since land which has been mined needs to be rehabilitated afterwards, and miners are also exposed to occupational health hazards associated with coal dust (van Horen 1996a).

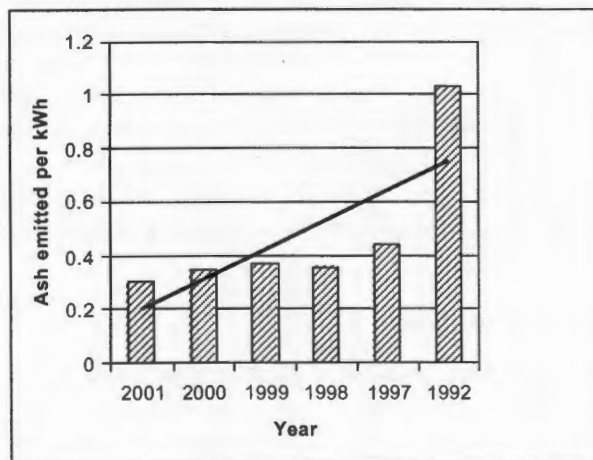


Figure 7.1: Ash emitted per kWh of power (data provided by Eskom)

In rural areas, where approximately 40% of the South African population live, wood and coal are often used to meet household energy needs, particularly of the poor, so that people in these regions are particularly exposed to indoor air pollution. Non-electrified fuel sources are an important source of fuel, since these communities are either not yet grid-electrified or continue to opt for coal despite being electrified. A coal stove, for example, can provide for cooking, space heating and water heating (Williams 1994), and also form a core social focal point. To provide equivalent supply options using electricity would require considerable expense and at least three appliances – a stove, a heater and a geyser.

Indoor air pollution increases the risks of chronic obstructive pulmonary disease in adults (primarily women) and acute respiratory infections in children, in some cases leading to death. It is also associated with certain cancers (domestic coal use may contribute to lung cancer, for example), infant mortality, low birth weight, cataracts and tuberculosis (Sparks et al. 2003).

Bearing the above in mind, from a sustainability perspective it may be useful in the longer term to consider renewable energy sources in addition to coal (Sparks et al. 2002). Households should also be encouraged, or provided with incentives or opportunities, to move away from using coal to meet their space heating and cooking needs, especially considering the health problems and costs associated with this fuel. At the very least and in the context of affordability, there needs to be better ventilation in coal-burning households.

7.2.5 Natural gas-based power generation

South Africa has two gas-fired power stations, with a total maximum capacity of 171MW; it is expected that more gas-fired power stations will follow after the completion of investments by Sasol in large natural gas fields in Namibia and Mozambique, as well as the development of recent natural gas finds off the coast of South Africa. Sasol is fully involved in the ownership of a gas field in Mozambique and is presently building a pipeline to South Africa, following the signing of an agreement between the governments of the two countries. Shell International is also investigating building a gas pipeline from Namibia to Cape Town, to bring gas from the offshore Kudu fields to a potential gas-fired power station in Cape Town.

While natural gas is considered to be a better fuel alternative to coal or liquid fuels used for electricity generation, its production, processing and transportation by pipeline can also be a major contributor to GHGs in terms of fugitive emissions. However, efficiency measures through good housekeeping and prevention of leaks could lead to emissions being cut to reasonable and acceptable levels.

Opting for combined cycle power plants as opposed to simple cycle gas turbines would also contribute to reducing GHG emissions. This is in effect due to relatively high efficiencies of combined cycle plants (of the order of 52%), compared to 30%-35% for the simple cycle. In addition, combined cycle power plants have the advantage of short installation time and very low emission levels of NO_x. The exhaust gases consist of typically 3-3.5% CO₂ (by volume), corresponding to emission level of approximately 0.4kg CO₂/kWh.

7.2.6 Nuclear energy potential impacts

Koeberg, the only source of nuclear power in South Africa, generates 60 tonnes of high-level radioactive waste annually in the form of spent fuel. 90% of the radioactivity is lost through ten years of underwater storage in spent pools (World Energy Council 2003), but the remaining 10% needs to be stored safely and in such a manner that there is not seepage into groundwater or human exposure to the risks of radiation. In its favour, nuclear power results in no air pollution, but the disposal of hazardous waste and other aspects of nuclear plant safety have been much-debated environmental concerns for some time.

The Pebble Bed Modular Reactor (PBMR), a new type of nuclear power unit, is now being investigated by Eskom Enterprises and will in all likelihood be built at Koeberg. The PBMR technology also has the potential to be exported. An environmental impact assessment (EIA) was conducted on the PBMR and an approval Record of Decision was passed in 2003, but is being appealed by various environmental groups. In addition, one of the conditions of approval of the EIA was the completion of a Radioactive Waste Management Policy and Strategy by the Department of Minerals and Energy. This was produced in draft form in July 2003 and is presently circulating for public comment (DME 2003).

The nuclear energy sector of the future needs to be able to exist without state support (which it received in the apartheid era), since low energy prices will help South Africa to continue in its drive as a competitive manufacturing exporter (Eberhard 1994). In terms of the future environmental sustainability of nuclear energy in South Africa, the economic costs of this energy power source will need to be weighed against environmental costs and benefits, such that a sustainable energy future is achieved.

7.2.7 Biomass fuel impacts

The most obvious biomass fuel source is trees, with other sources being crops (e.g. sugarcane), aquatic plants and organic waste (e.g. from waste dumps). Approximately 16 million South Africans rely on wood for space heating and cooking (van Horen 1996a; 1996b). While wood collection is often free, collection times may be lengthy (up to three hours per load, several times a week) due to sustainability of supply, making it burdensome on the households concerned (CSIR 2000). The indoor air pollution health impacts associated with wood as a fuel are of a similar nature to those associated with coal. There are also vegetation impacts linked to wood as a fuel source. In many areas denudation of indigenous vegetation is the result. However, in the Cape Flats of the Western Cape the situation differs, since much fuelwood is derived from alien vegetation, such as Port Jackson willow, so that collection of firewood may be an indirect advantage though assisting with the clearing of invasive aliens (Sparks et al. 2003).

Biogas and landfill gas, both derived from organic waste, are two potential sources of energy for space heating and lighting. Biogas requires a reliable and appropriate supply of animal and plant material, while landfill gas is generally obtained from landfill sites. General application of either of these gases is therefore limited. However, there are two notable landfill gas sites: the Grahamstown landfill project, which supplies a nearby brick kiln, and the Johannesburg landfills, which provide methane to the chemical industry (CSIR 2000). Landfill gas is produced as a matter of course in landfills through the decomposition of organic matter. However, it can be an environmental hazard, since it may explode if incorrectly managed, so that sealed landfill compartments and extraction wells need to be created (CSIR 2000).

A 1985 study by Williams considered the potential for biomass energy from crops, since the agricultural sector is capable of converting agricultural land to such uses. However, crops as an energy source have generally not taken off, perhaps at least partly because of food crops' competing claims for scarce land and water resources.

Biomass is an important renewable energy source, but sustainability of production is a key factor here, particularly as South Africa is a water-stressed country (EDRC 2003). In order to be viable, biomass as a fuel source needs to be investigated in more detail.

7.2.8 Renewable energy and environmental issues

7.2.8.1 Wind

While the use of wind turbines for the production of electricity is expanding rapidly throughout the world, studies have expressed three main environmental concerns related to this technology – sight pollution, bird strikes and turbine noise. Some of these studies relate to perceptions rather than realities, and therefore it is important that studies be conducted to determine the potential of the effects in a particular locality before making any conclusive decisions. While, for example, there has been concern about bird strikes from wind turbines, studies have indicated that migratory birds can fly in large numbers in close proximity to turbines without any mortalities, and that bird collisions with wind turbines are rare events (Toronto Hydro n.d.). Noise has also been cited as an environmental problem associated with wind turbines, although, at a 350m distance, a car going at 64km/hr emits more noise (55dB) than a wind turbine (35-45dB) and a heavy duty truck emits noise of 65dB level.

7.2.8.2 Solar

While production of solar panels can be highly toxic and result in a substantial amount of GHG emission, use of SHSs does not produce any emissions or waste products that can adversely affect the environment. However, disposal of SHSs at the end of their lifetime can pose health, safety and environmental problems if not addressed appropriately. This is especially so in cases of extensive deployment of the systems, such as in South African rural areas, where people are not well informed about some of the hazards of improper handling of the discarded components. Concerns associated with SHS components relate to disposal of light fixtures, batteries and the solar panels. Some of the associated aspects of these components, which are largely a product disposal rather than use concern, are listed in Table 7.2.

Table 7.2: Environmental concerns linked to SHS components

<i>SHS component</i>	<i>Environmental concern</i>	<i>Problems associated with the concern</i>
Light fixtures	Mercury in florescent lamps, broken glass	Mercury contents in the lamps, injury due to broken lamps
Lead-acid batteries	Sulphuric acid (H ₂ SO ₄) in batteries, pure lead, and other heavy metals	Water, food contamination by heavy metals
Solar panels	Crystalline or amorphous silicon	Heavy metals, injury

Light fixtures

Fluorescent lamps are the most common light facilities in SHS because they are more energy-efficient than incandescent lamps. Their biggest disadvantage, however, is that they contain mercury, a highly persistent and toxic chemical that can build up to dangerous concentrations in fish, wildlife, and human beings. Mercury is essential to the operation of fluorescent lamps. The mercury vapour inside a fluorescent lamp is electrically energised to emit ultra-violet (UV) light. Phosphor, a luminescent material that coats the inside of fluorescent lamps, absorbs this UV energy, which causes it to fluoresce, re-emitting visible light. Inhaling mercury vapours or indirect ingestion can be toxic to the nervous system. Even very low mercury doses can significantly affect the brain and spinal cord, particularly the developing nervous system of a foetus or young child. Depending on the level of mercury in the mother, it can have varying effects on foetal development and health, including visible physical deformity, and affecting the intellect and many other nervous system functions of the child. Adults who have been exposed to too much mercury might begin to experience trembling hands and numbness or tingling in their lips, tongues, fingers or toes. These effects can begin long after the exposure occurred. At higher exposures, walking could be affected, as well as vision, speech and hearing (MPCA 1998). It is therefore important for standards to be set on the mercury content of fluorescent lights. While measures for disposal of spent lamps might be difficult to administer, a special case could be made for rural areas electrified with SHS by offering an incentive when a spent fluorescent lamp is delivered for recycling. Education on disposal is important.

Batteries

Heavy metals in batteries used for recharging SHSs are the major concern. Such batteries last for an average of three years. In a community with very many SHSs, disposal of batteries at the end of their lifetime can be a serious problem. Major material constituents in lead-acid batteries include lead, lead oxide, lead sulphate, water, sulphuric acid and some traces of antimony and arsenic. To prevent some material components contaminating the food chain, it is important that attention be given to educating rural communities in appropriate handling of scrapped batteries. Service providers can take the responsibility with respect to the disposal of the batteries.

Solar panels

Studies have been done to assess the risks associated with solar panels, for example in case of fire or broken modules. It has been accepted generally that such risks are negligible or small, but it is suggested, however, that long term risks should not be ignored (Alsema et al. 2003). While certain panel materials might aggravate environmental concerns if exposed, their glass encapsulation reduces the chances of their leaching out of the cell. Double glass encapsulation helps significantly to prevent this. Amorphous silicon panels, however, are known to have little or no toxic materials and thus pose no significant health concerns in their disposal, apart from those associated with disposal of glass material.

There is currently very limited recycling of solar panels. Conventional glass recycling can be applied for glass panels. Consideration or standards should therefore be given in the choice of materials for module encapsulation for panels to be used in South Africa.

7.2.8.3 Hydropower environmental aspects

Being relatively dry, South Africa does not have much to offer in terms of hydropower generation. There are currently six hydro schemes in South Africa, most of which are operated

by Eskom (see Table 7.3). It is generally considered that large hydros are an environmental concern. While this is unlikely to be a problem in South Africa, the country has a unique biodiversity endowment and ecological sensitivity that necessitates stringent environmental measures even in the case of small hydro projects. The low number of fresh water sources in the country is another source of concern with respect to sustainable development compliance in the use of rivers for hydro-electricity generation in the country.

Table 3: Hydro-electricity in South Africa

<i>Station</i>	<i>Maximum capacity (MW)</i>	<i>Location</i>
Gariep	360	Orange River
Vanderkloof	240	Orange River
Colly Wobbles	42	Mbashe River
Second Falls	11	Umtata River
First Falls	6	Umtata River
Friedenheim	3	
Lydenburg	2	Ncora River
Ncora	2	Ncora River
Piet Retief	1	
Ceres	1	
Total hydro capacity	668	

South Africa has two pumped storage electricity generation schemes, pumping water to an elevated dam from which it can be released to generate electricity when needed. One advantage attributed to such schemes is the fact that they reuse water. However, even for what might be seen as a low environmental profile pumped storage electricity generation scheme, construction of the Palmiet station was subjected to acute environmental scrutiny because of the ecological and biodiversity sensitivity of the project location. Whether large or small, implementation of hydro projects in South Africa will necessitate careful consideration of both environmental and social impacts.

7.3 Critical global issues relating to energy for sustainable development

7.3.1 Greenhouse gas emissions and climate change

The highly energy-intensive South African economy makes the country one of the highest emitters of GHGs in Africa, and it stands above the OECD region average in energy sector emissions. It was ranked as the fourteenth-highest CO₂ emitter from fuel combustion in 2000, and was the nineteenth most carbon-intensive economy, measuring kgCO₂ / 95\$ PPP (IEA 2002). South African per capita emissions are higher than those of many European countries, and more than three-and-a-half times the average for developing countries (see Table 7.4).

Table 7.4: Fuel combustion carbon dioxide emissions intensity and per capita, 2000

Source: IEA (2002)

	<i>CO₂/cap (tonnes/capita)</i>	<i>CO₂/GDP (kg/1995 US\$)</i>	<i>CO₂/GDP PPP (kg/1995 PPP\$)</i>
South Africa	6.91	1.73	0.79
Africa	0.86	1.16	0.43
Non-OECD	2.24	1.73	0.64
OECD	11.10	0.45	0.51
World	3.89	0.69	0.56

Key: PPP = purchasing power parity, GDP = Gross domestic product

Reliance on coal energy sources is the main reason behind this emissions profile. Coal-related sources of GHGs in South Africa include electricity generation and production of synthetic liquid fuels. Plentiful supplies of inexpensive coal have provided a basis for large-scale coal-fired power stations and heavy reliance on coal within the power sector. The high emissions profile in industry stems from energy-intensive activity areas such as iron and steel, aluminium, ferrochrome and chemicals – the same sectors that make up a large share of South African exports. Other major emission sources include oil refining, coal mining and gas extraction, wood burning and the burning of coal and oil to produce heat. A summary of South Africa's total emissions in 1994 for major GHGs indicates is shown in Table 7.5.

Table 7.5: Sector emissions, 1990 and 1994

Source: RSA (2000)

Category	Mt CO ₂ Equivalent							
	CO ₂		CH ₄		N ₂ O		Aggregated	
	1990	1994	1990	1994	1990	1994	1990	1994
Energy	252.02	287.85	7.29	7.89	1.58	1.82	260.89	297.56
Industrial process	28.91	28.11	69.0	26.0	1.81	2.25	30.79	30.39
Agriculture			21.30	19.69	19.17	15.78	40.47	35.46
Waste			14.46	15.61	0.74	0.83	15.19	16.43
Total	280.93	315.96	112.05	69.19	23.3	20.68	347.35	379.84

Because the specific energy efficiency of many sectors is also lower than average (see Chapter 2), emissions per unit of economic output are high – 45% higher than developing countries and 70% higher than the industrialised OECD (IEA 2001). Table 7.5 shows that the energy sector contributed about 78% of South Africa's total GHG emissions in 1994 and more than 90% of CO₂ emissions.

The government has been supportive of regional and global initiatives to reduce GHGs and other air pollutants. South Africa ratified the UNFCCC in 1997, thereby taking the obligation to prepare a national GHG emission inventory by 2000. By the first quarter of 2004 the latest published estimate of South Africa's total GHG emissions is for 1994.

In 1998 the government developed a climate change policy discussion document and circulated a national response strategy for public comment. In 2002 South Africa ratified the Kyoto Protocol. In 2000 the South African government has compiled the first Initial National Communication to UNFCCC, and after cabinet approval this was submitted to UNFCCC at COP-9 in 2003.

7.3.2 Other global energy-environment related agreements/protocols

South Africa as a nation is active in the environmental sphere, including its hosting of the WSSD in 2002 in Johannesburg. The government has also signed and ratified a number of conventions and treaties that address energy and environment conservation for sustainable development. Besides the UNFCCC and the Montreal Protocol, mentioned earlier, some of the other signed conventions that may be linked to sustainable development include the following:

- The Convention to Combat Desertification (Paris, 1994).
- The Convention relative to Preservation of Fauna and Flora in their Natural State (London, 1993).
- The Convention on Biological Diversity (1992).
- The Convention on the Prevention of Marine Pollution from Ships (1973).
- The Convention on International Trade of Endangered Species of Wild Fauna and Flora (1973).

- The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters (1972)
- The Convention Concerning the Protection of World Cultural and Natural Heritage (1972).
- The Convention on Wetlands of International Importance Especially as Waterfowl Habitat (1971).
- The African Convention on the Conservation of Nature and Natural Resources (1968).

7.4 Outlook for the future

7.4.1 Future environmental policy goals

Energy and economic development in the context of sustainable development requires a sound framework for environmental performance. The environmental policy framework can be set up on three major bases: voluntary, regulatory, and market-based.

Voluntary mechanisms

Voluntary mechanisms refer to non-obligatory agreements or aspects of corporate responsibilities that would push organisations to take measures on appropriate environmental performance. Such initiatives are usually on the basis of an understanding that the players will contribute positively to environmental conservation and avoid any form of degradation. Such initiatives are becoming more and more popular everywhere, and are often linked with social responsibility duties that companies or organisations feel they have towards communities. The government can play a pivotal role in terms of appeals and awareness-raising for communities in different sectors to become more active in environmental management. While voluntary initiatives are not binding in nature, they can be negotiated between government and relevant players.

Regulatory mechanisms

These are basically command-and-control measures, whereby the government can decide to set standards on issues such as emissions, discharges and noise. Regulatory mechanisms would require a legislative framework, thus making non-compliance a criminal offence. For such mechanisms to be successful, an effective and efficient enforcement base would be of critical significance. While such measures can be an effective way of environmental management, their administration is usually difficult and expensive, as they require institutions for monitoring, regulation and enforcement.

Market-based mechanisms

Market-based instruments work on the basis of instituting fiscal instruments (taxes and charges) whereby the polluter pays in monetary terms. The assumption is that the taxes and charges will prompt a behaviour change through market signals, with certain undertakings, lifestyles and acquisitions considered as very expensive. This mechanism is usually regarded as being the least-cost option for controlling environmental degradation, and its use has grown significantly in many countries. Such mechanisms are considered to help control the environment, act as a source of revenue to the government, and, depending on the government budget system, the revenue generated can be earmarked for specific environmental programmes.

It is important to note that of the three mechanisms mentioned above, no single mechanism can be said to be the best suitable. A combination of these three mechanisms – however proportioned – would be a reasonable approach. The government can decide to what level it can use one mechanism to address environmental performance based on prevailing national circumstances.

While it may be deemed necessary to have criteria or standards against which compliance can be measured, such initiative could only be a feed-back mechanism for further policy decisions which may involve shifting a particular aspect of mechanism from one category to the other. This would imply for example, that a voluntary mechanism aspect could evolve to a regulatory mechanism at some stage.

7.4.2 Future commitments on GHG reductions

Being a non-annex I country, South Africa does not have emission reduction targets in the first commitment period that runs from 2008-2012. However, with the high GHG emission profile among developing countries, the government in South Africa recognises that adequate measures have to be taken as the effort against escalating GHG emissions becomes more urgent.

Participation by South Africa like many other developing countries could take many forms, the extreme code being taking on quantified emission reduction targets. One approach that has been of considerable debate amongst developing countries has been one that focuses on implementing policies for sustainable development. This approach revolves on the premise developing countries like South Africa already have policies and measures that have been taken for technological, environmental or economic development, but result in GHG emission reduction or climate change mitigation. This approach, referred to as sustainable development policies and measures (SD-PAMs) would build on the right to sustainable development by non-annex I countries, as outlined in the UNFCCC. The SD-PAMs approach is built on the national development objectives and priorities, and streamlining these to meet sustainable development pillars of economic, environmental and social criteria. This is achieved either by putting in place more stringent policies or by implementing new measures that align the development path to follow a sustainable course (Winkler et al. 2002).

For South Africa, the SD-PAMs approach would therefore focus on development objectives of economic growth, job creation and access to key services, such as, to mention just a few, housing, water, transport and access to modern energy services. Such an approach would not only enhance reduction of GHG emissions, but would also acknowledge country's unique circumstances and development objectives.

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