Energy security in South Africa

FINAL REPORT

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by

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Executive summary

The world has changed much since the concept of energy security emerged in the 1970s and recent years have seen increasing attention being paid to the issue. Although the G8 group of countries in 2006 included reducing of energy poverty in its Action Plan for Global Energy Security, the issue of energy security for developing countries is rarely mentioned (GNESD, 2007)

The notion of energy security has evolved over the years and the new energy security paradigm focuses on concerns and fears around energy security that is fuelled mainly by the following:

- fossil fuel depletion (peak oil, etc);
- reliance on foreign sources of energy;
- geopolitics (such as supporting dictatorships, rising terrorism, "stability" of nations that supply energy);
- energy needs of poorer countries, and demands from advancing developing countries such as China and India;
- environmental issues, in particular climate change;
- world population growth.

South Africa is well endowed with natural resources, including coal, gold, diamonds, metals and minerals, with coal accounting for 75% of the fossil fuel demand and 91% of electricity generation. Electricity continues to play an important role in the economy with the industrial sector consuming the highest proportion followed by the residential and mining sectors. Coal is used in both the generation of electricity and the production of synthetic fuel (petrol, diesel, paraffin, LPG and other chemicals).

The main objectives of the study were to analyse, at both national and household levels:

- threats (present and future) to energy security;
- different strategies/measures undertaken by South Africa to improve energy security; and
- the impacts of the measures/strategies to improve energy security.

At the *national* level this study analysed the threats (present and future) to the three main energy supply sources, namely coal, electricity and liquid fuels, as well as cross-cutting issues (institutional/political, scarcity of water and climate change). Key indicators used to analyse the threats included the following:

1. Net energy import dependency: South Africa shows a reasonably low level of import dependency, which makes the country less vulnerable to disruptions in international energy supply and substantial increases in prices of imported energy.
2. Diversification of energy resources: shows an improvement over time.
3. Energy intensity: The South African economy is highly energy intensive compared to other developing countries.
4. Energy reserves: South Africa has good coal reserves, but will remain largely dependent on the import of oil and natural gas, because of limited reserves. South Africa has high levels of renewable energy potential, especially for solar and wind along the coastline.
5. Investments in new power plants/gas & oil exploration and renewable energy: Since 2005 Eskom has embarked on a new built programme, which includes the building of mainly new coal power plants and the refurbishing of old power plants. On completion this will double its current capacity to about 80 000 MW.
6. Net energy import as a % of GDP and energy import as a % of export earnings: Both vulnerability indices show a remarkable increase from 2002 to 2006. This poses a significant security threat to South Africa in terms of dependence on energy imports as well as increases in the costs of imported energy.

Other threats include the unreliable supply of coal to power stations is one of the causes of the current electricity crisis in South Africa. Another threat to energy security is the rising price of coal. From 2006 to 2007 it rose sharply from US$65 to $100 a tonne.

In the electricity supply industry the main threats to security of supply are inadequate generation capacity, limitations of the transmission system, poor maintenance, lack of skills and unreliable and inadequate supply of coal. Disjointed co-ordination between government departments and various spheres of government render greater energy security of supply futile. Water is a major input in the generation of electricity from coal-fired power stations and because the bulk of Eskom's electricity comes from these, a reliable and adequate supply of a scarce resource like water at a predictable price is of paramount importance to sustain security of electricity supply

At the *household* level the key threats to energy security are:

1. The rising cost of electricity as a result of Eskom's new build programme.
2. The price of paraffin is linked to the volatility of the international oil markets, which poses a threat to security of supply for the poor. The country has a good distribution network and paraffin is easily available in urban areas. On the other hand, the paraffin distribution chain is characterized by many resellers (middle persons) which make paraffin more expensive.
3. Poorer people pay a larger share of their income on energy.
4. The price of LPGas is unregulated and the country has a poor distribution network. This coupled with the high upfront cost for gas cylinders, make the use of LPGas less competitive.
5. Transport is another factor which affects the cost and availability of fuels as well as appliances. This impacts especially on rural households who have to travel significant distances to buy fuels like paraffin; or they have to buy smaller quantities from local traders at a much higher price. In the case of paraffin and LPG, where there are several steps in the distribution chain, the mark-ups at each step raise the final price, increasing the energy burden of the poor which contributes to their energy insecurity (Prasad, 2006).
6. The commercialization of firewood and the depletion of forests mean further energy poverty and deteriorating livelihoods. The country lacks detailed information on the use of fuelwood and other non-commercial fuels like dung and plant residues.

The country has taken many positive measures to improve the energy security of the country at both national and household level.

In 2005 the government published the Energy Efficiency Strategy which sets targets for energy efficiency in the industrial and mining sectors, commercial sector, residential sector and transport sector. The Strategy sets a national target of 12% and 10% for the residential sectorto be achieved by 2015. In residential sector energy efficiency measures include energy efficient housing shells, the use of CFLs, the use of geyser insulation blankets, the installation of solar water heating, replacing other fuels with LPG for cooking, and replacing paraffin with electricity for lighting. The application of these combined measures could save about R1 billion and reduce CO_2 emissions in 2025 by 4 Mt (Winkler, 2006).

In 2004 the DME produced the *White Paper on Renewable Energy Policy for South Africa* which sets a target of additional 10 000 GWh of renewable energy contribution to final energy consumption, to be produced mainly from biomass, solar and small-scale hydro. This has the potential to create 35 000 jobs, adding R5 billion to the GDP and R687 million to the incomes of low-income households (DME, 2004).The renewable energy is to be utilised for both power generation and non-electric technologies such as solar water heating and biofuels.

South Africa has high levels of solar radiation varying between 4.5 and 6.5 kWh/ m^2 compared to about 3.6 kWh/ m^2 for parts of the United States. The best wind resources are found mostly along the coast with wind speeds of up to 6 m/s.

Low prices for coal and electricity, the high cost of renewable energy technologies compared to conventional energy supplies and the lack of consumer awareness on the benefits and opportunities of RE are some of the main barriers to the implementation of RE.

In December 2007 the government published a Biofuels Industrial Strategy. This strategy is driven mainly to address issues pertaining to poverty and economic development. It seeks to achieve a 2% penetration level of biofuels in the national liquid fuel industry which amounts to about 400 million litres per annum. The biofuels strategy aims to support a variety of national priorities like job creation, sustainable development and Black Economic Empowerment.

The Southern African Power Pool (SAPP) was formed in 1995 to increase electrification of the region. The SAPP is focused on producing hydropower from the Inga hydropower plant in the DRC which has a potential of generating up to 100 000MW using the Congo River. Other than trade in electricity, the procurement of natural gas from Mozambique and Namibia by Sasol for synfuel production is another positive outcome of regional cooperation by the SAPP.

In the light of the current national electricity crisis Eskom has embarked on a massive New Build Programme to double its generation capacity from about 40 000 MW to 80 000 MW by 2025.

Solar water heating is a matured industry in South Africa and about 18% of the urban residential electricity consumption could be replaced by SWHs (CaBEERE, 2004). Solar water heating could provide around 25% of the total target of 10 000 GWhs by 2013. SWH industry has the potential of adding R1.3 billion to the GDP and R176 million to the income of low-income households. It is estimated that manufacturing, installing and servicing of SWHs will create 6 000 jobs.

The promotion of SWHs is hampered by low cost of coal-based electricity generation and the lack of regulations in national and local building codes Many poor people live in areas without piped water and can therefore not benefit from normal SWH systems even if installation is subsidized. The uptake of renewable energy technologies like SWHs will be slow because of the upfront cost of these technologies which are much higher than electric geysers.

A number of other measures have been introduced to enhance energy security. These include the National Electrification Programme which saw household electrification levels increase from 36 % in 1994 to 71 % in 2004. In 2003 the government introduced the Electricity Basic Services Support Tariff (EBSST) to assist poor households with a record of using less than 150kWh monthly. These households qualify for a free allocation of 50kWh of electricity per month. In 2004 government introduced an Integrated Household Clean Energy Strategy to promote the Basa Njengo Magogo method of lighting a fire, low-smoke fuels and housing insulation.

The government is piloting a few Integrated Energy Centres in rural communities to provide a range of fuels and appliances as well as information on household energy usage. Through bulk buying these centres would be able to obtain fuels and appliances at lower costs and thereby reduce the costs associated with high transport costs and multiple-step distribution chains (Winkler, 2006).

Contents

Acronyms and abbreviations used

BEE	Black economic empowerment
BFP	Basic fuels price
CEF	Central Energy Fund
CFL	Compact fluorescent light
CoUE	Cost of unserved energy
DBSA	Development Bank of Southern Africa
DEAT	Department of Environmental Affairs and Tourism
DoH	Department of Housing
DME	Department of Minerals and Energy
DSM	Demand-side management
EDC	Energy Development Corporation
ERC	Energy and Development Research Centre
ESCO	Energy services company
FBE	Free basic electricity
FBAE	Free basic access energy
GDP	Gross domestic product
GEF	Global Environment Facility
GNESD	Global Network on Energy for Sustainable Development
GTZ	German Technical Co-operation organization
GWh	GigaWatt hours
HSRC	Human Sciences Research Council
IEA	International Energy Agency
IeC	Integrated energy centre
IPP	Independent power producer
LPG	Liquefied petroleum gas
Mtoe	Million tonnes of oil equivalent
MW	MegaWatt
NEP	National Electrification Programme
NER	National Electricity Regulator
NERI	National Energy Research Institute
Nersa	National Energy Regulator of SOuth Africa
NGO	Non-governmental organisation
OECD	Organisation for Economic Cooperation and Development
PBMR	Pebble-bed modular reactor
PJ	PetaJoule
ProBEC	Program for Biomass Energy Conservation in Southern Africa
PUC	Productive use container
R&D	Research and development
RDP	Reconstruction and Development Programme
REFSO	Finance and Subsidy Office for Renewable Energy
SA	South Africa
SADC	Southern African Development Community
SANERI	South African National Energy Research Institute
SAPP	Southern African Power Pool
SHS	Solar home system
SSN	Southsouthnorth
Tfc	Total final energy consumption
UNIDO	United Nations Development Organisation
VAT	Value added tax
W	Watt
WRI	World Resources Institute
ZAR	South African currency - rand

1. Introduction

The concept of energy security first emerged with the oil crises of the 1970s. Historically, the debate around energy security refers to the availability of a regular supply of oil and gas, in sufficient quantities and at an affordable price. The world has changed much since the concept of 'energy security' emerged in the 1970s and recent years have seen increasing attention being paid to the issue. Different countries and regions adopt various ways of achieving energy security depending on whether they are net importers or exporters of energy. The International Energy Agency (IEA), which primarily represents the energy security interests of the OECD countries, which are mainly net importers, emphasizes access to a sufficient amount of reliable energy at an acceptable price. With the advent of issues pertaining to climate change becoming more important in policy making-decisions, a more inclusive definition of energy security is the one espoused by the World Energy Council (WEC), which emphasizes energy sustainability – access and reliability, and security and environmental impacts.

But agreeing on its importance is not the same as agreeing on what it means. Consuming countries declare that they want 'security of supply', as defined above. Exporting countries, whether Russia or in the Middle East, turn it around and talk about 'security of demand'- sufficient access to markets and consumers to justify future investment (and protect their national revenues). Probe further and the differences become even sharper. For Russia, energy security is about the state retaking control of the 'commanding heights' of the energy industry and extending that control downstream, over the critical export pipelines that provide a substantial part of government revenues. For Europe, today's concerns centre not on oil, but on natural gas and on the debate about dependence on gas from Russia. For Japan, the question is quite different: how to compensate, in running the world's second largest economy, for the absence of virtually any domestic resources (www.globalization.org). For China and India, it is assuring that energy does not hold back the economic growth they need for development and to avoid social turbulence (Teri, 2007).

Although the G8 group of countries in 2006 included reducing of energy poverty in its Action Plan for Global Energy Security, the issue of energy security for developing countries is rarely mentioned (GNESD, 2007). Furthermore, the notion of energy security is usually analysed from the perspective of a particular country and not from the perspective of users of different energy fuels or sectors. Different types of energy being used to satisfy different needs, the security of supply of all energy sources should be studied in order to get a global picture of the main threats to the satisfaction of energy needs of developing countries (GNESD, 2007).

The concept of energy security forms part of the larger pattern of relations among nations as well as the political and socio-economic relations within nation states. How those relations go will do much to determine how secure we are when it comes to energy.

The notion of energy security has evolved over the years and the new energy security paradigm focuses on concerns and fears around energy security that is fuelled mainly by the following:

- fossil fuel depletion (peak oil, etc);
- reliance on foreign sources of energy;
- geopolitics (such as supporting dictatorships, rising terrorism, 'stability' of nations that supply energy);
- energy needs of poorer countries, and demands from advancing developing countries such as China and India;
- environmental issues, in particular climate change; and
- world population growth.

The objectives of this study are to analyse

- at *national* level:
    - threats (present and future) to energy security;

- different strategies/measures undertaken by South Africa to improve energy security; and
- the impacts of the measures/strategies to improve energy security.

- at *household* level:
  - threats (present and future) to energy security;
  - measures/strategies undertaken to improve the energy security;
  - impacts of energy strategies and measures on energy security.

The electricity sector in South Africa is dominated by the state-owned national utility Eskom, which owns and operates more than 90% of generation assets, the whole transmission grid, and a significant portion of the distribution industry, especially in rural areas. The remaining generation assets are owned by private producers and local authorities, who were officially discouraged from building additional plant from the 1960s onwards. Local authorities (municipalities) have a right of supply in their areas of jurisdiction, although for a number of historical reasons Eskom distributes electricity in many local authorities. Eskom in most cases also sells electricity directly to large industrial customers. Electricity is regulated by the National Energy Regulator of South Africa (Nersa), which licenses all operators and approves tariffs. The key government institution in the energy sector is the Department of Minerals and Energy (DME), which formulates and implements energy policy, and oversees a group of associated institutions, including Nersa, the National Nuclear Regulator (which oversees nuclear safety), the Nuclear Energy Corporation of South Africa (which undertakes nuclear research) and the Central Energy Fund, which is the holding company for the national oil company PetroSA, as well as owning the recently-established South African National Energy Research Institute (SANERI) and the Energy Development Corporation (formed to promote renewable energy).

For the past two decades South Africa has enjoyed secure, reliable and cheap electricity supply. However, electricity blackouts together with national load-shedding incidents in the Western Cape in 2006 and recently on a national scale in 2008, have brought home to South Africans the fact that security of supply will be tenuous in the foreseeable future. This, coupled with fuel shortages in 2005 and projected challenges revealed by studies conducted since then, have made it necessary for South Africa to join a great number of countries and change its approach to energy security. Energy security has become a priority for the South African government. Concerns are real – without access to reliable, clean, affordable, safe and ample energy, the economy cannot develop and a lack of energy security feeds into the cycle of poverty.

The White Paper on Energy Policy of the Republic of South Africa was published at the end of 1998. The following relevant policy objectives are set out in this paper:

1. Securing supply through diversity – given the increased opportunities for energy trade, particularly in the Southern African region, government will pursue energy security by encouraging a diversity of both supply sources and primary energy carriers.
2. Increasing access to affordable energy – Energy security for low-income households is critical to reduce poverty and improve living standards. Basic energy needs must consider costs, access and health (DME, 1998).

Three distinct periods can be identified in the history of energy policy making in the country: apartheid period (1948 to 1994) – due to political isolation, energy policies were mostly secretive and centered on energy security. From 1994 to 2000, after the advent of democracy, policies were directed at addressing the injustices faced by the majority of the population (equity and justice were primary goals). After 2000, energy policies focused on targets like job-creation, energy security and the recognition that energy production and use had to proceed in a sustainable manner to protect both local and global environments (Winkler, 2006).

The South African economy is energy-intensive – the country uses a large amount of energy per economic output. But while the annual per capita energy consumption is 2.4 tons of oil equivalent (toe); although large, this figure is still much lower than for the United States of America where the figure is 8 toe (WRI, 2005). The energy economy is dominated by coal, which contributes to over

70% of the country's primary energy (DME, 2005b). National coal reserves are plentiful, with peak production expected around 2070 (Dutkiewicz, 1994). Of the total final energy consumption (TFC) of liquid fuels, 72% is derived from crude oil (most of crude oil refined is imported), 23% from coal via the Sasol coal-to-oil process and more than 7% from natural gas. Although there are small oil reserves off shore, petroleum supply is associated with high import dependency.

Gas field reserves are limited and consumption accounts for 2% of primary energy supply and 1% of final consumption (DME, 2005b). Electricity supplies 28% of the national TFC and Eskom supplies 95% of the electricity demand, with 91% of the country's electricity coming from coal, with small amounts generated from hydro, pumped storage (4%) and nuclear (5%). Approximately 70% of the country is grid electrified (85% urban and 50% rural). Because of high costs associated with grid extension, this has resulted in an increased use of solar home systems (SHSs) in some rural areas.

Renewable energy makes up 9% of the total energy usage in the country of which 8% is from fuelwood. The commercial exploitation of renewable energy sources is currently limited, but the cost of renewable energy technologies will decline as it matures (Winkler, 2006).In March 2005 the government published the Energy Efficiency Strategy which sets targets for energy efficiency in the industrial and mining sectors, commercial sector, residential sector and transport sector. The Strategy sets a national target of 12% to be achieved by 2015.

South Africa is a member of the Southern African Power Pool (SAPP) which is made up of the countries in Southern Africa. The key objectives of the SAPP are to promote regional energy cooperation and optimize the use of electricity in the region.

Commercial and non-commercial biomass is estimated to supply approximately 20% of the national final energy consumption (Winkler, 2006). Most firewood is consumed directly by households and small amounts are used for charcoal production. Firewood, dung and crop residues are used for cooking and heating by poor households mainly in rural areas. It is estimated that about 7 million tons of wood is used annually for this purpose and has an energy content of approximately 86 PJ.

In December 2007 the government published a Biofuels Industrial Strategy. This strategy is driven mainly to address issues pertaining to poverty and economic development. It seeks to stimulate rural development and poverty reduction. Furthermore, biofuels can contribute towards the achievement of the renewable energy strategy; energy security and reduce greenhouse gas emissions (DME, 2007).

South Africa was selected for the purpose of the study because of the availability of secondary data/information, access to stakeholders and the author's familiarity with the South African energy sector. Moreover, the country has produced energy security and efficiency strategies which have the potential to be replicated elsewhere, or from which valuable lessons could be learned.

This paper is divided into six sections. Section 2 outlines the methodology in terms of how the objectives of the study are to be achieved and how the analysis will be carried out. In section 3 a brief overview of the socio-economic and energy profile of South Africa is presented. Section 4 discusses the threats to energy security at the national level and examines the impacts of measures and strategies to enhance energy security. Similarly, the next section discusses the threats to energy security at the household level and examines the impacts of measures and strategies to enhance energy security. The last section presents the conclusion and offers suggestions for the next phase of the study.

Taking into account the various approaches, the one most appropriate to the South African situation is: 'Energy security means ensuring that diverse energy resources, in sustainable quantities and at affordable prices, are available to the South African economy in support of economic growth and poverty alleviation, taking into account environment management requirements and interactions among economic sectors' (DME, 2007).

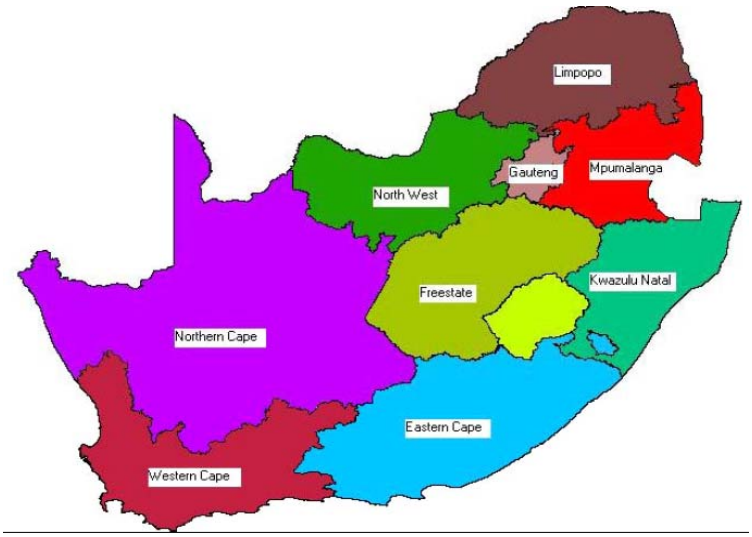


Figure 1: Map of South Africa

2. Methodology

In order to achieve the objectives of the study, indicators will be proposed to address the key components of energy security: the physical availability of energy in adequate quantities; prices that are reasonable; issues of sustainability, socio-economic development and safety for all sectors and citizens. Policy and literature reviews of relevant documents and studies have been examined.

2.1 At the **national** level energy security will be evaluated through the following indicators:

1. ***Net Energy import dependency*** – this is measured by the Net Energy Import Ratio (NEIR)

   NEIR = NEI/ (DS +NEI), where NEI is the net energy import to the country during the time period considered, and DS is the domestic supply of energy.

2. ***Diversification*** of energy sources – measured by using the Shannon-Wiener Index (SWI)

$$SWI = -\sum_i S_i \times Ln(S_i)$$

3. ***Energy intensity****:* compare energy intensity with GDP per capita
4. ***Depletion of energy reserves of different fossil fuels and their rate of depletion***

   Reserve to production ratio (R/P ratio) = estimated reserves/current annual extraction. Including renewable energy potential
5. ***Investments into new power plants and gas and oil exploration including investments in renewable energy***
6. ***Net energy import as a % of total GDP and net energy import as a % of total export earnings to compare the change in macroeconomic vulnerability to imported energy over time***

In addition to the above indicators this report will also analyse threats to national energy security in terms of cross-cutting issues like scarcity of water, institutional/political issues and climate change.

Measures/strategies and their impacts to enhance energy security at the national level will be analysed in terms of energy efficiency, renewable energy and demand side management, as well as

other measures and their impacts like the Southern African Power Pool, Eskom's New Build Programme, cogeneration, and IPPs.

At the **household** level energy security will be evaluated through the following indicators:

1. Share of commercial energy consumption.
2. Expenditure on energy: (i) as a % of monthly household expenditure and (ii) as a % of monthly household income for different income groups
3. Access in terms of % of households using modern fuels for different end-uses

Measures/strategies and their impacts to enhance energy security at the household level will be analysed in terms of energy efficiency and demand-side management, renewable energy, NEP, EBSST, FBAE, the role of the Paraffin Safety Association and the government's Integrated Household Clean Energy Strategy.

This study will rely mainly on secondary data that will be obtained from key government departments (DME, Statistics South Africa), Eskom, and Nersa as well as from data on socio-economic and household energy surveys conducted by research organizations and NGOs.

3. Socio-economic and energy profile of South Africa

3.1 Main socio-economic factors

South Africa has a population of 47 million people of whom the majority live in urban areas. The country has nine provinces and a land area of 1.2 million square kilometers.

The country is well endowed with natural resources including coal, gold, diamonds, metals and minerals. The economy is highly based on energy production and use, with coal accounting for 75% of the fossil fuel demand and 91% of electricity generation.

South Africa is classified as a middle-income country with characteristics of both a developed and developing nation. In 2008 South Africa had a Gross Domestic Product of $663 billion (based on purchasing power parity), which ranks it as the world's 20th biggest economy. South Africa contributes 38% of Sub-Saharan Africa's GDP. It has a productive, industrialised economy and a modern infrastructure, with well-developed financial, legal, communications, energy, and transport sectors, but also large income gaps, a dual economy and the country faces considerable social challenges.

Population growth and projections have elicited much debate in South Africa, especially given the high incidence of aids infections and how this will impact on population growth. The Actuarial Science Society of South Africa has developed the ASSA model (includes the influence of HIV/AIDS) to make population projections for the period 2001 to 2030. This study (see Figure 3.1) shows the population to grow to 51.5 by 2025, gradually levelling to 2030.

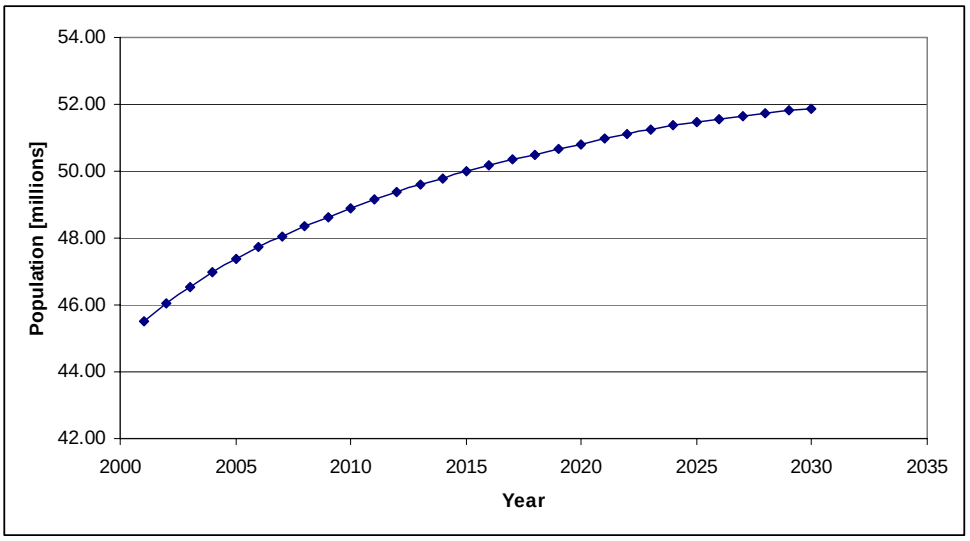


Figure 3.1: ASSA population projection model: 2001 – 2030
Source: Haw and Hughes (2007)

GDP (Gross Domestic Product) is another important driver of energy demand. Projections of GDP growth are often influenced by politics, and in the case of South Africa the incidence of HIV/AIDS has a significant influence on the GDP of the country. Over the past 12 years, GDP growth has fluctuated between 0.5 and 5% for 2006 (Haw & Hughes, 2007). Figure 3.2 shows an average growth rate of 4.74% over the planning period, peaking at 6% in 2016.

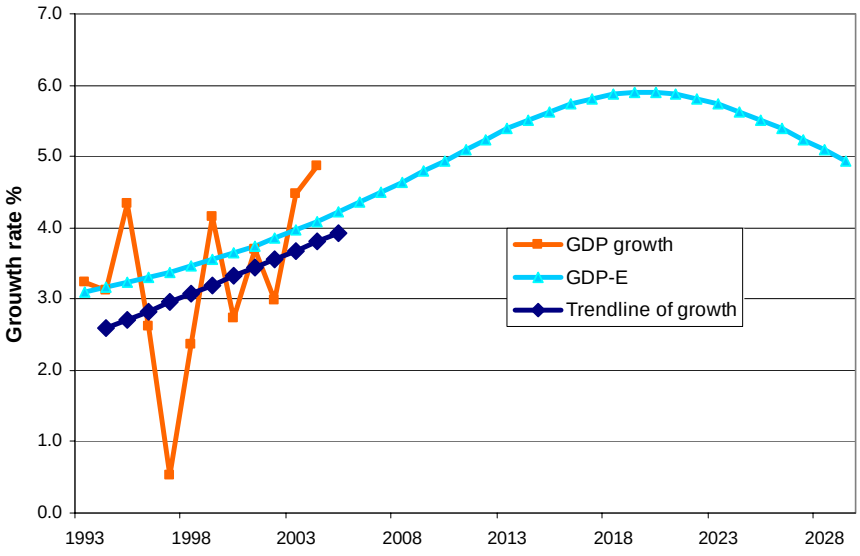


Figure 3.2: South Africa's GDP growth
Source: Haw and Hughes (2007)

South Africa's tourism industry is one of its fastest-growing industries and the government considers it as a key sector to boost the country's economic growth. The tourism industry has been identified as a high-growth potential area (due to its employment generation potential) in the government's Accelerated and Shared Growth Initiative for South Africa, which aims to lift GDP growth to 6% per year.

Tourism is closely linked to infrastructure development and the government, keeping in view the 2010 FIFA World Cup, is investing heavily in the infrastructure development like transportation, facilities, hospitality sector, and stadia construction etc. In 2005, the tourism industry of South Africa contributed 8.8% to GDP, which is expected to rise to 14% by 2014.

3.2 Present energy situation

Over 70 % of the country's primary energy is derived from large coal reserves. South Africa has small reserves of crude oil and natural gas and large reserves of uranium.

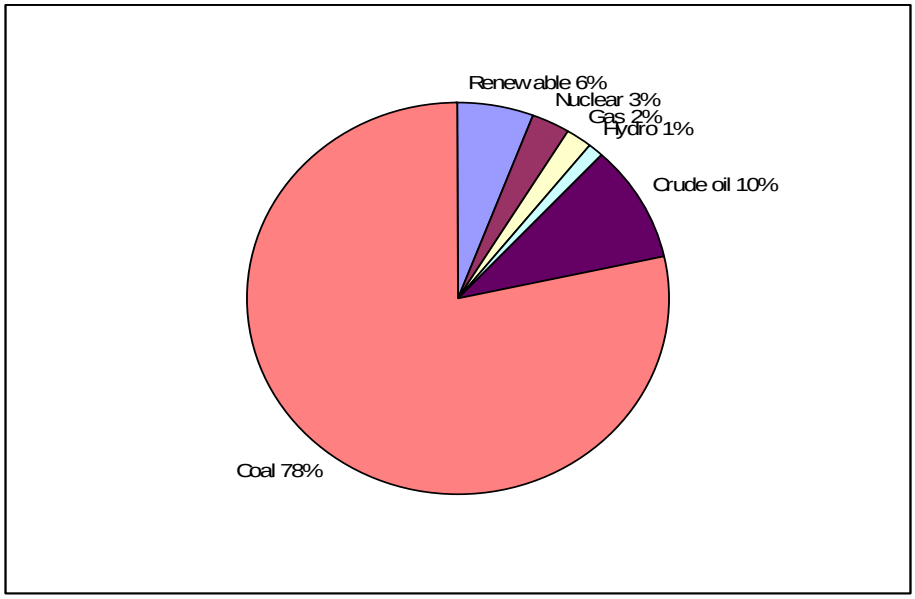


Figure 3.3: Primary energy supply, 2000
Source: DME (2002)

Biomass is an important source of energy, both as firewood for the rural poor and to supply the sugar refining and pulp and paper industries.

Energy demand in South Africa has been and continues to be dominated by heavy industries and mining. These industries are very energy intensive and rely on the availability of cheap coal and electricity. Figure 3.4 shows the share of final energy consumption in South Africa, 2000.

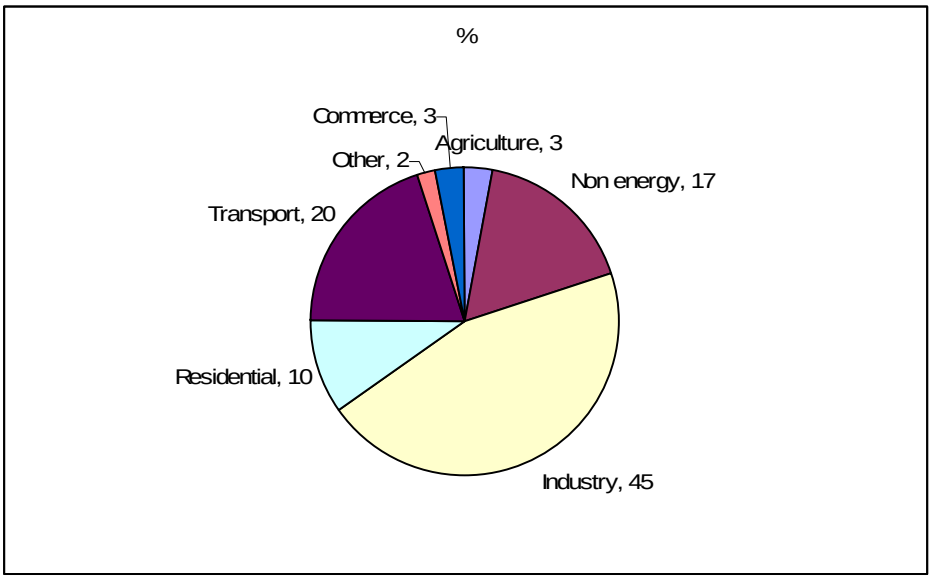


Figure 3.4: Share of final energy consumption in South Africa, 2000
Source: Based on SANEA (2003)

Demand for electricity

Electricity continues to play a pivotal role in the South African economy. The industrial sector consumes the highest proportion; followed by residential and mining (see Figure 3.5).

Over the last decade the reserve margin has fallen significantly as a result of growth in demand of around 3% per year and a very limited amount of new capacity commissioned.

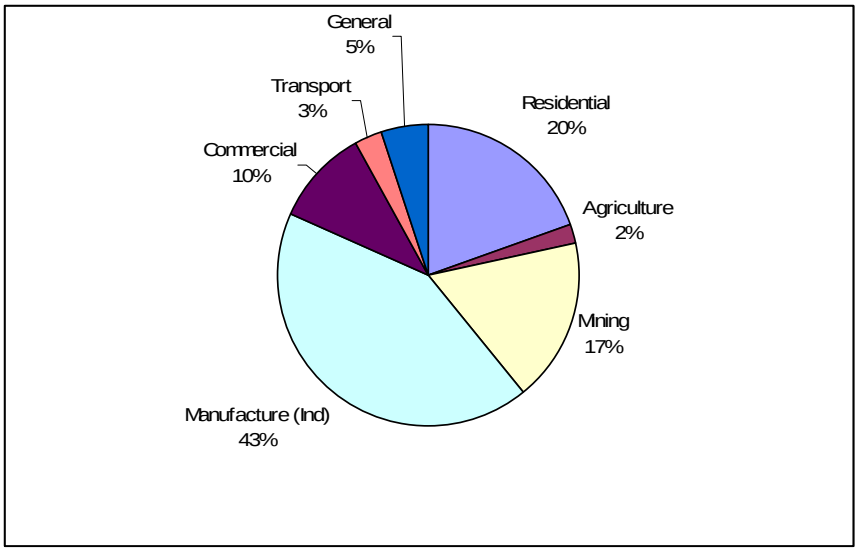


Figure 3.5: Demand for electricity by sector in South Africa
Source: NER (2001a)

Demand for liquid fuels

The demand for liquid fuels is dominated by petrol and diesel. The transport sector accounts for over 80% of demand, whilst paraffin and LPG are important for the residential sector. A recent trend is that the demand for jet fuel has increased whilst the demand for petrol has decreased and the demand for diesel has increased (Winkler, 2006).

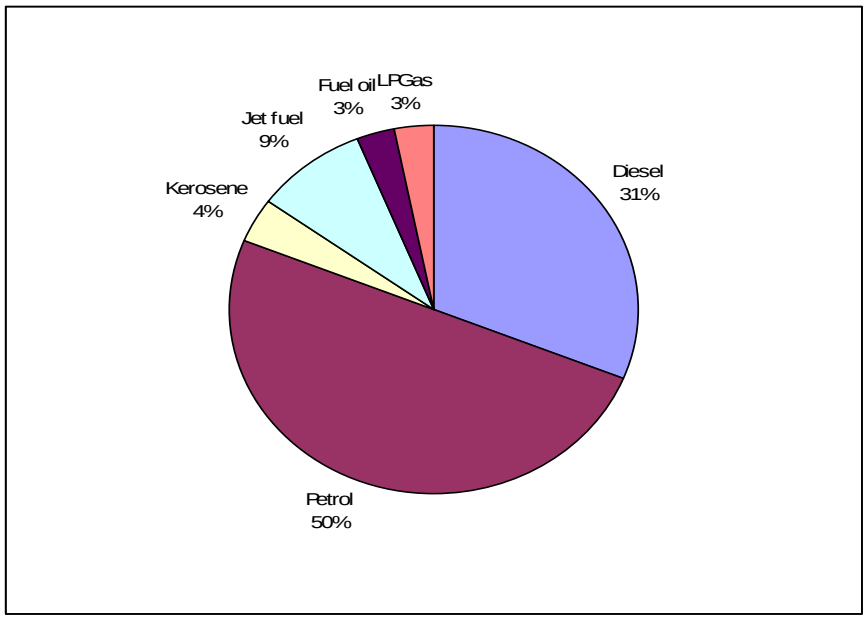


Figure 3.6: Consumption of major liquid fuels, 2001
Source: DME 2002

Household energy demand
Household energy demand varies according to location and socio-economic status. Energy services like cooking, space heating, lighting and water heating are met by a variety of fuels. Figure 3.7 shows the final energy demand by energy carrier.

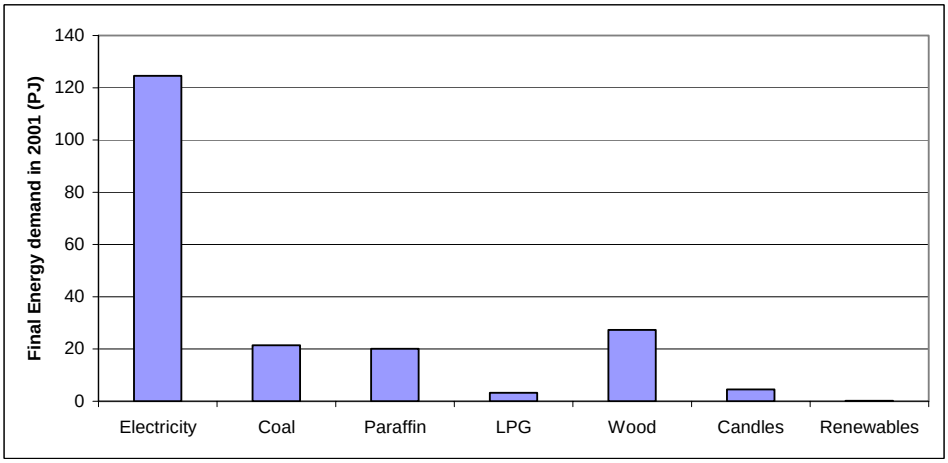


Figure 3.7: Final energy demand in the residential sector by energy carrier
Source: Winkler (2006)

3.3 Future energy scenarios
Figure 3.8 shows a steady upward trend in energy consumption for different sectors. Demands grows from 2 209 PJ in 2001 to 6 655 PJ in 2030 – 300% increase over this period. Table 3.1 illustrates the percentage growth in fuel consumption by major energy demand sector.

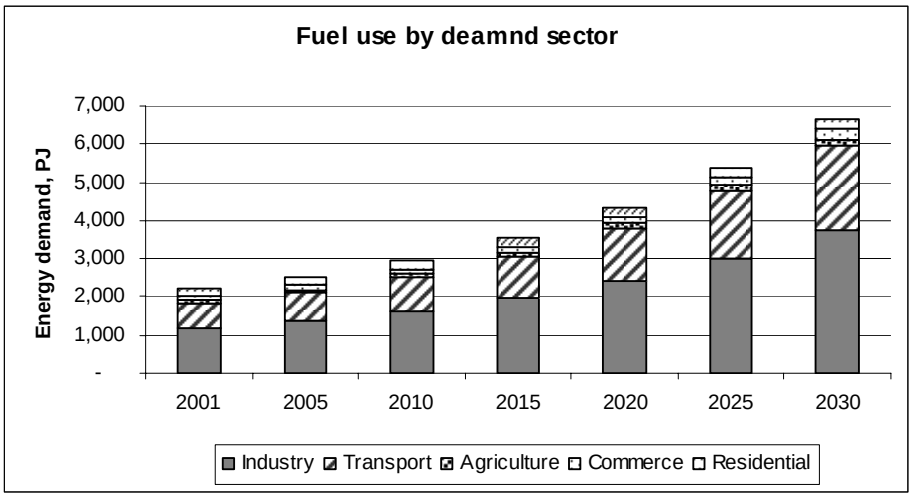


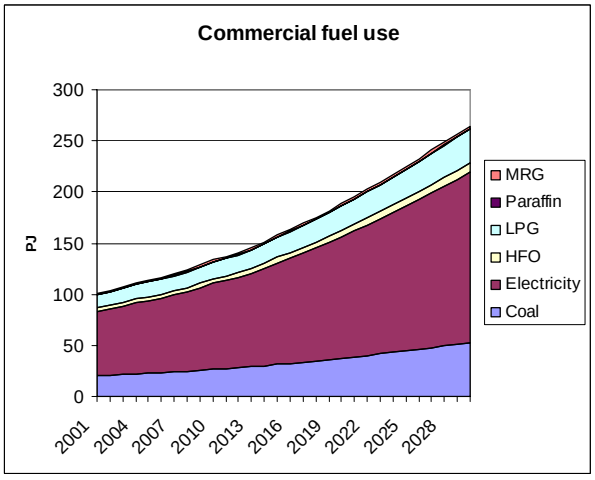
Figure 3.8: Fuel consumption by major energy demand sectors
Source: Haw and Hughes (2007)

Table 3.1: Fuel consumption by major energy demand sector and percentage growth

Source: Haw and Hughes (2007)

	2001	***2005***	***2010***	***2015***	***2020***	***2025***	***2030***	***% increase***
Industry	1 206	1 387	1 639	1 962	2 408	3 014	3 765	312.27%
Transport	634	720	882	1 112	1 407	1 783	2 218	349.83%
Agriculture	73	76	82	93	109	129	153	210.56%
Commerce	100	112	132	156	186	222	262	262.48%
Residential	197	209	221	231	240	249	257	130.49%
Total	**2 209**	**2 504**	**2 956**	**3 555**	**4 350**	**5 397**	**6 655**	

Figure 3.9 shows the increase in fuel demand for four major energy sectors. All sectors show a notable increase, with the exception of the use of coal in the residential sector.



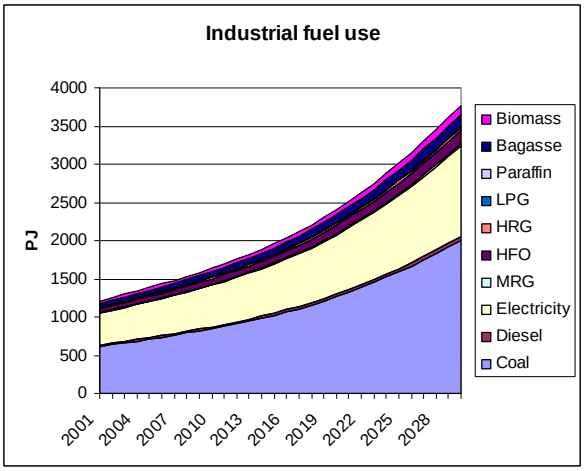
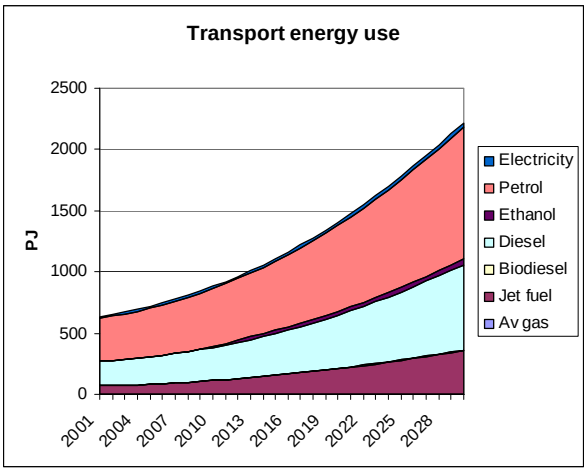


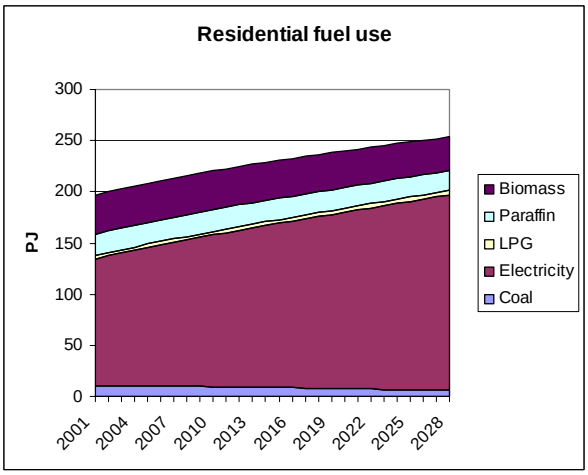
Figure 3.9: Fuel demand in each sector
Source: Haw and Hughes (2007)

3.4 Availability of national resources

The energy sector is critical to the country, contributing approximately 15% to GDP, and employs about 250 000 people. The three key energy supply sectors in the country are coal, liquid fuels and electricity. The country is endowed with large coal deposits – coal accounts for about 75% of primary energy consumption used mostly for electricity generation, whilst a significant amount is used to produce synthetic fuel and petrochemical operations. Sasol and Petrosa are the two major players in the synthetic fuel industry. Sasol is the world's largest manufacturer of oil from coal. The country has small deposits of oil and natural gas and imports most of its natural gas from Mozambique. The country's prospect for the development of natural gas was also boosted with the discovery of reserves near the Namibian border. South Africa has proven oil reserves of 15 million barrels, located offshore in the Bredasdorp basin.

In 2006 South Africa produced 200 000 barrels per day (bbl/d) of oil, of which 30 000 bbl/d was





crude oil, and 170 000 bbl/d consisted of mostly synthetic liquids from coal and natural gas. Almost 60% of the country's oil consumption is imported. In 2006 the country consumed 519 000 bbl/d of oil, of which 319 000 bbl/d was imported. The majority of crude oil imports come from Saudi Arabia and Iran. South Africa has four major oil refineries: Sapref (172 000bbl/d), Enref (118 750 bbl/d), Calref (110 000 bbl/d) and Natref (87 547 bbl/d).

Petrosa converts natural gas into fuels like petrol, paraffin, distillates and LPG. LPG is underutilized, at only 2% of total energy consumption in South Africa compared to an international average of usage of 20%.

Renewable energy makes up 9% of the total energy consumption. The majority of this energy is generated from wood and dung and not from modern energy sources. The potential for wind energy is good along the entire coast, with wind speeds of up to 6 m/s. The country has also high levels of solar insulation over most of the country, but in particular in the Northern Cape.

Eskom is the state-owned national utility that provides electricity to South Africa as well as to a number of Southern African countries. Eskom is an integrated monopoly, generating 95% of the country's electricity, as well as two-thirds of the African continent's. It operates and owns the national transmission system which is made up of more than 300 000 kms of power lines, of which 27 000 kms constitutes the national transmission grid. Ninety two percent of electricity is produced from 24 coal fired power stations. South Africa has one nuclear power station, the only one on the African continent, two gas turbine generators, two conventional hydroelectric plants and two pumped storage stations. Eskom exports electricity to Botswana, Lesotho, Mozambique, Swaziland, Namibia and Zimbabwe.

3.5 An overview of the household sector

According to the 2001 Census more than half of the population live in urban areas. It has amongst the highest income disparities in the world, with estimations that 13% live in 'first world conditions' while the majority live in 'third world conditions'. Of the approximately 12 million households in South Africa, close to 15% live in informal housing.

Electrification is taking place rapidly. Recent estimates suggest that by 2025, 92% of households will be electrified, with 87% using electricity only, and 5% using electricity together with other fuels. (Winkler et al 2006).

By the end of 2004, approximately 71% of households had access to electricity – 85% in urban areas and 54% in rural areas.

Table 3.2: Access to grid electricity according to household income in 2002.

Source: UCT (2002)

Quintile	Urban households		Rural households		Number not electrified	
	Number	% electrified	Number	% electrified	Urban	Rural
1 (Poor)	*483 201*	*54*	*1 525 820*	*38*	*223 505*	*952 543*
2	*845603*	*65*	*1 169 135*	*46*	*297 355*	*636 526*
3	*1 328 804*	*74*	*693 555*	*62*	*342 774*	*272 679*
4	*1 691 205*	*87*	*336 869*	*74*	*250 671*	*93 174*
5 (Wealthy)	*1 751 605*	*100*	*277 422*	*99*	*0*	*2 169*
All quintiles	***6 100 418***	***85***	***4 002 801***	***54***	***1 057 750***	***1 957 090***

The inequalities in wealth which have resulted from past social and economic policies have meant that many people cannot use electricity optimally, even if they access to it. Such households have to rely on paraffin, candles and fuelwood, especially for their thermal needs. Table 3.3 shows the consumption of different fuels for different end uses for all households.

Table 3.3: Distribution of households by main energy source for lighting and cooking

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

Fuel	Lighting (%)	Cooking (%)
Electricity	*69*	*51*
paraffin	*7*	*21*
Candles	*23*	
LPG		*3*
Coal		*3*
Wood		*21*
Other	*1*	*1*

Higher income households depend almost entirely upon electricity to meet their energy needs. This group spends 3–5% of their income on energy. Low-income households spend 10–20% of their income on energy (Cape Town Energy Strategy, 2003).

A vast range of income groups in the household sector means that the demand can differ significantly. Higher income households use more electrical energy and have a broader range of appliances than poorer households. The latter group uses more traditional, less clean fuels and appliances that are less efficient. In rural areas a larger number of the poor use wood than in urban areas. Poorer households closer to the coal mines use mostly coal.

In order to capture these differences the household sector is divided into six different categories. The six household types are defined in Table 3.4:

Table 3.4: Different household types and number of households, 2001

Source: Winkler, 2006

Household	Number of households	Share of all households	Notes and assumptions
Urban rich electrified (UHE)	*4 074 438*	*36.4%*	*100% of rich urban households are electrified*
Urban poor electrified (ULE)	*1 255 728*	*11.2%*	*Remainder of urban HHs are poor*
Urban poor unelectrified (ULN)	*1 349 240*	*12.0%*	*Rest of urban HHs must be unelectrified*
Rural rich electrified (RHE)	*1 181 279*	*10.5%*	*Assume 84% of rich rural HHs are electrified*
Rural poor electrified (RLE)	*1 095 449*	*9.8%*	*Remainder of rural electrified poor*
Rural poor unelectrified (RLN)	*2 249 571*	*20.1%*	*Rest of rural HHs must be unelectrified; number of HHs includes the few rich rural unelectrified*

Table 3.5 shows the different household types and numbers in 2001 and the projected number of households in 2030.

Table 3.5: Household type and number of households of that type

Source: Haw and Hughes (2007)

	2001	% share	2030	% share
Rural rich electrified (RHE)	*1 181 279.238*	*10.54*	*1 852 596.721*	*13.75*
Rural poor electrified (RLE)	*1 095 449.288*	*9.78*	*2 315 745.901*	*17.19*
Rural poor unelectrified (RLN)	*2 249 570.731*	*20.08*	*463 149.1802*	*3.44*
Urban rich electrified (UHE)	*4 074 437.503*	*36.36*	*6 190 668.426*	*45.94*
Urban poor electrified (ULE)	*1 255 728.28*	*11.21*	*2 564 705.491*	*19.03*
Urban poor unelectrified (ULN)	*1 349 239.96*	*12.04*	*88 438.12037*	*0.66*

Poor households, with regard to energy consumption, are considered to be those in the bottom two quintiles of income (an annual per capita income of less than R4 033). Households that fall into a ‘middle income class’ have been included in the ‘rich’ category (Winkler, 2006) due to the similar fuel and appliance availability and use. The Final energy demand by each household type in 2001 is shown in Figure 3.10

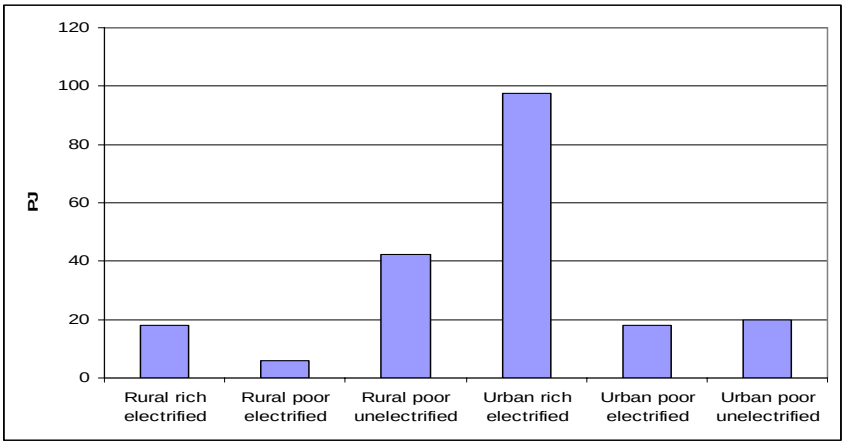


Figure 3.10: Final energy demand for each household type, 2001
Haw and Hughes (2007)

Household energy demand in the household sector is disaggregated into cooking, lighting, space heating, water heating and other electrical demands for each household type. The energy use for the different household types by end use in 2001 is shown in Figure 3.11. High income urban households use the most energy. Another difference between the households is also the type of fuel used.

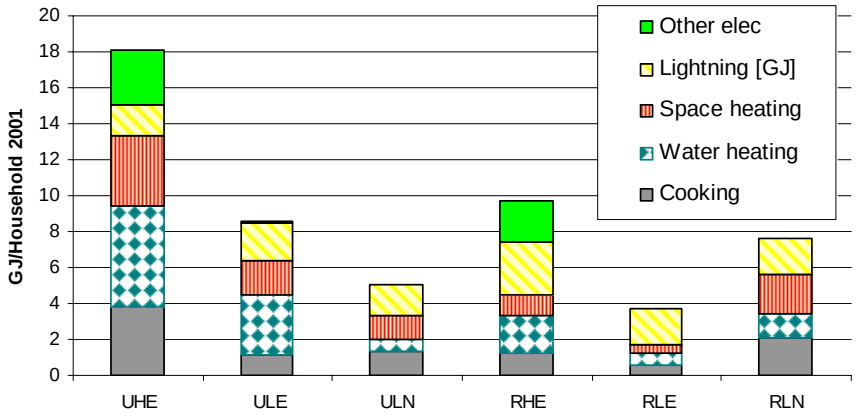


Figure 3.11: Energy use for different household types
Source: Haw and Hughes (2007)

4. Threats to energy security, measures to enhance energy security and their impacts at the national level

4.1 Threats to energy security

Coal, liquid fuel and electricity are the three main energy supply sectors in the energy economy of the country. Each of one of the three subsectors as well as two cross-cutting issues will be separately assessed for current and potential threats.

4.1.1 Net Import dependency

South Africa shows a reasonably low level of import dependency, which makes the country less vulnerable to disruptions in international energy supply and substantial increases in prices of

imported energy. In table 4.1, imported energy accounts for about 20% of total primary energy supply in 2005. From 1998 to 2005 the annual growth in imported energy shows a decline.

Table 4.1 Net energy import ratio

Source: DME, 1998, 2005

	Unit	1998	2005
Total primary energy supply	TJ	**4,639,613.65**	**5,078,962.39**
Net primary energy import	TJ	983,341.74	1,017,563.29
NEIR	**%**	**21.2**	**20.0**

Coal

South Africa has enough coal for at least the next 50 years, calculated at current production levels. The country's huge coal reserves are estimated to be between 38 and 55 billion ton (Winkler, 2006).

The country is not dependent on the import of coal for electricity generation, synthetic fuel production or domestic use. The country is however dependent on the import of coking coal for iron and steel production.

Over 70% of the country's primary energy comes from coal, approximately half being used for electricity generation and a quarter for synfuels. The production of coal is dominated by several large multinationals, which produce coal for the national and international markets, and are also under long-term contracts for electricity production. The coal market became deregulated in 1992 and is currently being monitored and overseen by the DME, which plays a facilitating role in the export of coal.

Coal-fired power stations are dependent on coal supplied by multinationals, which have lately supplied more coal to lucrative coal markets in India and China. The unreliable supply of coal to power stations is one of the causes of the current electricity crisis in South Africa according to Eskom chief executive Jacob Maronga, who said in *The Epoch Times* (18 February 2008), that 'there has been a surge of demand for coal, and as a result of that, some companies who used to be the reliable suppliers of coal to Eskom are beginning to see greener pastures elsewhere to the detriment of South African society.' As a result of the international financial turmoil the country's coal exports are projected to decline by 1.2 % (DME, 2007/8).

Another threat to energy security is the rising price of coal. From 2006 to 2007 it rose sharply from US$65 to $100 a tonne. This has serious implications for price increases in electricity as well as for households dependent on commercial coal for cooking and heating.

For coal to play its deserved role in energy security, its many detrimental environmental impacts must be addressed. This will require not only clean coal technologies for new plants, but also rehabilitation and refurbishment of existing inefficient plants.

Energy security is not threatened by dependence on imported coal but by issues related to internal supply and the rise in coal prices internationally.

Electricity

South Africa exports and imports electricity to neighbouring countries like Botswana, Zimbabwe, Lesotho, DRC, Namibia and Swaziland. The export and import balance is zero which does not make the country dependent on the import of electricity.

The country is currently facing a serious electricity supply problem due to spiralling demand for power and a rapidly dwindling access capacity. The supply/demand situation on the national grid remains tight and thus the prospect of load shedding remains a daily possibility for the next 5 to 7 years.

Eskom operates most of the generation and transmission components of the electricity supply industry in South Africa and has a legal obligation to maintain security of supply at the wholesale level (i.e. generation and transmission). Distribution is undertaken by both the municipalities and by Eskom. The generation, transmission and distribution systems all affect the supply quality to the customer and outages on any of these components can result in interruptions to customer supply. Failures of generation or transmission are important because such failures can affect large sections of the system and therefore can have widespread consequences (Wilson & Adams, 2006).

Secure electricity supplies are required to underpin national economic development and any event that brings the current level of security into question is inevitably of national concern. The loss of electricity supply incidents nationally has demonstrated six possible factors which threaten security of supply (NERSA, 2008).

- the low generation reserve margin that is available nationally: currently the reserve margin is about 5 to 6 %, well below an international standard of 15%. Higher GDP growth rates increase pressure on the electricity supply system.
- the limitations of the transmission system: the recent National Energy Regulator of South Africa (NERSA) report painted a bleak picture of electricity distribution in the country.
- poor maintenance of infrastructure: a report by the National Energy Regulator of South Africa (NERSA) concluded that in the case of the Western Cape outages, there was negligence and that remedial and maintenance procedures were inadequate.
- poor planning: policy uncertainty between 1998 and 2003. Government considered breaking up Eskom and introduce competition in generation and private investment. Eskom was prohibited from building new generation capacity during this period.
- lack of skills: The NERSA report further states that a critical shortage of skills are seen to be the main threats to the continued supply of power.
- inadequate/unreliable supply of coal.

The cost of interruptions to customers and the outcome of the associated planning process is thus very dependant upon how the cost to customers is evaluated. The cost of unserved energy (CoUE) is a measure of the value that customers place upon security of supply and is estimated by attempting to quantify the cost of energy not supplied to customers as a result of energy shortfalls. Intrinsically the CoUE is very difficult to estimate accurately. Customer surveys in the USA have indicated that CoUE is in the range US$2 000 to US$50 000 per MWh depending upon the frequency and duration of outages and their consequences to particular customers. Eskom has used a figure of R20 470 per MWh while Nersa's consultants have proposed using R18 228 per MWh. Press reports of losses to customers of R6 billion associated with outages in the Cape suggest that these figures may seriously underestimate the CoUE. If the figures in the press are correct the CoUE in South Africa could be around R350 000 per MWh, which is some 17 times greater than the figure used by Eskom. Using a CoUE energy figure of this magnitude would tend to increase the 'optimal' reserve margin by some 4% to 5%. A number of customers in the Cape have chosen to purchase and operate their own diesel generators, which implies that such customers place a high value on their security of supply (Wilson & Adams, 2006).

Liquid fuels (crude oil and natural gas)

South Africa has small deposits of crude oil and natural gas. About 60% of the country's total crude oil consumption is imported from the Middle East, Nigeria and Angola. The remaining 40% is produced by Sasol's coal-to-liquid plant and Petrosa's natural gas-to-liquid plant (the latter making liquid fuels from natural gas piped from the offshore F-A field near Mossel Bay).

The country has limited oil reserves in the Bredasdorp Basin. The two fields have proven reserves of 49 million barrels. It is producing between 30 000 and 40 000 barrels a day, which replaces about 10% of the country's imported oil.

Table 4.2: Crude oil NEIR

Source: DME, 1998, 2005

	Unit	**1998**	**2005**
Total primary energy supply	**TJ**	**1,162,648.05**	**1,054,319.19**
Net primary import	**TJ**	897,696.39	772,179.90
NEIR	**%**	**77.2**	**73.2**

The country has a high crude oil import dependency of more than 70 %(see Table 4.2).Demand for imported crude oil shows a small decline between 1998 and 2005.

South Africa's large dependency on imports of crude oil from the Middle East increases its vulnerability and insecurity of supply. Matters are further compounded by the weak exchange rate of the local currency to the US dollar, the trading currency on the international oil market, and the high crude oil prices of over $100 per barrel. This means that the domestic price is influenced by supply and demand for petroleum products in the international markets. Furthermore the South African economy is wholly integrated into the global economy which makes it vulnerable in the wake of peak oil.

In 2006 the DME conducted a study into the country's liquid fuel strategic stocks and found that in the event of total fuel supply disruption the country would lose at least R925 million per day. This raises a fundamental question about government's role in securing energy security (DME, 2006).

South Africa has small natural gas reserves off the south and west coasts. The gas is piped to Mossgas near Mossel Bay, which makes petrol, diesel and paraffin from natural gas. The reserves are expected to run out by late 2008 and PetroSA is currently exploring adjacent blocks as well as potential gas fields along the west coast. Currently an 895km pipeline is being built to bring natural gas from Namibia and Angola to Sasol.

Table 4.3: Natural gas NEIR

Source: DME, 1998, 2005

	Unit	**2004**	**2005**
Total primary energy supply	**TJ**	**84,152.32**	**153,077.74**
Net primary import	**TJ**	6,980.54	45,383.31

NEIR	**%**	**8**	**30**

According to available statistics the country imported natural gas from 2004. Table 4.3 shows a rapid increase in the net energy import ratio from 2004 onwards.

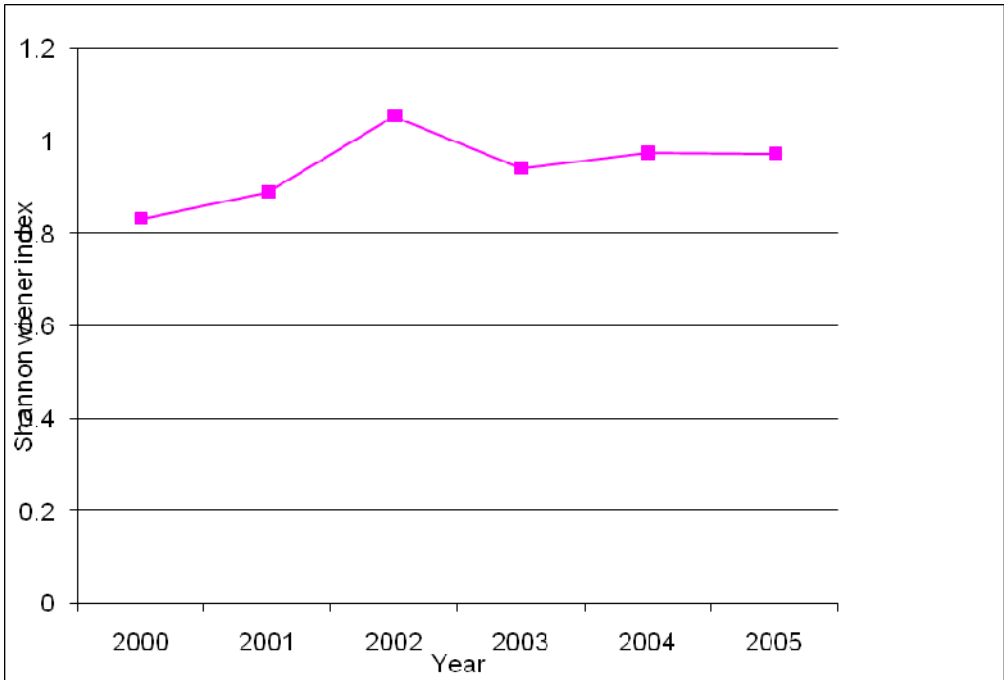
Sasol also uses natural gas imported from Mozambique for the production of synfuels and this has led to a decrease in the use of coal. Pipeline infrastructure is owned by the state pipeline company Petronet and is regulated by Nersa (Winkler & Marquad, 2007/8). Sasol owns the coal reserves used for the production of synfuels and this secures a greater reliability of supply.

4.1.2 Diversification of energy resources

Coal, crude oil and natural gas were the main primary energy types supplied during the last six years. Diversification of primary energy supply shows an improvement over this period of time. A higher index value denotes better diversification of primary energy supply.

Figure 4.1: Diversification of energy sources

Source: DME,2000-2005



4.1.3 Energy intensity

The South African economy is highly energy intensive compared to other developing countries. This means that for every rand (dollar) of economic output, a large amount of energy is required (Hughes et al, 2002). Annual per capita energy consumption in South Africa is 2.51 tons of oil equivalents (Toe) compared to a world average of 1.67. Table 4.4 below compares the energy intensity of South Africa to other countries (Haw, 2007).

Table 4.4 Energy intensity in South Africa compared with other countries
Source: Haw 2007.

	TPES/capita(Toe/capita)	TPES/GDP(Toe/000 1995 US$)	TPES/GDP(Toe/000 PPP 1995 US$)	Electricity consumption per capita (national ave)-kWh/capita
South Africa	2.51	0.63	0.29	4 533
Africa	0.64	0.86	0.32	501
OECD	4.78	0.19	0.22	8 090
World	1.67	0.30	0.24	2 343

The main reasons for this high energy intensity include the dependence of the economy on industries such as mining and metal processing as well as low cost of energy, especially electricity. This low cost of energy encourages the development of more energy intensive industries, because there is little incentive to improve energy efficiency. However, there is currently a shortage of excess capacity and South Africa will need to look at increasing the generation capacity if economic growth is to continue (Haw, 2007).

4.1.4 Energy reserves

The potential for solar energy is good especially in the Northern Cape. Wind power potential is good, mainly along the coast. The potential for hydro power is limited as South Africa is a relatively dry country. Figure 4.2 gives an estimate of the country's non-renewable energy reserves.

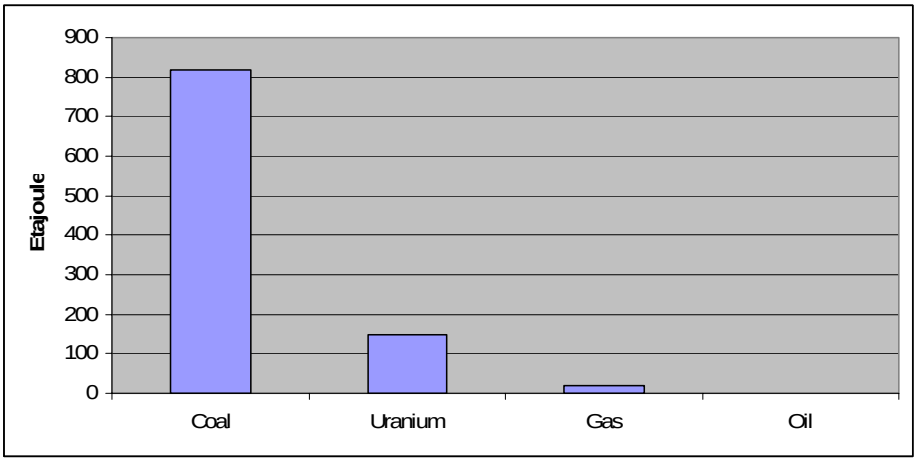


Figure 4.2: South African energy reserves (excluding renewables)
Source: Coal: estimate from DME (2003); Uranium: WEC.ASA (1995); Gas: estimate from Holiday; Oil: PetroSA

Table 4.5: An estimation of the country's untapped potential energy reserves/resources.

Source: DME, 2003

Energy carrier	Reserve/resource	Comment
Coal	55 billion tons	Coal technology is well developed and inexpensive. Coal reserves are currently

		under re-appraisal
Oil	Potential reserves (P90)-40 million barrels Potential resource – 5 billion barrels	Oribi/Oryx audited remaining reserves at 12 million barrels plus Sable field reserves of 150 million barrels sufficient for four years production. Untested deep-water potential
Natural gas	Reserves (P50): 1.3 tcf Potential resource: 25 tcf-	A/E-M and sattelites audited (P50) 0.5 tcf and 11.8 million barrels condensate
Hydro	~ 300 MWe potential	South Africa classified as a water stressed country and therefore has limited potential
Uranium	261 000 tonnes	Uranium beneficiation and fuel fabrication are done outside the country

For the technical feasible potential for renewable energy by technology see Table 4.13.

South Africa also imports energy (electricity, natural gas) from neighbouring countries. Table 4.6 gives an estimation of neighbouring energy reserves/resources.

Table 4.6: Estimation of regional energy reserves/resources

Source: DME, 2003

Country	Reserves/resources	Comment
Mozambique	Gas: 2.0 tcf proven 5 tcf potential Hydro: 50 000 MWe	865 km pipeline completed in 2004 – with an initial carrying capacity of 120 MGJ/y Cahora Bassa 1 800 MWe – the majority assigned to Eskom
Democratic Republic of the Congo (DRC)	Hydro Gas: > 50 bcf proven Oil: > 200 million barrels	Potential for approximately 50 000-100 000 MWe of hydro generated electricity at Inga.
Zimbabwe	No oil and gas reserves Coal	Large coal reserves and potential for coal bed methane.
Namibia	Gas: 1.2 tcf proven	Investigations currently underway to import gas to the western Cape
Angola	Oil: 5.4 billion barrels proven Gas: > 20 tcf	

4.1.5 Investments into new power plants and gas and oil exploration including investments in renewable energy

Electricity
For many years Eskom, the national utility, has operated in an environment of surplus capacity. However, this surplus capacity has now been almost exhausted with increased consumer demand and economic development. Eskom's power system will remain tight over the next five years with an increased likelihood of power interruptions. This trend is set to continue at least until the first new coal-fired base load power station is commissioned in 2011.

Since 2004/5 Eskom has embarked on a new capacity expansion programme. Government has declared that of the new power stations to be built, Eskom will target 70%, whilst the balance will come from Independent Power Producers (IPPs). The Department of Minerals and Energy (DME) has already procured approximately 1000MW of new capacity from IPPs through a competitive tender process.

Additional power stations and major power lines are being built on a massive scale to meet rising electricity demand in South Africa. Eskom's capacity expansion budget is R343/$34 billion up to 2013 and is expected to grow to more than a trillion rand by 2026. Ultimately Eskom will double its capacity to 80 000MW by 2026 (Eskom, 2009).

Since the programme started in 2005, an additional 2 582MW has already been commissioned. The plan is to deliver an additional 16 304MW in power station capacity by 2017.

The return to service of the three mothballed coal-fired power stations has progressed well. The original planned target date of end October 2011 for commercial operation of all 23 units (3 800MW installed capacity) will be achieved. The programme also includes the building of two pumped storage power stations which will be operational by middle 2013. The programme also includes the upgrading and extension of transmission lines and the building of new substations.

Oil and gas

PetroSA, the country's national oil company, is progressing well with the building of a crude oil refinery near Port Elizabeth. It would produce up to 200 000 barrels of fuel per day and should be on stream in 2014/15 (DME, 2007/2008)

Renewable energy

South Africa has high levels of renewable energy potential, especially for solar and wind along the coastline. Presently it has a renewable energy target of 10 000 GWh to be achieved by 2013.In order to kick-start and stimulate the renewable energy market, the NERSA (National Energy Regulator of South Africa) has approved Renewable Energy Feed-in Tariff (REFIT) guidelines in March 2009. The REFIT would be an incentive structure aimed at encouraging renewable energy technologies through power generation and non-electric technologies such as solar water heating and biofuels.

The Darling Wind Power Company is the first independent power producer in the country operating since middle of 2008 and feeding directly into the national grid. Darling Wind Farm consists of four turbines of 1.3 MW capacity generating a total of 5.2 MW. The company sells green electricity to the City of Cape Town with whom it has entered into a power purchasing agreement in 2006.

4.16 Economic significance of energy imports

The value of total imports increased significantly from 2004 onwards, exceeding the total value of exports, making South Africa a net import country (see table 4.7). Crude oil makes up more than 80% of energy imports followed by natural gas and coke. Both vulnerability indices (see tables 4.8 and 4.9) show a remarkable increase from 2002 to 2006. This poses a significant security threat to South Africa in terms of dependence on energy imports as well as increases in the costs of imported energy.

Table 4.7: South Africa: Grand total exports and imports (sum for period in ZAR million)

Source: National Treasury, 2009

Source: National Treasury, 2009

Year	Total exports	Total imports
2002	311678.4	272682
2003	274544.4	256796.4
2004	294405.05	304615.28
2005	329934.7	349210.97
2006	395297.9	462060.86
2007	493035.35	561675.4

Table 4.8: Net energy import as a % of GDP

Source: National Treasury,2009

	2002	2006
GDP (2000 ZAR)	982,122 million	1 174 078 million
(a) Total energy import bill (2000 ZAR)	2882360477	6331416293
(b) Total energy export earnings (2000 ZAR)	2512222380	2418847497
N1 % (a-b)/GDP	**0.04**	**0.33**

Table 4.9: Net energy import as a % of total export earnings

Source: National Treasury, 2009

	2002	2006
(a) Total energy import bill (2002/2006 ZAR)	33250910477	84790327001
(b) Total energy export earnings (2002/2006 ZAR)	28980997389	32393205692
N2 % (a-b)/Total earnings from exports	**1.4**	**13.4**

4.1.7 Other threats

Institutional/political

Another threat to energy security at the national level is the poor coordination between government departments and the different spheres of government at the provincial and local level. A glaring example of this is the lack of knowledge and understanding by the municipalities when it comes to the implementation of the free basic alternative energy policy – a DME-driven policy which is to be implemented by municipalities that constitutionally report to the Ministry of Provincial and Local Government. It is such disjointed co-ordination between government departments and various spheres of government that may render greater energy security of supply futile.

Water scarcity

Water is a major input in the generation of electricity from coal-fired power stations and because the bulk of Eskom's electricity comes from such a source, a reliable and adequate supply of a scarce resource like water at a predictable price is of paramount importance to sustain security of electricity supply. An average wet cooled power stations use about 1.5 to 2 litres of water per kWh, whilst the dry cooled power stations use about 0.1 to 0.2 litres per kWh. As the production capacity of power stations increases the amount of water needed to for cooling also increase. Eskom is currently recommissioning some of its mothballed coal-fired power stations as well as building new ones. This will further drain the country's scarce water resources and an inadequate supply of water to these power stations poses a threat to security of electricity supply.

Climate change

The South African energy economy is largely fossil fuel-based. It is the largest emitter of carbon dioxide in Africa and has the second most carbon intense economy in the world. The National Climate Response Strategy for South Africa acknowledges the dangers climate change would have on the South African economy – exports of fossil fuels could in future be penalized.

4.2 Measures and their impacts to enhance energy security

4.2.1 Energy efficiency

A key focus of energy security is managing the energy demanded by all sectors in the economy. In March 2005 the government published the Energy Efficiency Strategy which sets targets for energy efficiency in the industrial and mining sectors, commercial sector, residential sector and transport sector. The targets are voluntary and to be achieved through standards, awareness campaigns, energy management systems, appliance labelling and investment in research and development. The Strategy sets a national target of 12% to be achieved by 2015. The Strategy will cover all energy-using sectors and will be implemented through sectoral implementation plans.

The country's economy is largely based on mineral extraction and processing which is by its nature very energy intensive. Low electricity prices have meant that there has been little incentive to save electricity. The unit price of electricity is amongst the cheapest in the world (DME, 2005). South African electricity prices are low by international standards i.e. South African electricity prices are less than half of those in the United States and the United Kingdom and about a third of those in Germany and Spain and a fifth of those in Denmark.

The industrial and mining sectors are the heaviest consumers of energy, accounting for more than two-thirds of national electricity consumption. It is in these sectors that the greatest opportunities for saving lie by replacing old with new technologies and applying best energy management practices.

The DME has established the National Energy Efficiency Agency to oversee the implementation of energy efficiency and demand-side management projects, as well as the measuring and verification of these projects. Tables 4.10 and 4.11 show the potential monetary savings achievable by implementing the Strategy.

Table 4.10: Potential monetary savings (electricity)

Source: DME (2005)

Year	Savings (PJ)	Million kWh	Total savings (R)
2011	*29*	*8.0555555556*	*1 611 111.11*
2012	*45*	*12.5*	*2 500 000.00*
2013	*63*	*17.5*	*5 250 000.00*
2014	*81*	*22.5*	*6 750 000.00*
2015	*101*	*28.055555556*	*11 222 222.22*
	Total for 5 years	***R 27 333 333.33***	

Table 4.11: Potential monetary savings (petrol)

Source: DME (2005)

Year	Savings (PJ)	Kilolitres	Total savings (R)
2011	*6*	*184 352.9679*	*737 411 871.73*
2012	*7*	*215 078.4626*	*967 853 081.65*
2013	*8*	*245 803.9572*	*1 155 278 599.04*
2014	*9*	*276 529.4519*	*1 354 994 314.31*
2015	*10*	*307254.9466*	*1 536 274 732.77*
	Total for 5 years	***5 751 812 599.50***	

In order to successfully implement the Strategy it is important to understand the barriers that will confront it. The barriers below are some of the traditional barriers relating to the state of the country itself (DME, 2005):

- Energy pricing – because of the historically low unit cost of coal and electricity (though the latter has increased incrementally over recent yeas) there is a perception amongst commercial and industrial companies that the medium and high cost interventions cannot justify lengthy payback periods.
- Lack of information – efficiency benefits and opportunities are often overlooked because of a lack of knowledge and information about energy efficiency.
- Institutional barriers – Misconceptions are frequently encountered within industries that energy efficiency will disrupt production.
- Lack of investment confidence – Investors may be reluctant to tie-up financial resources in long-term projects.

The energy efficiency improvements will be achieved through economic and legislative means, information activities, energy labeling, performance standards, energy audits, DSM and efficiency technologies (DME, 2005).

The target was based on reducing final energy demand against a baseline figure derived from a energy model constructed for the DME's 2003 Integrated Energy Plan. The target will be implemented according to a series of sectoral strategies. In the wake of the launch of the Strategy, a voluntary Energy Efficiency Accord was signed by the Minister of Minerals and Energy and 37 businesses (primarily energy intensive industries and energy supply industries, but also a bank, a retail chain and the cement industry association), whereby the businesses committed to meeting the targets set out in the Strategy, with a higher target of 15% adopted by mining and industrial signatories

DSM is a key component of the energy efficiency strategy and it refers to collaborative programmes aimed at reducing electricity demand through encouraging efficient use, particularly at peak periods. The key objective of DSM is efficient use of electricity, without influencing the customer production

and satisfaction levels, resulting in significant cost savings for the provider and thus the consumer as well. This is a joint initiative between the DME, National Energy Regulator and Eskom and it aims to save 4 255MW of generation capacity over a 25-year period

DSM strategy comprises a dual approach: to reduce electricity demand at peak periods (07:00 – 10:00 and 18:00-20:00) by shifting load to off-peak periods and by overall electricity consumption reduction through the installation of energy efficient equipment and optimising processes. Sustainable DSM projects often involve a combination of both methods. For commercial and industrial clients, energy audits are undertaken to establish potential savings and the installation of energy efficient equipment. For example, First National Bank is saving R2.2 million per year on electricity following a lighting and air conditioning retrofitting project.

One of the first DSM projects launched by Eskom in 1999 was the efficient lighting initiative called Bonesa. This was jointly funded by the Global Environment Facility and Eskom over a period of 3 years. Currently the use of compact fluorescent lamps (CFLs) through customer education, advertising and marketing is being promoted. Eskom DSM reported that CFLs represented 32% or 64 MW of the total MW savings for 2004 (Holtzhausen, 2005). The price of CFLs dropped from between R60-R80 (1996) to R13-R20 (2004) due to joint sales promotions with local suppliers and increased volumes.

The annual target of 152MW of energy-efficiency and demand-side management projects in completion stage was exceeded by 12.66% with 171MW (2005: 237MW, 15 months). The performance is measured by independent monitoring and verification bodies. Eskom implements energy efficiency demand-side management through energy services companies (ESCOs) that are assessed and registered each financial year. DSM applied in the commercial, industrial and mining sectors focus on building lighting retrofits, heating ventilation, air conditioning optimization, the use of variable speed drives, compressor efficiency and plant lighting retrofits. Table 4.12 shows the potential future savings from energy efficiency DSM in MW.

Table 4.12: Potential future savings from energy efficiency and DSM (MW)

Source: NER (2002)

	Low penetration		Moderate penetration		High penetration	
	2010	2020	2010	2020	2010	2020
Industrial and commercial energy efficiency	*567*	*878*	*889*	*1270*	*890*	*1270*
Industrial and commercial load management	*355*	*444*	*428*	*535*	*510*	*535*

In 2003 Eskom launched a pilot DSM schools programme at the intermediary and high schools level. As a result of the success of this programme a national rollout was started in 2004. The programme aims to provide learners with the necessary knowledge and skills to manage their own electricity use wisely in order to reduce the costs to their households as well as the impact on the environment. This energy audit educates the learners on the electricity consumption of different appliances in the home and about peak electricity demand periods, as well as saving tips that can be implemented to reduce

Transport efficiency

The transport sector uses three quarters of petroleum products, making it the obvious place to apply efficiency measurements. Standards for cleaner fuels have been developed and from 2006 all vehicles use unleaded petrol. The taxi recapitalisation project is currently being implemented, although the progress is very slow. This project will focus on the safety of taxis, which will also address energy efficiency in that subsidies will be given for the scrapping of old petrol powered taxis and their replacement by new , safer, diesel powered taxis which will be more energy efficient.. The DME has been running a public education programme aimed at motorists driving habits with a view to more fuel saving efficiencies. The energy efficiency strategy has a target of an improvement in transport efficiency of 9% by 2015

Marketing and awareness
An integrated marketing and communication strategy was developed in support of the DSM objective of saving 152 MW annually and to enhance DSM's overall marketing and public awareness campaigns. The strategy consists of diverse programmes including Energy Efficiency Month and the Power Play TV game.

In September 2005 the DME and Department of Finance (DF) introduced a renewable energy subsidy scheme which would focus on providing once off capital grants for eligible projects. The funds available are limited to R14.5 million for the period 2005/6 to 2007/8. A more sustainable long-term support mechanism is currently under development by the DME.

In 2005 the Mondi Business Paper Mill in Richards Bay managed to reduce its purchased energy consumption by more than 40%. Together with the energy saving they also realized water savings of 18%. The annual energy and water cost saving is about R38-million which goes straight to the bottom line. The Mondi plant has already exceeded the 2015 target as set by the National Energy Efficiency Strategy of South Africa. However, they have already indicated that they plan to improve their energy efficiency even further (Hendricks, 2006).

Energy efficiency improvements in industry (to achieve a target of 12% by 2014) will save around 770 Mt CO_2 over the 25-year period, and save a net R18 billion. Commercial energy efficiency (also with a target of 12% by 2014) could save about R13 billion, and a reduction in CO_2 emissions in 2025 of 12 Mt CO_2 with interventions in improved building design and improved HVAC efficiency (Winkler, 2006).

4.2.2 Renewable energy

At present South Africa's renewable energy (RE) accounts for approximately 9% of the total energy consumption. Most of this energy is generated from fuelwood and dung and not from modern RE technologies. The potential for RE production in South Africa is estimated at 86 843 GWh, which corresponds to about 49 % of the electricity consumption in 2001 (DME, 2004).

In 2004 the DME produced the White Paper on Renewable Energy Policy for South Africa which sets a target of additional 10 000 GWh of renewable energy contribution to final energy consumption, to be produced mainly from biomass, solar and small-scale hydro. This has the potential to create 35 000 jobs, adding R5 billion to the GDP and R687 million to the incomes of low-income households (DME, 2004).The renewable energy is to be utilised for both power generation and non-electric technologies such as solar water heating and biofuels. In late 2005 the DME completed a Renewable Energy Target Monitoring Framework to ensure that progress towards the 2013 RE target is effectively monitored (DME, 2005a).

Table 4.13 shows the estimated theoretical potential contribution of the different RE technologies.

Table 4.13: Technical feasible potential for renewable energy by technology up to 2013

Source: DME (2005)

Renewable energy	GWhs	%
Hydro	*9245*	*10.3*
Pulp and paper	*110*	*0.1*
Sugar bagasse	*5848*	*6.9*
Wind	*64102*	*74*
Landfill gas	*598*	*0.7*
Solar water heating –		
Residential	*4914*	*6*
Commercial	*2026*	*2*
TOTAL	*86 843*	*100*

Solar: South Africa has one of the highest levels of solar radiation in the world. The average daily solar radiation varies between 4.5 and 6.5 kWh/ m^2 compared to about 3.6 kWh/ m^2 for parts of the United States and about 2.5 kWh/ m^2 for Europe and the United Kingdom (DME, 2004).

Wind: The best wind resources are found mostly along the coastal regions with wind speeds of up to 6 m/s.

Biomass: South Africa is a dry country and large parts of the country are not suitable for biomass development. About 1.2% of the country is under forest, so that that the conditions for biomass are generally poor. It is none the less an important source of energy sugar refining, pulp and paper as well as for domestic use in rural areas (Winkler, 2006).

Hydro: There is a significant potential for development of all categories of hydropower in the short and medium terms in specific areas of the country (Figure A1). For example, the Eastern Cape and KwaZulu Natal provinces are endowed with the best potential for the development of small, i.e. less than 10 MW, hydropower plants. The advantages and attractiveness of these small hydropower plants are that they can either be stand-alone or in a hybrid combination with other renewable energy sources. Further, advantages can be derived from association with other uses of water (e.g. water supply, irrigation, flood control, etc), which are critical for the future economic and socio-economic development of South Africa (DME, 2004). The total potential for all types of hydro power in South Africa is 13 560 MW (DME, 2002). The major barriers are high initial cost, the required significant initial investment, the lack of awareness of benefits and opportunities of renewable energy, the centralised structures of conventional energy, financial, legal, regulatory and institutional barriers and the lack of open access to key energy infrastructure such as the national electricity grid, liquid fuels and gas infrastructure (DME 2004).

The following general barriers to the further implementation of renewable energy have been identified (DME 2004):

- Low prices for coal and electricity.
- Competition for resources with other development priorities.
- Many renewable energy technologies remain expensive, on account of higher capital costs, compared to conventional energy supplies for bulk energy supply to urban areas or major industries.
- Financial: High initial capital costs; Implementation of renewable energy technologies needs significant initial investment and may need support for relatively long periods before reaching profitability. Subsidies for competing fossil fuels
- There is a lack of consumer awareness on benefits and opportunities of renewable energy.
- The economic and social system of energy services is based on centralized development around conventional sources of energy, specifically electricity generation, gas supplies, and to some extent, liquid fuel provision.
- Legal and regulatory barriers need to be overcome in order to implement renewable energy technologies and develop markets. There is no legal framework for independent power producers. There are no sufficient government regulations/incentives to stimulate the adoption of RETs by businesses and industries as well as the availability of credit to purchase of RETs.
- There is a lack of non-discriminatory open access to key energy infrastructure such as the national electricity grid, certain liquid fuels and gas infrastructure.

In 2005 the Department of Minerals and Energy established its Finance and Subsidy office for renewable energy (REFSO). The government has approved R4 million to support renewable energy projects for 2005, with more funding secured for 2006-2007. The REFSO mandate includes the management of renewable energy subsidies, and the provision of advice to developers and other stakeholders on renewable energy finance and subsidies (including size of awards, eligibility, procedural requirements etc), as well as opportunities for accessing finance from other sources (DME, 2005b).

In 2006 the Central Energy Fund, which is involved in the search for appropriate energy solutions to meet the future energy needs of the country, established the Energy Development Corporation (EDC) to pursue commercially viable investments in renewable energy.

Eskom is committed to investigate and implement options for the diversification of the energy mix and amongst others, renewable energies with a view to reduce its reliance on coal. For the past ten years Eskom Research, Development and Demonstration, through its Bulk Renewable Energy development programme, has been involved in research of new technologies. Eskom has implemented the following programmes:

Solar energy cookers
Since 1996 the DME and GTZ (German Technical Co-operation organization) have been collaborating on testing the social acceptability of seven different models of solar cookers. Duue to its success the solar cookers are now presented as part of a renewable cooking appliance bundle, including a solar stove, a fuel-efficient wood or coal stove and a heat retained cooker, the HotBag.

Wind
Eskom is investigating a wind energy demonstration facility at Klipheuwel in the Western Cape. The three wind turbines produced a total of 9,826 GWh since the commissioning of the first wind turbine in 2002. The turbines delivered an availability of between 89,78% and 94,63% during 2004, with an energy use factor of between 13,32% and 15,89

Solar
In 2002 a solar dish stirling system was commissioned which sent out a total net energy of 6 438 kWh in 2004. The system was damaged in October 2004 and no electricity was generated for the rest of the reporting period. The research and demonstration has confirmed that the dish is not yet a commercially viable option.

Biomass
Eskom is planning to pilot a biomass gasification technology in the Eastern Cape. Initial discussions started with the affected community and the University of Fort Hare. The energy produced from the gasifier will be utilised for development within the community. It is projected that the system will generate 100 kW of energy.

Ocean energy
Eskom is investigating the feasibility of using ocean energy as a future primary energy source. A resource assessment of the wave and tidal power density along the South African coastline is being researched by Renewable Energy Institute at the University of Stellenbosch. The study is aimed at assessing international technologies and determining which technology to implement in South Africa.

Other renewable energy programmes and strategies
Eskom is rolling out one million SWHs over the next three years. This will be subsidized up to 30%. The potential savings of this programme is 650 MW. The programme targets households, commerce and industry.

Eskom and the DME are embarking on a fuel switching programme, looking at substituting electricity for cooking with LPGas in order to lower the burden of electricity generation. Within the next two months the DME plans to resolve issues in respect of supply and pricing of LPG. It is expected that this programme will save 500 MW.

In December 2007 the government published a Biofuels Industrial Strategy. This strategy is driven mainly to address issues pertaining to poverty and economic development. It seeks to achieve a 2% penetration level of biofuels in the national liquid fuel industry which amounts to about 400 million litres per annum. The biofuels strategy aims to support a variety of national priorities like job creation, sustainable development and Black Economic Empowerment. It seeks to stimulate rural development and poverty reduction. Furthermore, biofuels can contribute towards the achievement of the renewable energy strategy; energy security and reduce greenhouse gas emissions (DME, 2007).

4.2.3 Other measures and their impacts

In 1995 the Southern African Power Pool (SAPP) was created to develop electricity trade, reduce energy costs and promote greater supply stability for the region's 12 national utilities: Botswana Power Corporation (BPC); Electricidade de Mocambique (EDM); Angola's Empresa Nacional de Electricidade (ENE); Electricity Supply Commission of Malawi (Escom); South Africa's Eskom; Lesotho Electricity Corporation (LEC); Namibia's NamPower; Swaziland Electricity Board (SEB); the Democratic Republic of Congo's (DRC) Societé Nationale d'Electricité (SNEL); Tanzania Electric Supply Company (Tanesco); Zimbabwe Electricity Supply Authority (Zesa) and Zambia Electricity Supply Corporation (Zesco).

Electricity trade continues to grow at a rate of approximately 20% per annum. The SAPP aims at providing electricity to all SADC countries in an environmentally sound manner and also focuses on producing hydropower from the Inga hydropower plant in the DRC which has a potential of generating up to 100 000MW using the Congo River. Other than trade in electricity, the procurement of natural gas from Mozambique and Namibia by Sasol for synfuel production is another positive outcome of regional cooperation by the SAPP.

In the light of the current national electricity crisis Eskom has embarked on a massive New Build Programme to double its generation capacity from about 40 000 MW to 80 000 MW by 2025. In the first phase open cycle gas turbines are being added to help with peak demand; three mothballed coal-fired power stations are being recommissioned and few new coal-fired power stations are being planned. It is also plans an expansion of its nuclear capacity with new pressurized water reactors (PWRs) and possibly pebble bed modular reactors (PBMRs) to provide 25% of electricity by 2025. The total cost of the expansion programme is estimated to be R300 billion. The bill for the expansion programme will ultimately be paid by the consumer and many analysts see sharp increases in the price of electricity from 2008 and beyond. Most of the power stations to be build by Eskom will be coal-fired and this will further deplete the country's coal reserves and contribute to global warming and climate change

Co-generation programmes are currently being promoted in the industrial and mining sectors. Waste heat recovery or combined heat power are efficient options and a cheaper alternative to supply side expansion. Co-generation technology provides greater conversion efficiencies than traditional generation methods as it harnesses heat that would otherwise be wasted. This can result in up to more than a doubling of thermal efficiency or higher heat values.

In addition to Eskom's expansion programme, government has opened up power generation to private investors with a 30% of new generation capacity to be sourced from independent power producers (Hallows & Munnik, 2007).

The first commercial wind farm is currently under construction near Darling, about 75 km from Cape Town. It is a joint partnership between the national government, the Danish government, the Central Energy Fund and the Darling Independent Power Producing Company. This R70 million project is the first independent power producing company in South Africa. By July 2008 it should be fully operational and will produce 5.2 MW electricity from four wind turbines. The City of Cape Town has signed a twenty year purchasing power agreement with the company. Electricity will be fed into the national grid and will then be 'wheeled' through the national grid and onwards to customers who have chosen to pay an extra 25c per kilowatt-hour (kWh) surcharge to receive a 'green' power supply. One of the main benefits of the project is that it creates an enabling environment for similar projects and it will go a long way in inspiring confidence in the capital outlay of renewable energy technologies (www.southafricainfo/doing_business/economy/windpower.htm).

5. Threats to energy security, measures to enhance energy security and their impacts at the household level

5.1 Threats to energy security

5.1.1 Share of commercial energy consumption

In 1999 the residential sector consumed 18% of final energy, of which biomass contributes 14%, electricity 62%, coal 8%, paraffin 12%, and LPG and candles 2% each. In 2004 the household sector consumed 21% of final energy of which biomass contributes 12%, electricity 68%, coal 6%, paraffin 10%, LPGas 3-4% and candles 2% (DME 2005). Multiple-fuel use is still prevalent with an increase in the use of electricity and a slight decrease in the use of paraffin between 1999 and 2004.

Table 5.1 shows the key electricity indicators for South Africa from 1985 to 2005

Table 5.1: Electricity indicators in South Africa

Source: Ziramba, E. 2008

Year	Electricity consumption GWh	Electricity consumption/GDP kWh/$	Electricity consumption kWh/capita	World Electricity consumption kWh/capita
1975	74,894	.845	2801.12	1471.02
1980	98,951	1.052	3644.44	1718.18
1985	143,491	1.317	4298,1	1869,37
1990	167,226	1.406	4431.48	2066.55
1995	187,825	1.498	4433.59	2145.52
2000	210,670	1.462	4416.57	2322.26
2005	244,920	1.423	4847.64	2595.74

Between 1975 and 2005, electricity consumption had increased by more than 200%, whilst over the same period per capita consumption had almost doubled and is above world per capita consumption.

Until the middle 1990s the electricity intensity (electricity consumption/GDP) showed an upward trend which means that electricity consumption was higher than economic growth.

5.1.2 Expenditure on energy

Low-income households spend 10-20% of their income on energy, whilst medium to high-income households spend 3-5% of their income on energy (Cape Town Energy Strategy, 2003). The average energy burden of poor households in remote rural villages is 18%. After an allocation of 50kWh free basic electricity per month the energy burden is reduced to 12% as illustrated in Table 11. Other than electricity which is subsidised for the poor, the sale of paraffin is exempted from VAT (value added tax) which is 14%.

Table 5.2: Mean expenditure by poor households on electricity and other fuels, as a percentage of total household expenditure

Source: Prasad & Ranninger (2003)

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

In rural areas, where more than 40% of the population live, wood and coal are used to meet most of poor households' energy needs, which means that people in these households are exposed to noxious emissions.

In view of the rising demand for coal worldwide, especially from China, coal prices are likely to rise rapidly which will have significant effects for the country's energy economy. Higher coal prices will increase the price of electricity and will also increase the energy cost burden of those people who use coal for cooking and heating.

Levels of energy insecurity are difficult to quantify because they are tied to other socio-economic factors threatening the survival of the poor. However, there is little doubt that energy poverty contributes to the plight of the most vulnerable members of the household such as the elderly, the infirm and very young. Cost and availability are the most important determinants of poor people's choice of fuels. Cost refers to the price of the fuel but also the cost of the appliance to use the fuel.

Transport is another factor which affects the cost and availability of fuels as well as appliances. This impacts especially on rural households who have to travel significant distances to buy fuels like paraffin; or they have to buy smaller quantities from local traders at a much higher price. In the case of paraffin and LPG, where there are several steps in the distribution chain, the mark-ups at each step raise the final price, increasing the energy burden of the poor which contributes to their energy insecurity (Prasad, 2006).

Since 2000 the energy burden (expenditure) facing poor low-income households increased remarkably. Table 5.3 illustrates the increases in electricity and paraffin for the period 1994 to 2007.

Table 5.3: Electricity and paraffin price increases from 1994 to 2007

Source: SSA (2007) and own calculations

Year	Average electricity (c/kWh)	% increase from 1994	Average paraffin (R/litre)	% increase from 1994
1994	*20.6*	*0.0*	*1.2*	*0.0*
1998	*28.7*	*39.3*	*1.3*	*8.3*
1999	*30.9*	*50.0*	*1.6*	*33.3*
2000	*33.2*	*61.2*	*2.7*	*125*
2001	*36.2*	*75.7*	*2.9*	*141.7*
2002	*38.8*	*88.3*	*3.3*	*175.0*
2005	*43.8*	*112.6*	*5.5*	*358.3*
2007	*47.2*	*129.1*	*6.5*	*441.7*

Since 1994 the price of electricity has increased by over 100%, less severely than the increase in paraffin. In the light of the current electricity crisis, Nersa has approved an almost 30% increase in the price of electricity to be implemented in July 2008.

Table 5.4 indicates how much different income groups for rural and urban areas spent on energy per month. In absolute terms, households (both rural and urban) spent more on energy as income levels increase. The poor spends proportionally more on energy than the rich.

Table 5.4: Monthly income and household expenditure on energy in rural Limpopo and urban Khayelitsha

Source: Prasad and Visagie 2006.

	Q1 (LOW)	Q2	Q3	Q4	Q5 (HIGH)
Rural Limpopo					
Mean monthly income in Rand	341	613	934	1,424	2,812
Monthly energy expenditure Rand	64	89	79	98	160
% of monthly income spent on energy	19	15	8	7	6
Urban Khayelitsha					
Mean monthly income in Rand	514	928	1,448	2,1249	4610
Monthly energy expenditure Rand	74	93	90	104	133
% of monthly income spent on energy	14	10	6	5	3

Table 5.5 shows fuel use for cooking by income quintile in rural Limpopo and urban Khayelitsha. The rural households include solar home system owners, electrified and unelectrified households. In rural households we see a decrease in the use of fuelwood from the lowest to the highest quintile

Table 5.5: Household fuel use for cooking according to income quintiles in rural Limpopo and urban Khayelitsha, South Africa (%)

Source: Prasad & Visagie, 2006.

	Q1 (LOW)	Q2	Q3	Q4	Q5 (HIGH)
Rural Limpopo					
Fuelwood	98	93	96	89	79
Kerosene (paraffin)	2	2	22	5	2
LPGas	0	2	0	0	13
Electricity	0	4	2	5	7
Urban Khayelitsha					

Fuelwood	0	0	0	0	0
Kerosene (paraffin)	58	43	48	25	13
LPGas	7	5	5	2	13
Electricity	35	48	52	73	73

A small percentage of rural households use electricity for cooking, mostly in the higher income households. In urban areas the use of kerosene decreases with increase in income and quite a large percentage of households use electricity for cooking, increasing with income.

Paraffin

Almost a quarter of the South African population use paraffin for cooking, whilst 14.6% use it for heating (Statssa, 2001). The price of paraffin rose by over 400% since 1994, whilst people's income rose with the rate of inflation (~ 6% per annum), thus resulting in a significant energy cost increase for especially the poor. The price of paraffin is linked to the volatility of the international oil markets, which poses a threat to security of supply for the poor. The country has a good distribution network and paraffin is easily available in urban areas. On the other hand, the paraffin distribution chain is characterized by many resellers (middle persons) which make paraffin more expensive. Although the government sets a maximum price at which paraffin may be charged, this is seldom monitored. The price of paraffin is on average 10% more expensive in rural areas than urban areas.

The use of paraffin in informal settlements is also associated with fires caused mostly by the use of cheap and dangerous appliances in some cases. Paraffin ingestion is common amongst children who mistake paraffin for soft drink. People's health is also negatively affected by the use of paraffin. Paraffin, like electricity and LPG, is a dangerous fuel but made more dangerous by the way it is packaged in South Africa. Energy supply can only be secure if it is supplied safely and appliances do not pose a threat to people's lives. As a result of the toxicity inherent in paraffin itself, the unregulated nature of the supply chain, the inefficient design and quality of paraffin appliances and the poor and often stressed living environments in which they are used, a host of vulnerabilities are created.

The externality costs associated with the use of paraffin use are high. Treasury Report (National Treasury Report, 2003) estimates that the use of approximately 700 million litres of paraffin each year results in a loss of R104 564 million through death, burns and ingestions, a burden 50 times higher that the annual R2.1 million turnover in paraffin sales (HSRC, 2006).

Coal

Coal remains the fuel of preference for cooking and space heating in low-income households in the central Highveld region near coal mines. Coal is the lowest priced energy source available in the region and in some instances it is collected free near the mines. Approximately 1 million households use just over 1 million tons of coal per annum (DME, 2004). The use of coal, especially in winter, leads to high concentrations of air pollution which has detrimental effects on the health of the surrounding communities. Studies in the Vaal Triangle have shown that children have an approximately tenfold higher incidence of respiratory tract disease than children elsewhere. This costs the state funded health care programmes almost R455 million per annum, and this does not include the total health and environmental cost to society. The price of coal has almost doubled over the past year which will increase poor people's spending on energy.

Fuelwood

Approximately 21% of people use wood for cooking and 25% of people use it for heating (SSA, 2001). Fuelwood is mostly used by the rural poor for cooking and heating. Most of the fuel used is collected rather than purchased. Very poor households depending on non-commercial fuelwood sources are less likely to shift to commercial fuels unless their economic circumstances improve. This enforced dependence on non-commercial fuels brings with it a number of sustainability issues – health impacts, environmental degradation, decreased productivity and energy poverty (Winkler, 2006). The commercialization of firewood and the depletion of forests mean further energy poverty

and deteriorating livelihoods. The country lacks detailed information on the use of fuelwood and other non-commercial fuels like dung and plant residues.

LPG
On average 2% of the population uses gas for cooking and heating. Amongst the poor the usage of LPG is negligible because of the high cost of gas and gas appliances compared to paraffin and electricity. The LPG distribution network is also poor compared to the availability of paraffin.

5.1.2 Access to modern fuels for cooking and lighting

By 2001, 67% of the population, or 30.8 million people, had access to electricity. In rural areas the proportion of the population with access was 50%; in urban areas it was 80%. Table 5.6 shows the urban and rural electrification levels from 1998 to 2001.

Table 5.6: Urban and rural electrification information from 1998 to 2001
Source: Based on figures from Statistics South Africa (2003)

Year	*Type of area*	*% electrified*
2001	Rural	49.10
	Urban	77.20
	Total	66.10
2000	Rural	45.75
	Urban	74.24
	Total	62.95
1999	Rural	46.29
	Urban	79.81
	Total	66.31
1998	Rural	42.59
	Urban	76.69

The 2001 Census showed that many households are still using multiple fuels. Comparing energy sources used for cooking in 1996 and 2001 (Table 5.7). Households using electricity have increased by only 4.3%.

Table 5.7: Comparing energy sources for cooking in 1996 and 2001
Source: Census data 1996 and 2001 from Statistics South Africa (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

5.2 Measures and their impacts to enhance energy security

5.2.1 Enhancing energy efficiency

In the Energy White Paper (1998) government sets the following intentions:

- Promotion of energy efficiency standards and codes for thermal performance of buildings

- Energy efficiency education and awareness raising campaigns and programmes and
- The introduction of a domestic appliance labeling programme.

The Energy Efficiency Strategy sets a target of 10% for the household sector to be achieved by 2015 through awareness campaigns, appliance labelling and investment in research and technology development. The core objectives of the Energy Strategy for the household sector are to:

- combat pollution on health grounds;
- mitigate the effects of peak demand on power capacity;
- introduce standards for housing and labeling/efficiency standards for household appliances; and
- introduce state-of-the-art technologies.

In the residential sector energy savings will be achieved through awareness raising and education programmes; the introduction of appliance labelling; the standard for energy efficiency housing will be made mandatory by its incorporation into the National Building Regulations (DME, 2005).Energy efficiency measures include energy efficient housing shells, the use of CFLs, the use of geyser insulation blankets, the installation of solar water heating, replacing other fuels with LPG for cooking, and replacing paraffin with electricity for lighting. The application of these combined measures could save about R1 billion rand and reduce CO2 emissions in 2025 by 4 Mt (Winkler, 2006).

Low-cost houses have been built with no consideration to energy efficient design principles. Poor households have to spend large amounts of money on fuel for space heating and normally, dirty, polluting fuels such as coal and paraffin are used. By designing houses in an energy efficient manner, the amount of energy required to keep the house comfortable could be reduced dramatically, thereby saving money as well as improving the air quality inside and outside the house. The benefits of energy efficient design are (IIEC, 2003):

- improved comfort of the home all year-round;
- reduced household space heating requirements in winter, i.e less emissions and smoke inhalation if burning fossil fuels to heat the home;
- up to 60 percent reduction in electricity use associated with environmentally sound houses in South Africa;
- Reduced energy bills that will allow home-owners to have spare money to pay for services or other priorities;
- Improved health and safety of occupants from reduced indoor smoke and fewer fires from faulty heating and cooking devices;
- Improved air quality of life for residents and communities; and
- climate change mitigation and emissions reductions.

With specific reference to the low-cost housing sector, the DME has assisted in the development of appropriate guidelines in conjunction with the Department of Housing (DoH) and all other public authorities responsible for housing standards and construction. These guidelines will facilitate minimal lifetime costs and adequate thermal comfort levels. Although both White Papers mention energy efficient housing design, very few measures have been implemented due to cost constraints. The household sector also has great potential for energy saving given the National Housing Programme. Ultimately, building design plays an important part in determining the energy usage of households. In the residential sector savings to households from greater energy efficiency measures can directly contribute to poverty alleviation in the low-income household sector.

Low-income electrified households: three interventions have been identified that have the potential to result in reduced electricity consumption and reduction in carbon dioxide emissions. Replacing electric geysers with solar water heaters (SWHs) will result in a reduction in energy for water heating of 1 132 kWh per year (SSN, 2004). This translates into an annual average cost saving of

33.5% per unit for low-income electrified households. Total saving across the electrified low-income households will reach 346 GWh by 2020 (Winkler, 2006). Installation of ceilings will result in less electricity being consumed and less dependence on other fuels. If a $30m^2$ house is fitted with a ceiling the electricity saving is estimated to be 1 345 kWh/ annum representing an average saving of 19.4%. Total savings across the electrified low-income households would reach 508 GWh by 2020. Replacing incandescent lights with CFLs by 2020 will resulting 223 kWh reduction in electricity annually.

Middle-to-high-income households: Replacing an electric geyser with a SWH has the potential monthly electricity saving of 43% per household. Total saving reaches 1 735 GWh by 2020. GHG emissions savings will be 1.018 million tons carbon dioxide per annum (Winkler, 2006). Replacing incandescent lights with CFLs will result in a saving of 335.7 kWh per household. Total savings reach 6 584 GWh by 2020. GHG emission savings will amount to 85 500 tons of carbon dioxide per annum (SEA, 2003).

According to Howells (2003) the thermal efficiency of buildings can be improved through the addition of insulation, ceilings and general efficiency building standards. An improvement in insulation will result in a 30% reduction in space heating requirements. Haw and Hughes (2007) assume a high penetration rate of 65% on electric geysers by 2015. Geyser blankets have the potential to save 14 % of energy heating costs.

Eskom initiated a massive CFL drive following the power outages in the Western Cape. In the base case a low penetration rate is assumed (5.3%) in urban areas and 1.9% in rural areas. The reference case assumes a penetration of 40% by 2015 in urban areas and 35% in rural areas. The penetration levels are expected to increase to 60% and 50% by 2030 in urban and rural areas respectively (Haw et al, 2007).

The household appliance-labelling programme forms part of the residential energy efficiency sector programme. The objective of the residential sector programme to achieve a final energy demand reduction of 10% by 2015. Under the appliance labelling programme it will be mandatory for all electrical household appliances to be labelled according to the national energy efficiency standards by 2012 (DME, 2005).

A key barrier to a successful implementation of the Energy Efficiency Strategy at the residential level is lack of information – efficiency benefits and opportunities are often overlooked because of a lack of knowledge and information about energy efficiency.

In late December 2005 a bolt ripped one of the turbine motors at the Koeberg Nuclear Power station near Cape Town. This plunged the Western Cape into a prolonged electric supply crisis marked by blackouts and load shedding over a period of eight months. The objectives of an Eskom recovery plan were met through a short term DSM programme. Table 5.8 outlines the planned and actual savings achieved through the recovery plan. The roll out of CFLs performed the best, followed by energy efficiency campaigns and customer self-generation where businesses and industries use their own generating devices during peak periods. The switching from electricity cooking to cooking with gas performed rather poorly. Poor households were asked to exchange their electric two-plate stoves for gas burners and were given a few free gas vouchers. Most of the poor reverted to cooking with electricity after using the gas vouchers as LPG is more expensive than electricity and the gas supply network is not well developed in townships. The price of LPGas is unregulated and is much more expensive than subsidised electricity for the poor (50 kWhs free per month).

Table 5.8: Short term DSM savings

Source: Hallowes & Munnik (2007)

Order of savings	Means	Planned saving (MW)	Actual savings (MW)	Detail
1	*Efficient lighting*	*150*	*229*	*Roll out of 5 million CFLs*
2	*Energy efficiency campaigns*	*80-160*	*80-160*	*Promotion & advertising, specific appeals, pool pump switch off in winter and gas rather than*

				electricity
3	*Customer self generation*	*50*	*58*	*Awareness and promotional campaigns and customer visits*
4	*Switch load to gas*	*50*	*22*	*Mostly poor households replacing electric cooking with gas*
5	*Industrial & commercial efficiency*	*40*	*12*	*Schools, hotels, malls and office blocks. Lighting, duel fuel systems and building management. Eskombuilding retrofit*
TOTAL		***400***	***418-498***	

5.2.2 Promoting renewable energy

Currently four concessionaires are providing solar home systems (SHSs) in four of the original six rural concession areas. The SHS is subsidized from the National Electrification Programme at a cost of R3 500 per connection. The customer pays a R100 connection fee and R58 per month. Each system has a 50 W output and provides enough electricity for four lights, a radio, a black and white TV and the facility to charge a cell phone. Critics point out that it does not go far enough to satisfy the thermal needs of the poor.

Solar water heating is a matured industry in South Africa and about 18% of the urban residential electricity consumption could be replaced by SWHs (CaBEERE, 2004). Solar water heating could provide around 25% of the total target of 10 000 GWhs by 2013 (national renewable energy target set by Government). SWH industry has the potential of adding R1.3 billion to the GDP and R176 million to the income of low-income households. It is estimated that manufacturing, installing and servicing of SWHs will create 6 000 jobs. SWHs improve welfare of the poor by having hot water and spending less for it (hot water improves hygiene and health).The market provides 3 niches for the dissemination of SWHs. If all RDP houses (low-income households) are fitted with SWHs 6.5 million people will enjoy the comfort of hot water and pay less for it. Second niche is middle-to-high income groups-to be targeted Third niche is in the commercial and public sectors such as hospitals, offices and prisons (Prasad & Visagie, 2005).

In the past the promotion of SWHs use to be hampered by low cost of coal-based electricity generation and the lack of regulations in national and local building codes. Since July 2008 the price of electricity has increased by over 30% and this coupled with the introduction and development of a stimulating regulatory environment may contribute to the expansion of the SWH market. Many poor people live in areas without piped water and can therefore not benefit from normal SWH systems even if installation is subsidized. Unless renewable energy technologies like SWHs are subsidised the uptake will be slow because of the upfront cost of these technologies which are much higher than electric geysers.

In the light of the recent blackouts in certain parts of the country, solar water heating is gaining popularity. The City of Cape Town is in the process of implementing a bylaw on new homes. Table 5.9 shows the potential penetration rate for SWHs into new houses.

Table 5.9: Penetration rate of SWHs in different household types

Source: Haw & Hughes (2007)

New houses	2008 (%)	2015 (%)	2030 (%)
Rural rich electrified	*20*	*25*	*60*
Rural poor electrified	*20*	*25*	*60*
Rural poor unlectrified.	*1*	*5*	*10*
Urban rich electrified.	*40*	*50*	*75*
Urban poor electrified.	*50*	*55*	*80*
Urban poor unelectrified	*2*	*7*	*15*

In Novenmber 2007 the DME published its Biofuels Strategy which seeks to stimulate rural economic development by creating sustainable income opportunities. One of the goals of this

strategy is to create jobs in underdeveloped areas, such as the former homelands, where agriculture was undermined by the apartheid system (DME, 2007). Governments sets a target of 2% penetration that has the potential to create 25 000 jobs. It will reduce unemployment by 0.6%; increase economic growth by 0.05%; achieve a balance of payment saving of R1.7 billion and a greenhouse gas saving of R100 million per annum (DME, 2007). Furthermore, the jobs-to-investment ratio is 100 times higher than for crude oil refinery.

5.2.3 Other measures

Access to electricity is generally seen as an important step in socio-economic development and many countries, including South Africa, are working towards universal access. Government energy policies in relation to the household sector have been, in fact, driven by the need to compensate for the injustices of the apartheid era. A priority for the government is to increase access to affordable energy services while minimizing the negative effects of energy use on personal health, the environment and to promote safety. To this end, government embarked on a National Electrification Programme (NEP) in the early 1990s, seeking to address the electrification backlog fully by 2012.

The first phase of the programme (1994-1999) was funded entirely by the electricity supply industry (Eskom and municipalities, the latter being responsible for distribution). By 2001, 67% of the population, or 30.8 million people, had access to electricity. In rural areas the proportion of the population with access was 50%; in urban areas it was 80%.

An evaluation of the first phase of the Electrification Programme concluded that, even though benefits are limited in households where electricity is only used for lighting and media purposes, electrification in general improved the welfare of households and communities through street lighting, improved health care services and enhanced educational outcomes at schools. Although the Programme has been a success in terms of expanding the numbers of South African households connected to the national grid, the following limitations were observed:

- The wider socio-economic development benefits of electrification seemed disappointing, partly because this improved 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 and subsidies.

Although the majority of urban and peri-urban poor in South Africa have access to grid electricity, affordability remains a major problem, and the 2001 Census showed that many households are still using multiple fuels. The majority of electrified households (both urban and rural poor) use electricity for lighting, but a large percentage use non-electric fuels for cooking and heating. This may be attributed to higher costs of electricity appliances compared to for example paraffin appliances. Other reasons may be that fuel wood is freely available and the fact that paraffin can be bought in small quantities and is easily available.

In 2003 the government introduced the Electricity Basic Services Support Tariff (EBSST) to assist poor households with a record of using less than 150kWh monthly. These households qualify for a free allocation of 50kWh of electricity per month. The implementation of EBSST is fraught with difficulties, not least of which are the various pricing and delivery limits imposed by the plethora of different distribution agencies (Prasad et al 2006). Although EBSST partially addresses the issue of affordability, it is not the only solution to the problem of energy poverty, as it does not reach people who are living without the electricity infrastructure, nor can people hope to be included in the infrastructure if they live on unauthorised land.

Targeting of the poor to receive the subsidy is a serious challenge. In many instances the less poor have also benefited from this poverty tariff. The government has recognized this fact and has developed a Free Basic Alternative Energy Policy (FBAE) for the poor. FBAE include alternative fuels/technologies (paraffin, LPG, renewable energy). This has the potential to advance access and promote a more equitable share in energy services. But currently capacity constraints (inadequate staff complements, lack of skills and skewed budgeting) at the municipality level make it hard to identify beneficiaries for FBAE.

Many of the poor resist the acceptance of alternative fuels to electricity as they believe it prejudices their chances of being connected to electricity in the future. This may largely be attributed to people's lack of information with regard to the FBAE policy. Focus group workshops have shown that people are willing to accept alternative fuels to electricity if they understand that it is a temporary measure and does not compromise their eligibility for electrification in the future.

Currently four concessionaires are providing solar home systems (SHSs) in four of the original six rural concession areas. The SHS is subsidized from the National Electrification Programme at a cost of R3 500 per connection. The customer pays a R100 connection fee and R58 per month. The system provides enough electricity for four lights, a radio, a black and white TV and the facility to charge a cell phone. Critics point out that it does not go far enough to satisfy the thermal needs of the poor.

Despite the fact that most of the urban poor have access to grid electricity, paraffin remains the fuel of necessity for cooking for a large number of urban households. This may be attributed to a good paraffin distribution network, easy access in slum areas, relatively cheap appliances and the fact that paraffin can be purchased in small quantities which match the irregular income streams of the poor. In 2001 the government exempted the sale of paraffin from value added tax (VAT) to make it more affordable to the poor. Because the urban poor live in high density areas, shack fires caused by the use of paraffin lead to the lost of lives and property as well as ingestion by small children.

LPG is used less frequently by the urban poor because of perceptions of danger associated with its use, poor distribution networks in slum areas, upfront cost for containers, high cost of appliances and the fact that LPG is relatively far more expensive than electricity and paraffin. In order to overcome these barriers, Totalgaz Southern Afica has produced a 5kg gas cylinder called Shesha. It is easily transportable and comes in a value pack with a burner and cooker top for a deposit of R50 per cylinder. Shesha comes with safety features and a connector that can be used for other appliances such as heaters lamps and cookers. It is meant to be distributed in rural areas and urban informal settlements. Thus far the take-off has been slow.

In 2004 government introduced an Integrated Household Clean Energy Strategy to promote the Basa Njengo Magogo method of lighting a fire, low-smoke fuels and housing insulation.

Basa Njengo Magogo technology: Government has developed an Integrated Household Clean Energy Strategy as a transitory measure between coal and the full use of electricity. The key components of the strategy are (DME, 2004):

- marketing and awareness of the low-smoke generating top-down ignition of coal fires (Basa Njengo Magogo);
- marketing and distribution of low-smoke fuels; and
- implementation of housing insulation and design.

The Basa Njengo Magogo method of lighting household coal fires is not only a least-cost option, but reduces smoke emissions by up to 50%. This technology is quiker to ignite than the conventional method of lighting coal fires; it burns longer for the same amount of coal and has been shown to use 20% less fuel.

Low-smoke fuels: Studies have shown that the use of low-smoke fuel reduces the particulate pollution from coal combustion by up to 50% (DME, 2004). The manufacture of low-smoke fuels is more costly than raw coal and the government is currently addressing the matter.

Housing insulation: The insulation of houses in terms of ceilings and wall insulation, especially of the informal type, reduces energy consumption. This reduces indoor air pollution, and other cleaner fuels like electricity, paraffin and LPG becomes more affordable. Government is currently investigating safe and affordable insulation material.

In 2001 government removed VAT from the price of paraffin in an effort to reduce the cost of the energy source most widely used by the urban poor.

The government is piloting a few Integrated Energy Centres in rural communities to provide a range of fuels and appliances as well as information on household energy usage. The plan is to establish these centres in areas with high energy needs and poor service provision. Such centres would have a special relevance in low-income rural areas where they would form an important component of the

government's Integrated Sustainable Rural Development Programme. The proposed centres would be public-private-community partnerships, with funding mainly from Sasol, local government and community groups. Through bulk buying these centres would be able to obtain fuels and appliances at lower costs and thereby reduce the costs associated with high transport costs and multiple-step distribution chains (Winkler, 2006).

The Paraffin Safety Association of Southern Africa (Pasasa) was formed in 1996 out of concern for the high levels of paraffin poisoning and safety issues related to the use of paraffin. After 2003 the association has expanded its activities to address all negative consequences of paraffin use, including burn injuries, township fires and the inhalation of toxic fumes. It set itself the goal of having the number of paraffin related incidents by 2009. To achieve this goal it is currently working on three fronts:

- providing education, awareness raising and training to paraffin users through a network of partnerships;
- working with industry, regulatory bodies and government to set standards and lobby for these standards to be made mandatory; and
- compiling a knowledge base about the domestic use of paraffin and its consequences.

Pasasa is currently piloting a safer paraffin project that aims to improve safety as well as the safe handling and use of paraffin. The intention is that government can design policies to make safer paraffin stoves available to the broader South African population who use paraffin.

6. Conclusions and suggestions for the next phase of the study

6.1 Energy security at the national level

This report has examined a number of key threats to national energy security for South Africa.The major threats to national security are:

1. South Africa shows a reasonably low level of import dependency generally. The net import dependency is around 20% which makes the country less vulnerable to disruptions in international energy supply and increases in prices of imported energy. South Africa imports mostly crude oil which provides 60% of the country's petroleum needs, the balance is locally produced through coal-to-liquid and gas-to liquid at Sasol and Mossgas. The main threats to the security of supply of coal are the increasing demand for coal due to the expansion of Eskom's generation capacity and as well as the dramatic increase in coal prices globally. Most of the Eskom power stations are inefficient and uses large amounts of coal and water. The scarcity of the latter could further threaten electricity generation.
2. Diversification of primary energy supply shows an improvement over the last six years. A higher Shannon-Wiener index value denotes better diversification of primary energy supply.
3. The South African economy is highly energy intensive compared to other developing countries. This means that for every rand (dollar) of economic output, a large amount of energy is required (Hughes et al, 2002). Annual per capita energy consumption in South Africa is 2.51 tons of oil equivalents (Toe) compared to a world average of 1.67.
4. In terms of energy reserves, the country has large amounts of coal with limited reserves for natural gas and crude oil. South Africa has good wind potential along the coast and a high solar radiation in especially the Northern Cape.
5. The country is investing billions of rands in building new coal-fired power plants and has created a framework to encourage investments in renewable energy.
6. The value of total imports increased significantly from 2004 onwards, exceeding the total value of exports, making South Africa a net import country. Both vulnerability indices show

a remarkable increase from 2002 to 2006. This poses a significant security threat to South Africa in terms of dependence on energy imports as well as increases in the costs of imported

Measures to address the threats could be summarised as follows:

1. In 2005 the government introduced an Energy Efficiency Strategy which sets a target of 12% to be achieved in 2015 by the industrial, commercial residential sectors. The DSM programme is very successful and has exceeded its annual target of 152 MW/annum. A DSM programme was developed for schools to raise awareness about energy efficiency measures and to encourage energy conservation at schools. The transport sector uses three quarters of petroleum products, making it the obvious place to apply efficiency measurements. Standards for cleaner fuels have been developed and from 2006 all vehicles use unleaded petrol.
2. In 2004 the DME produced the *White Paper on Renewable Energy Policy for South Africa* which sets a target of additional 10 000 GWh of renewable energy contribution to final energy consumption, to be produced mainly from biomass, solar and small-scale hydro. This has the potential to create 35 000 jobs, adding R5 billion to the GDP and R687 million to the incomes of low-income households (DME, 2004).The renewable energy is to be utilised for both power generation and non-electric technologies such as solar water heating and biofuels. The country has high levels of solar radiation and wind speeds of about 6 m/s along the coast and escarpment areas. The general barriers for the implementation of RE are: low cost of electricity, competition for resources with other development priorities, and many renewable energy technologies are currently expensive on account of high capital costs.
3. The biofuel strategy is driven mainly to address issues pertaining to poverty and economic development. It seeks to achieve a 2% penetration level of biofuels in the national liquid fuel industry which amounts to about 400 million litres per annum. The biofuels strategy aims to support a variety of national priorities like job creation, sustainable development and Black Economic Empowerment.
4. In 1995 the Southern African Power Pool was created to expand electricity trade, reducing energy costs and provide greater supply stability for the region. Trade in the region is growing at about 20% per annum.

6.2 Energy security at the household level

At household level the main threats to energy security can be listed as follows:

1. The share of household energy expenditure in relation to average income is higher for low-income households compared to higher income households.
2. The rise in the price of crude oil has increased the price of paraffin, a fuel used by a large percentage of urban and rural households for cooking and heating.
3. Due to the large investment in Eskom's new build programme, the cost of electricity has increased significantly and will increase in future. Concern is that many poorer households will revert to dirty fuels especially for cooking and heating.
4. Higher coal prices will increase the price of electricity and will also increase the energy cost burden of those people who use coal for cooking and heating.
5. More than 80% of people in urban areas have access to electricity and over 50% in rural areas have access to electricity. In urban areas access to clean energy is not the main problem, but rather the ability to afford clean energy services. In some rural areas the challenge is both affordability and access to clean energy services and appliances.
6. The price of LPGas is relatively high, is unregulated and the country has a poor distribution network.

7. Transport is another factor which affects the cost and availability of fuels. This impacts especially on rural households who have to travel significant distances to buy fuels like paraffin; or they have to buy smaller quantities from local traders at a much higher price.
8.

Measures to address the threats could be summarised as follows:

1. The Energy Efficiency Strategy sets a target of 10% for the household sector to be achieved by 2015 through awareness campaigns, appliance labelling and investment in research and technology development. In the residential sector, energy efficiency measurers such as energy efficient housing shells, the use of CFLs, the use of geyser insulation blankets, the installation of solar water heating, are being implemented.
2. Biofuels Strategy seeks to stimulate rural economic development by creating sustainable income opportunities. One of the goals of this strategy is to create jobs in underdeveloped areas, such as the former homelands, where agriculture was undermined by the apartheid system (DME, 2007). Governments sets a target of 2% penetration that has the potential to create 25 000 jobs. It will reduce unemployment by 0.6%; increase economic growth by 0.05%; achieve a balance of payment saving of R1.7 billion and a greenhouse gas saving of R100 million per annum (DME, 2007).
3. Through the first phase of the National Electrification Programme (1992 – 1999), Eskom and municipalities electrified more than 2.5 million disadvantaged households as well as schools and clinics which would otherwise not have been electrified. This increased the electrification rate from 36% in 1994 to 67% in 1999 – a great achievement by any standard.
4. Government realised that many poor households with access to electricity could not afford it and subsequently introduced the free basic electricity tariff, whereby poor households qualified for 50 kWh free electricity per month. This excluded a large section of the rural poor that is not electrified. The government recognized this and developed a Free Basic Alternative Energy Policy (FBAE) for the poor. FBAE include alternative fuels/technologies (paraffin, LPG, renewable energy).
5. In 2004 government introduced the Integrated Household Clean Energy Strategy which focused on marketing and awareness of the low-smoke generating top-down ignition of coal fires (Basa Njengo Magogo), the marketing and distribution of low-smoke fuels and the implementation of housing insulation and design.

6.3 Limitations and scope for further study

Many programmes in energy efficiency and renewable energy, aimed to promote energy security, were recently introduced and as such it is not possible to measure their impacts.

In South Africa renewable energy technologies are in their infancy. Energy efficiency programmes are well established and success/failures of these programmes better recorded. Micro-level impact assessments are hard to quantify and a number points could not be presented because no literature is available. A more in-depth assessment of threats and measures as well as their impacts would require more resources and a more narrow focus.

In a subsequent phase the study could focus on a more in-depth analysis of measures and strategies to enhance security and should include a form of primary research. Future research could also look at the impact of power sector reform/liberalization on energy security.

6.4 Recommendations

6.4.1 National

- The National Energy Regulator of South Africa should more rigorously regulate the supply and cost of coal to power stations and not leave it to market forces.
- Eskom should contract cross-border independent power producers (IPPs).

- Government should fast tract the establishment of IPPs because they provide more options in delivering electricity on time and will act as a useful benchmark for Eskom, who is a monopoly.
- Government should clarify who has responsibility for security of supply of electricity – is it the DME or Eskom?

6.4.2 Household

- Standards for paraffin appliances should be made mandatory.
- The electrification of poor households must continue as planned and not be affected by the current electricity crisis, because demand by poor households is negligible compared to electricity demand by industry.
- Many of the poor will not be able to afford the projected increase in the price of electricity, thus the DME must increase the 50 kWhs free basic electricity for the poor or have a differentiated tariff increase for the poor. The concern is that many of the poor who cannot afford the electricity tariff increases will refer tack to unclean and dangerous fuels.
- Increases in the price of crude oil affect the price of paraffin, a fuel used by a large percentage of the poor. Stronger regulation of the paraffin supply chain is necessary and subsidies for the poor should be considered.
- Improved identification and targeting of the indigent by municipalities is needed in order for these people to benefit from FBAE. Municipalities also lack the capacity to identify appropriate fuels for the poor.
- A reduction in the initial cost (or form of subsidy) of renewable energy technologies is critical to make it more competitive to conventional technologies.

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