National Accounts

Environmental Economic Accounts

Energy Accounts for South Africa: 2002–2006

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Discussion document: D0405.1.1

November 2009

Energy Accounts for South Africa: 2002–2006

Discussion document: D0405.1.1
November 2009

Published by Statistics South Africa, Private Bag X44, Pretoria 0001

Discussion document: Energy Accounts for South Africa: 2002–2006
Discussion document (D0405.1.1) Statistics South Africa
Pretoria: Statistics South Africa, March 2009

Discussion document (D0405.1.1)
Title continuous in English only
I Statistics South Africa
(LCSH)

1. Energy Supply – South Africa
2. Energy Consumption – Statistics
3. Energy Distribution
I. Title

DDC 333.7911

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List of abbreviations and acronyms

CEF	Central Energy Fund
CDM	Clean Development Mechanism
DEA	Department of Environmental Affairs (Department of Environmental Affairs and Tourism prior to July 2009, President's Minute No. 690)
DoE	Department of Energy (Department of Minerals and Energy prior to July 2009, President's Minute No. 690)
DWA	Department of Water Affairs (Department of Water Affairs and Forestry prior to July 2009, President's Minute No. 690)
Eskom	Electricity Supply Commission of South Africa
GDP	Gross domestic product
GWh	Gigawatt hour
IEA	International Energy Agency
kW	Kilowatt
kWh	Kilowatt-hour
LPG	Liquefied petroleum gas
m^2	Square metre
MJ	Megajoules
Mt	Million tons
MW	Megawatt
NERSA	National Energy Regulator of South Africa
NNR	National Nuclear Regulator
NO_X	Nitrogen oxide
PetroSA	Petroleum, Oil and Gas Corporation of South Africa
PJ	Petajoules
PV	Photovoltaic
SACU	Southern African Customs Union
SADC	Southern African Development Countries
SARS	South African Revenue Services
Sasol	South African Coal and Oil
SAPP	South African Power Pool
SEEA	System of Integrated Environmental and Economic Accounting
SI	International System of Units
SO_X	Sulphur oxide
Stats SA	Statistics South Africa
t	Tonnes
TJ	Terajoules
UNSD	United Nations Statistics Division
W	Watt

Executive summary and key findings

The South African economy depends heavily on energy resources provided from coal (Energy Digest, 2006)[1]. Coal is dominating primarily because it is relatively cheap and abundant. South Africa's coal mining is 47% underground mining and 53% opencast mining operations. Many of the deposits can be exploited at extremely favourable costs, and as a result a large coal mining industry has developed. South Africa exports coal to most of Europe and the Far East, amounting to 33%, through the Richards Bay coal terminal, making South Africa the fifth largest coal exporting country in the world.

Oil and gas explorations are limited in South Africa. Small oil and gas fields are situated off the south coast of Mosselbay. Due to the constriction size of these oil and gas fields in the country, 76% of crude oil is imported from the Middle East and Africa (Saudi Arabia, Iran, Kuwait, Yemen, Qatar, Iraq, Nigeria, Egypt and Angola), and the small gas fields in South Africa supply Mossgas, a project started in 1987 to exploit offshore gas deposits.

Other energy resources in South Africa include biomass (such as wood and dung), natural gas, hydropower, nuclear power, solar power and wind power.

South Africa has large coal and uranium reserves. In 2006, South African mines produced 246 million tons (Mt) of coal. Of this figure, 177 Mt was used locally, at a value of R16 billion, with export sales totalling 69 Mt at a value of R21 billion. South Africa has approximately 31 billion tons of recoverable coal reserves, making it the sixth largest holder of coal reserves in the world. Recoverable uranium reserves were estimated at 795 000 tons[1]. Limited reserves of hydropower exist. South Africa has a huge potential for developing solar power, especially in the Northern Cape, with considerable potential for wind power existing in the coastal regions.

Energy comprises about 15% of South Africa's gross domestic product (GDP); the major consumption sectors being industry, residential and transport, and creates jobs for about 250 000 people. The peak demand on the integrated system totalled 34 807 megawatt (MW) by June 2006. These figures demonstrate the growth of the South African economy and the importance of energy as a key driver of the country's economy[1].

This energy intensity[2] (refer to Glossary) as a measure of GDP is above average, with only 10 other countries having higher commercial primary energy intensities. It is largely as a result of the economy's structure, with dominating large-scale, energy intensive primary mineral beneficiation and mining industries. Coal, as the major indigenous energy resource, is relied on for the generation of most of the country's electricity and a significant proportion of its liquid fuels. South Africa produced 23 571 million litres of liquid fuel products in 2005. About 36% of local demand is met by locally produced synthetic fuels, largely from coal and from natural gas. Products refined locally from imported crude oil meet the remaining 64%. Diversification of the primary energy mix, the bulk of which comprises coal, is especially challenging. South Africa has an abundance of low-cost coal, which means that reliable and inexpensive supplies are at hand. On the face of it, this facilitates the Electricity Commission of South Africa's (Eskom) mandate of providing South Africa with affordable and reliable electricity. Yet Eskom also has a duty to manage environmental impacts and has a responsibility to combat climate change[1].

An important development is the first Energy Efficiency Strategy for South Africa, published in March 2005 by the Department of Energy (DoE) (prior to July 2009 called the Department of Minerals and Energy). The strategy acknowledges that significant potential exists for improving energy efficiency across all sectors of the country's economy. Its vision is to contribute towards affordable energy for all, and to minimise the damaging effects of energy use upon human health and the environment. This will be achieved by encouraging sustainable energy development and energy use through efficient practices. The strategy's national target is for an energy efficiency improvement of 12% by 2015. This target is expressed in relation to the forecast national energy demand at that time, and therefore allows for current expectations of economic growth. It is accepted that this target will be challenging but, at the same time, it is considered achievable.

Renewable energy will in future contribute more substantially than before to South Africa's energy mix. The DoE White Paper on Renewable Energy, approved by Cabinet in November 2003, sets a specific target of 10 000 Gigawatt hours (GWh) (0.8 Mt) as the renewable energy contribution to the country's final energy consumption by 2013. The target corresponds to approximately 5% of the present total annual electricity generation, and will be implemented in three phases during the period 2004 to 2013. The strategy will need to be monitored to determine the effectiveness of the measures and technologies employed to meet the target. Renewable energy will be produced mainly from biomass, solar, and small-scale hydroelectricity plants, and will be used for power generation and non-electric technologies, such as solar water heating and biofuels.

These national laws and policies will trigger a similar law reform process in provincial legislatures, as provinces translate them into procedures for implementation. Local government will also have to develop by-laws in accordance with national and provincial norms and standards[3].

Looking at the Supply and Use Tables presented in the Energy Account for South Africa 2002–2006, the following trends could be observed (also refer to Figure 1 below):

Coal resources

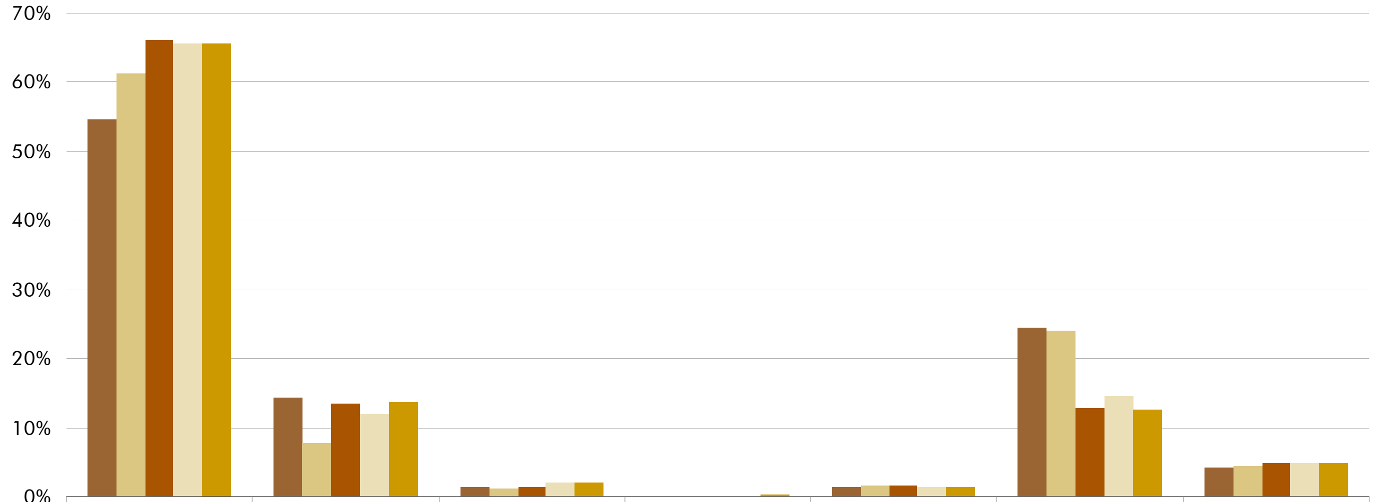
Coal supplied for domestic energy production in 2002 amounted to 5.6 million terajoules (TJ). The amount of energy generated from coal remained fairly steady around 5.8 million TJ from 2003 to 2006. Imports of coal for energy supply were negligible. The main industrial demand for energy produced from coal was electricity, gas and steam production, followed by manufacturing. The amounts of energy from coal resources for electricity, gas and steam production ranged between 2.0 million TJ in 2002; 2.2 million TJ in 2003; 2.4 million TJ in 2004; 2.0 million TJ in 2005; and 2.0 million TJ in 2006. Manufacturing used energy from coal steadily at 1.4 million TJ from 2002 to 2006. Coal exports for energy production ranged between 1.9 million TJ in 2002; 2.0 million TJ in 2003; 1.9 million TJ in 2004; 2.0 million TJ in 2005; and 1.9 million TJ in 2006.

Crude oil

Domestic energy production from crude relied largely on imports for energy generation. Imports of crude oil for energy generation fluctuated between 1.4 million TJ in 2002; 0.7 million TJ in 2003; 1.0 million TJ in 2004; 0.8 million TJ in 2005;

and 0.9 million TJ in 2006. The only industrial sector that used crude oil for energy was manufacturing: from 1.5 million TJ in 2002; 0.7 million TJ in 2003; 1.2 million TJ in 2004; 1.0 million TJ in 2005; and 1.2 million TJ in 2006. Exports of crude oil for energy were negligible.

Figure 1: Percentage supply of primary energy* (in terajoules) by source in South Africa, 2002–2006



	Coal	Crude oil	Gas	Hydro	Nuclear	Petroleum products	Renewables and waste
2002	54.5%	14.3%	1.2%	0.1%	1.3%	24.4%	4.2%
2003	61.2%	7.7%	1.0%	0.0%	1.4%	24.1%	4.5%
2004	66.0%	13.5%	1.4%	0.0%	1.6%	12.7%	4.8%
2005	65.5%	11.8%	1.9%	0.0%	1.4%	14.5%	4.8%
2006	65.6%	13.6%	2.0%	0.1%	1.2%	12.6%	4.8%

*Excludes electricity production.
Source: Department of Energy, Energy Balances for South Africa, 2006.

Gas

Domestic gas production as an energy resource remained stable around 0.1 million TJ from 2002 to 2006 with slight fluctuations between those years. Gas imports for energy were negligible. The main users of energy from gas production were electricity, gas and steam production; and manufacturing. Electricity, gas and steam production for use from gas remained stable around 0.1 million TJ from 2002 to 2006. Manufacturing used energy from gas resources ranging between 0.04 million TJ in 2002 to 0.1 million TJ in 2006.

Hydroelectric, nuclear and renewable energy

Hydroelectric, nuclear and renewable energy sources form a small part of domestic energy production. Hydroelectricity provided less than 1% of the primary energy supply from 2002 to 2006. Nuclear energy provided just over 1% of the primary energy supply from 2002 to 2006, and renewable energy contributed steadily from 4.2% in 2002; 4.5% in 2003 to 4.8% from 2004 to 2006. The amounts of hydroelectric and nuclear energy that were used were negligible. Renewable energy to generate electricity, gas and steam for use was stable at 0.2 million TJ from 2002 to 2006. Renewable energy was used for private consumption, at 0.2 million TJ between 2002 and 2006.

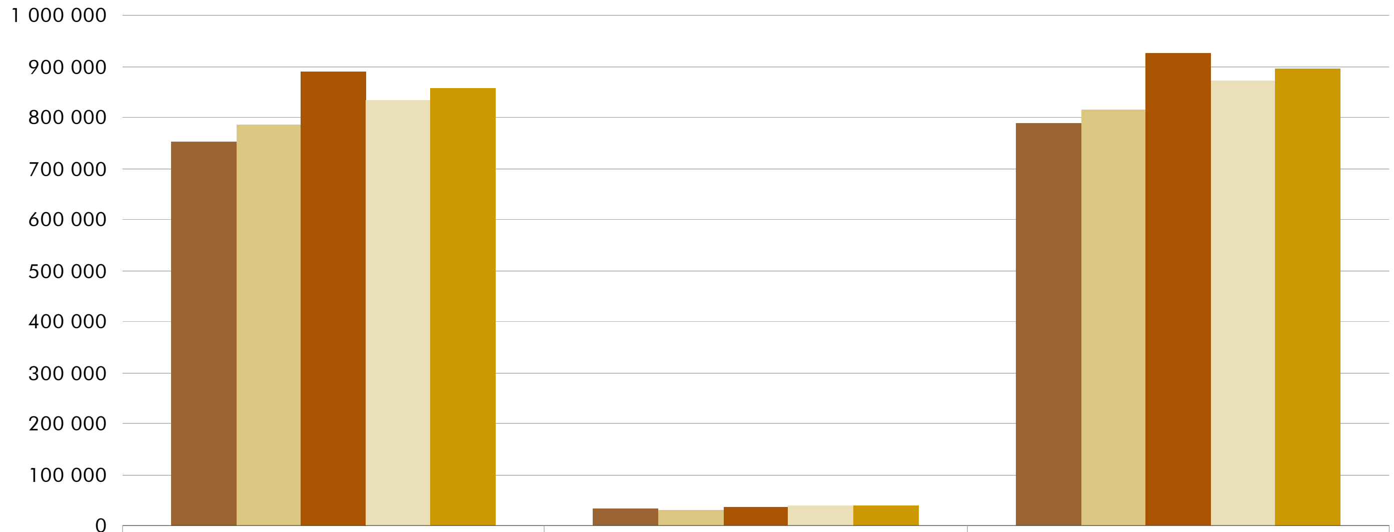
Petroleum products

Domestic production of energy from petroleum products was 2.4 million TJ in 2002; 2.3 million TJ in 2003; dropping to 1.1 million TJ in 2004; 1.2 million TJ in 2005; and 1.0 million TJ in 2006. The imports of petroleum products for energy production were negligible. The main users of petroleum products for energy in 2002 and 2003 were manufacturing, followed by transport, storage and communication. From 2004 to 2006 no petroleum products for energy were used by manufacturing. Manufacturing used petroleum products for energy ranging from 1.2 million TJ in 2002 to 1.1 million TJ in 2003. Transport, storage and communication used petroleum products for energy between 0.6 million TJ in 2002 to 0.7 million TJ in 2006. Exports of petroleum products for energy ranged between 0.5 million TJ in 2002 to 0.2 million TJ in 2006.

Electricity

Electricity is a secondary energy supplier that relies on the primary resources of coal, crude oil, gas, hydroelectric, nuclear, petroleum, and renewable energy as inputs to the production process. It needs to be excluded when comparing primary energy resources to avoid double counting. Three power stations were re-introduced by Eskom, and South Africa significantly increased its electricity output, while through the Integrated National Electrification Programme 3.5 million homes had been electrified[1]. Domestic production of electricity remained steady between 0.8 million TJ to 0.9 million TJ from 2002 and 2006. Imports of electricity were negligible (refer to Figure 2 below). The main user of electricity was manufacturing with 0.3 million TJ in 2002 and 2003; 0.4 million TJ in 2004; 0.3 million TJ in 2005 and 2006. The domestic sector was the second largest user of electricity starting at 0.1 million TJ in 2002; and 0.2 million TJ in 2003 to 2006.

Figure 2: Total electricity supply (in terajoules) in South Africa, 2002–2006



	Domestic production	Imports	Total supply
2002	752 919	34 186	787 105
2003	784 879	29 498	814 378
2004	890 631	35 345	925 976
2005	832 538	39 884	872 422
2006	856 008	38 246	894 255

Source: Department of Energy, Energy Balances for South Africa, 2006.

1. Introduction

The main aim of environmental accounts is to collect qualitative and quantitative information on both the state of natural resources and their progression within a consistent framework. The majority of economic and social activities towards income may lead to the degradation and depletion of natural resources, it is of utmost importance that such activities be managed in order to accomplish sustainable development.

Environmental economic accounts help by providing policy-makers with an information base on natural resources, thereby contributing to general knowledge on environmental issues at each level of decision-making, and to enhance the general awareness level of the public.

Energy accounts provide information on the levels of direct energy consumption by industries in relation to their production processes and consumption by private households. These accounts can also provide information on changes in the energy requirements of particular industries in relation to their output. This shows the macro-level impacts of new technologies and eco-efficiency measures and behavioural changes. They are also an indispensable prerequisite for reliable estimates of air emissions related to energy consumption.

The aim of this discussion document is to present and discuss the updated Supply and Use tables for the energy accounts for South Africa from 2002 to 2006.

2. The importance of environmental economic accounts for energy

Energy use causes significant environmental change – taking the form of air pollution, water pollution, biodiversity loss, and land use change. Coal is the predominant fossil fuel for energy use in South Africa, accounting for the bulk of the total energy used. The burning of fossil fuels for energy releases approximately 80% of all human-induced greenhouse gas emissions in the country. In 2002, large coal power stations producing electricity for the national grid were the largest producers of sulphur dioxide (71%) and nitrogen oxides (55%) in the country; they accounted for 36% of the total particulate levels in the air. Research shows that ambient air pollutant concentrations are highest in areas with high concentrations of industrial and power generation activity, namely Tshwane; Johannesburg; Mpumalanga Highveld; Vaal Triangle; eThekwini; and Cape Town. More than 40% of South Africans are exposed to 80% of the anthropogenic pollution emissions. Air pollutants occur not only as greenhouse gases but also in the form of smog, mercury, soot, and ash. Acid deposition may affect water quality, thereby affecting human and ecosystems that rely on water[4].

South Africa is the fifth largest exporter of coal in the world, and coal mining is South Africa's second largest foreign exchange earner after gold. Coal is used for many energy sources, with electricity being the predominant one. Fuel wood is the most widely used renewable energy source in South Africa. More than one-third of the country's population relies on it for daily energy needs. Alternative energy supplies are currently being investigated. These include solar, wind, natural gas, and hydroelectricity. Economic reasons play a vital role when considering the use of these renewable resources, as their commercial exploitation requires significant financial and technological investment[4].

Climate change caused by human activities is considered the most significant global environmental issue facing humanity today. The increased concentration of greenhouse gases such as carbon dioxide in the atmosphere, mainly caused by generation and consumption of energy, is driving climate change. South Africa emits more greenhouse gases per person than many industrialised countries[5, 6]. Reasons for this lie in our dependence on coal for cheap electricity, which is expected to continue in the short to medium term. Our energy intensity is very high, and is equivalent to that of developed countries. Carbon dioxide from the energy sector is the main source of our greenhouse gas emissions. A National Climate Change Response Strategy was compiled in 2004 by the Department of Environmental Affairs (DEA) (prior to July 2009 called the Department of Environmental Affairs and Tourism), which highlights the need to develop a sustainable energy programme. Given the cross-cutting nature of climate change, there are significant challenges to implementing the strategy effectively in the level of cooperative governance required, as well as in the financial resources needed. A few small-scale South African projects under the Clean Development Mechanism (CDM) of the Kyoto Protocol aim to reduce use of energy from fossil fuels such as coal, in this way reducing emissions of greenhouse gases. A Renewable Energy Policy for South Africa has been developed by the DoE. Several South African cities have developed energy strategies, which include renewable energy targets.

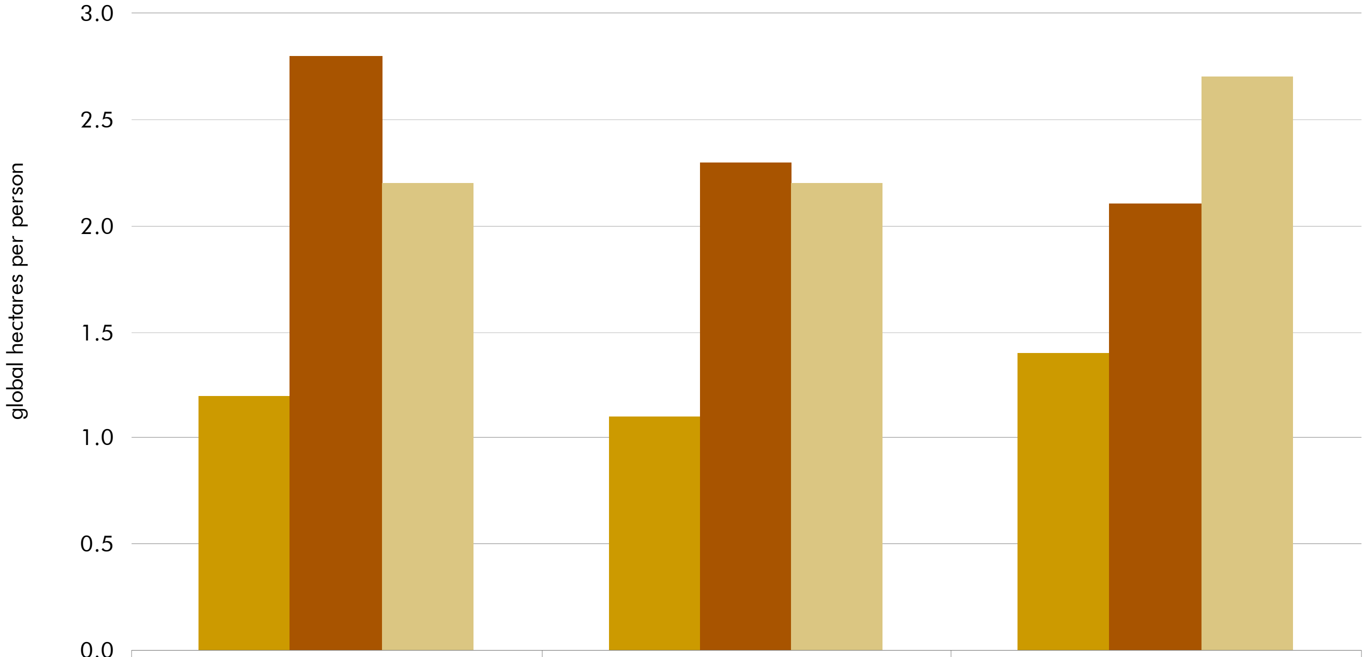
Measuring society's consumption of natural resources and waste output within the context of nature's renewable and regenerative capacity indicates the rate of progress towards environmental sustainability. One such measure is the Ecological Footprint, which measures people's natural resource consumption and quantitatively assesses the biological productivity (the amount of nature) required to produce the resources (food, energy, and material) and to absorb the wastes of any individual, city, region, or country. People consume resources and ecological services from all over the world, so the Ecological Footprint is the sum of these areas, wherever they are on the planet.

The Ecological Footprint for South Africa in 2005 was 2.1 global hectares per person, compared to the world average of 2.7 global hectares per person and the average for Africa of 1.4 global hectares per person (see Figure 3). Because of its high carbon emissions, South Africa's energy footprint is particularly high compared to other countries in Africa[7]. The average footprint values for South Africa mask regional differences within the country as well as differences between rich and poor people, but the message is clear: we are eroding our natural capital.

The linkages between the economy and the environment are summarised in Figure 4. A simplified view of the economy divides it into the two sectors of production and consumption, which are linked through the exchange of goods and services on the one hand, and factors of production on the other. The environment, typically ignored in conventional macroeconomic analysis, interacts with the economy in three ways: by supplying energy and materials, by taking up waste products, and by providing amenities.

There is some recycling of resources within both the consumption and production sectors (represented in Figure 4 by the R1 and R2 loops). The environment therefore, acts as a supplier of resources, a sink for waste resources (with a limited capacity to assimilate them), and as the provider of amenity (that is, of the qualities and facilities that make an area a pleasant and convenient place to live and work) and of spiritual and existence values to society.

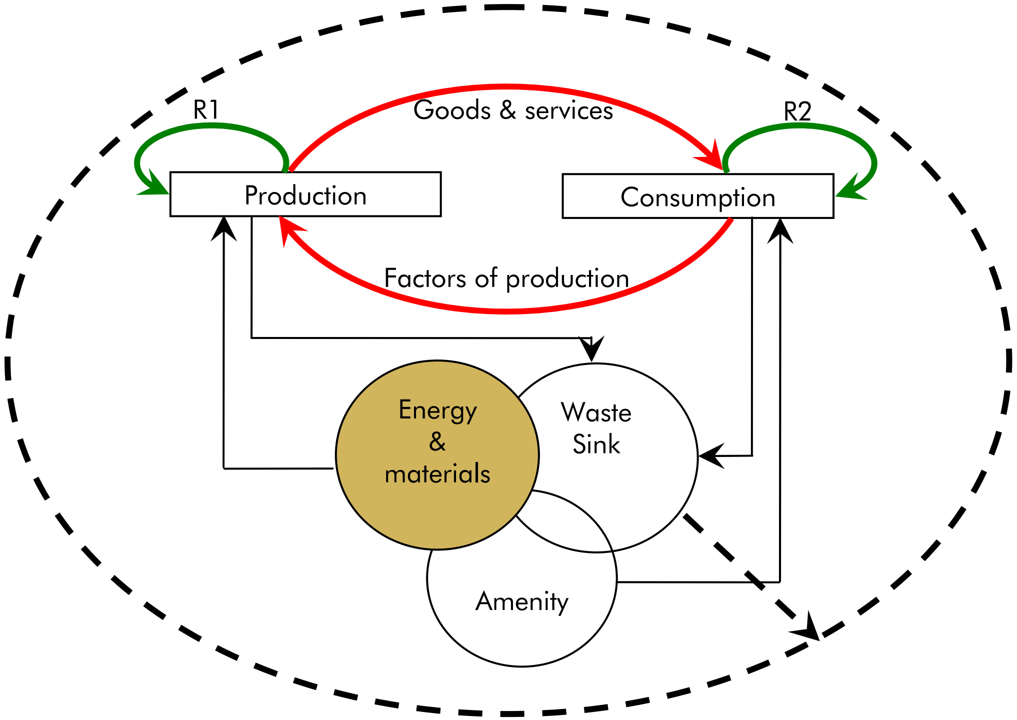
Figure 3: Ecological Footprint for Africa, South Africa and the World



	2001	2003	2005
Africa	1.2	1.1	1.4
South Africa	2.8	2.3	2.1
World	2.2	2.2	2.7

Source: World Wide Fund International, *Living Planet Reports 2002, 2004, and 2006.*

Figure 4: Interactions between the economy and the environment



Source: Hanley N, Shogren J and White B, 1997. *Environmental economics in theory and practice.* Macmillan, London.

The emphasis on growing the economy to provide employment has important consequences for the patterns of consumption and production, hence for the environment. Specifically, economies are driven and maintained by energy, the production of which causes serious pollution and degradation of the environment. Increased affluence through employment also leads to the increased consumption of natural resources and increased production of waste. Although the current energy accounts focus on physical quantities, it is a first step towards future environmental accounts that will need to include wastes and emissions to provide an overall picture of production and consumption of energy within the economy and its effect on environmental resources and ecosystems. Energy comprises about 15% of South Africa's gross domestic product (GDP); the major consumption sectors being industry, residential and transport, and creates jobs for about 250 000 people. The peak demand on the integrated system totalled 34 807 megawatt (MW) by June 2006. These figures demonstrate the growth of the South African economy and the importance of energy as a key driver of the country's economy[1].

3. South African classifications and methodology

The Energy Accounts for South Africa follows the System of Integrated Environmental and Economic Accounts (SEEA) 2003 developed by the United Nations Statistics Division (UNSD) (refer to Annexure 1). The SEEA 2003 has been adapted to South African circumstances. The columns that were excluded are: natural gas; steam and hot water; wood, straw and waste. The columns that were included are: nuclear power; hydropower; renewable energy and waste. The rows that were changed are: electricity, gas and water supply; wholesale and retail traders; financial intermediation; and public services were all included under 'commercial sector' in the South African tables because the data for South Africa does not allow the breakdown of the commercial sector according to the categories specified in the SEEA 2003.

The above changes were made in order for the framework to better apply to the resources and sectors used in South Africa. All the data used in the energy account are from the DoE. In the case of South Africa, road transport users were separated into passengers and freight, based on the assumption that passengers constituted 75% of transport used on roads, and freight the remaining 25% in 2006. This ratio was used as the basis for compiling the energy use accounts[7].

3.1 Energy resources

The main energy resources in the South African economy are coal, oil, gas, nuclear power, hydropower and renewable sources such as wind, solar, biomass and wave power. Figure 3 gives the distribution of primary energy supply by source in South Africa from 2002 to 2006.

The sources that supplied energy to South Africa from 2002 to 2006 were predominantly electricity that relied on coal, followed by petroleum products and crude oil with gas, hydro, nuclear power, and renewable energy contributing less than 10% of the total energy mix. Electricity supply increased sharply from 2005. Renewable energy includes resources such as biomass, wind and solar power.

3.1.1 Coal

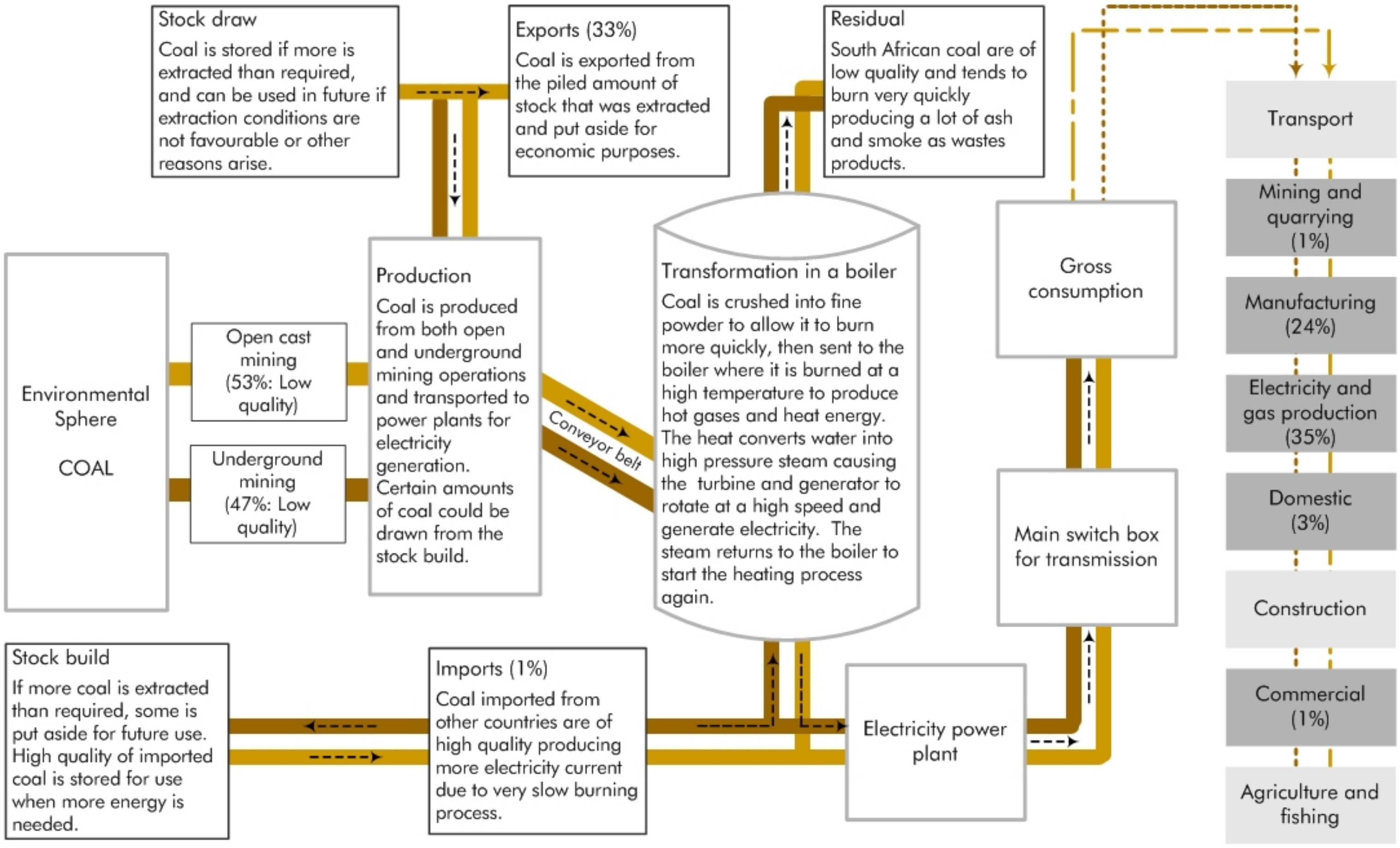
The South African energy sector is dominated by coal, and it is expected to remain the overall electricity generator until 2020. In 2006, South African mines produced 246 Mt of coal. Of this figure, 177 Mt was used locally, at a value of R16 billion, with export sales totalling 69 Mt at a value of R21 billion[1].

In 2002, South Africa's coal reserves were estimated at 53 billion tonnes with almost 200 years of coal supply left given current rates of extraction and proven resources. According to the latest mineral accounts for South Africa, 1980–2006, published by Statistics South Africa (Discussion document: D0405.2, December 2008), in 2006 there was 114 years left to depletion, given current rates of extraction and proven resources.

In South Africa, for the year 2002, the bulk of the primary energy needs was provided for by coal, which made it the most widely used primary fuel. In 2006 this is still the case. This is unlikely to change significantly in the next decade, and the situation is likely to remain until at least 2020, due to the relative lack of suitable alternatives to coal as an energy source. South Africa's coal production feeds the various local industries, with 80% used for electricity generation. Recoverable coal reserves in 2006 for South Africa were estimated at approximately 31 billion tons, which makes the country to be the sixth largest holder of coal reserves in the world[1].

The advantages of coal power for South Africa are that our country has abundant coal reserves, coal-fired power stations are reliable, our infrastructure to generate electricity from coal is well established, and burning coal is the most cost effective and energy efficient way of generating electricity. The disadvantages are that coal has the most severe waste problems of all energy sources. Building coal-fired power stations is a long and expensive process and South Africa's coal fields are concentrated in Mpumalanga, which limits the location options for power stations (see Map 1 in Annexure 1). Figure 5 below shows the flow of coal from production to consumers.

Figure 5: Flow diagram for coal – 2006



Footnotes:
In South Africa 53% of coal mining operations are open cast and 47% underground. Stock changes amount to just over 3%.
Consumption data is based on Energy Balances for South Africa, 2006.

Source: Statistics South Africa, 2009.

3.1.2 Crude oil and petroleum products

South Africa has very limited oil reserves and about 76% of its crude oil requirements are met by imports from the Middle East and Africa (Saudi Arabia, Iran, Kuwait, the United Arab Emirates, Yemen, Qatar, Iraq, Nigeria, Egypt and Angola).

Refined petroleum products such as petrol, diesel, residual fuel oil, paraffin, jet fuel, aviation gasoline, liquefied petroleum gas (LPG) and refinery gas are produced by the following methods:

- Crude oil refining (oil refineries);
- Coal to liquid fuels and gas to liquid fuels (South African Coal and Oil (Sasol)); and
- Natural gas to liquid fuels (Petroleum, Oil and Gas Corporation of South Africa (PetroSA)).

The wholesale and retail markets for petroleum products in South Africa are subject to a set of 413 government controls. The government regulates wholesale margins and controls the retail price of petrol. The industry has entered into product exchange agreements to serve different markets. Together, these controls provide for access to fuel throughout the country and protect consumers, while providing a reasonable return on investment to the oil industry and enhancing opportunities for employment.

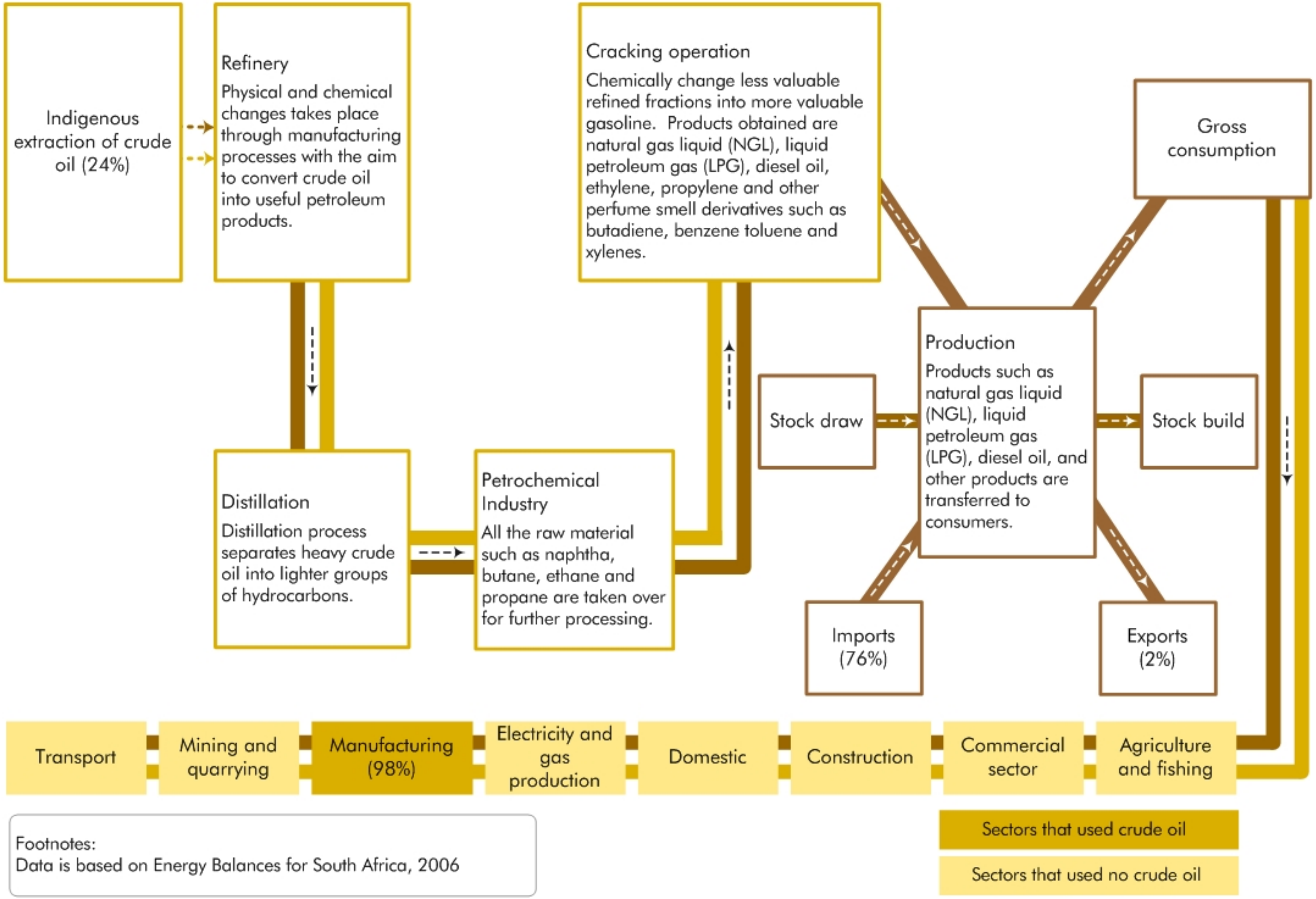
The refiners and wholesale marketers move products from the refineries by coastal barge, rail, truck and pipeline to roughly 200 depots. From these, about 4 600 service stations and 100 000 direct consumers (mostly farmers) are served.

The importation of refined products is restricted to special cases where local producers cannot meet demand. It is subject to state control to promote local refinery usage. When overproduction occurs, export permits are required and generally granted, provided that the needs of both South Africa and other Southern African Customs Union members are met. More diesel than petrol is exported, owing to the balance of supply and demand of petrol and diesel relative to refinery configurations. Although petrol and diesel make up the bulk of total liquid fuel exports, South Africa is also the main supplier of all other liquid fuels to Botswana, Namibia, Lesotho and Swaziland[1]. Figures 6 and 7 below show which sectors are the main users of crude oil and petroleum products.

3.1.3 Gas

Limited natural gas reserves exist around the South African coast. PetroSA exploits the reserves off the coast of Mosselbay, where the Mossgas plant converts the gas into liquid fuels. Sasol produces gas from coal and is researching prospects to import gas from Namibia. Even though gas consumption has increased in recent years, the importance of gas in the South African energy economy is still low compared with other countries (see Figure 8).

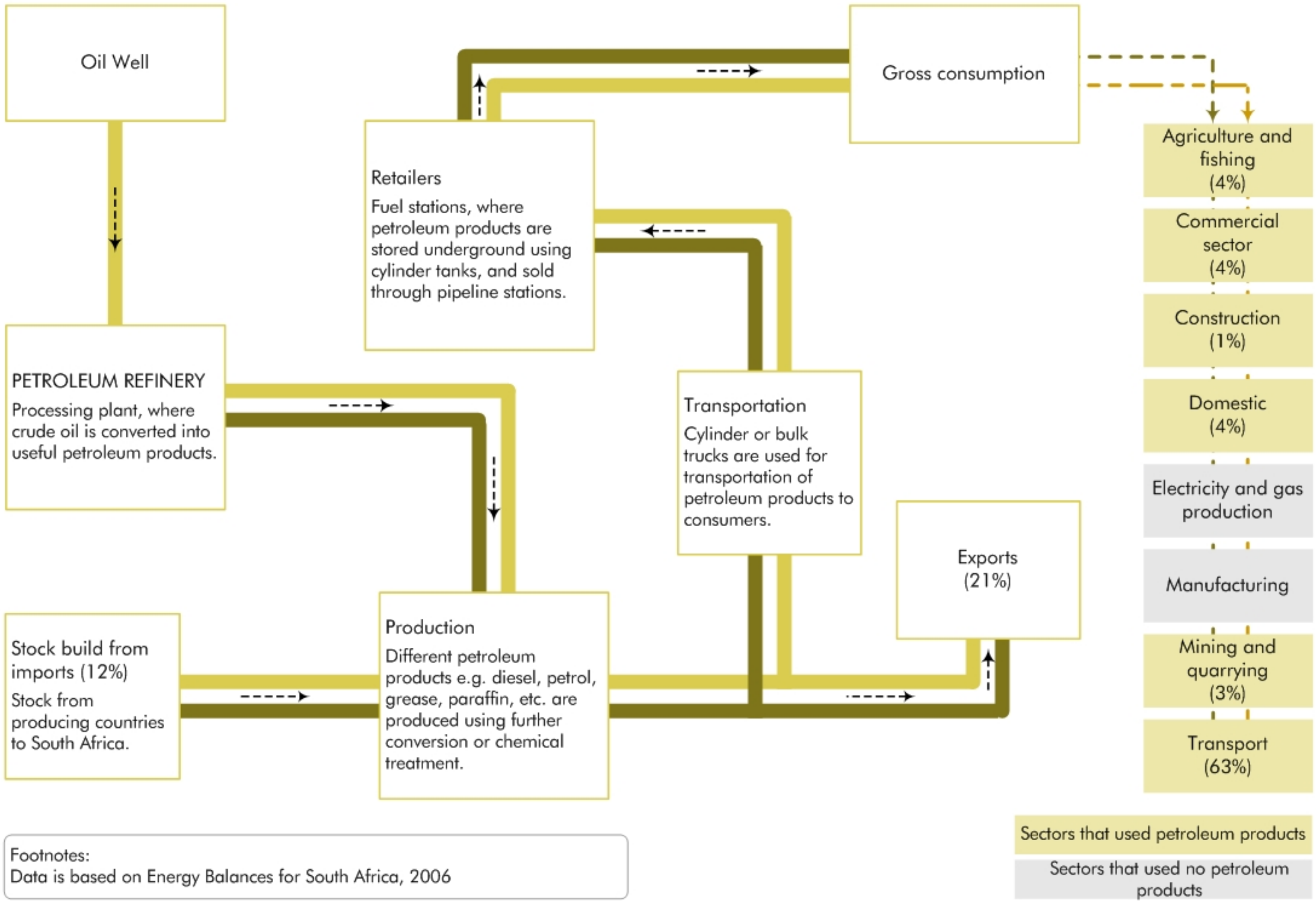
Figure 6: Flow diagram for crude oil – 2006



Footnotes:
Data is based on Energy Balances for South Africa, 2006

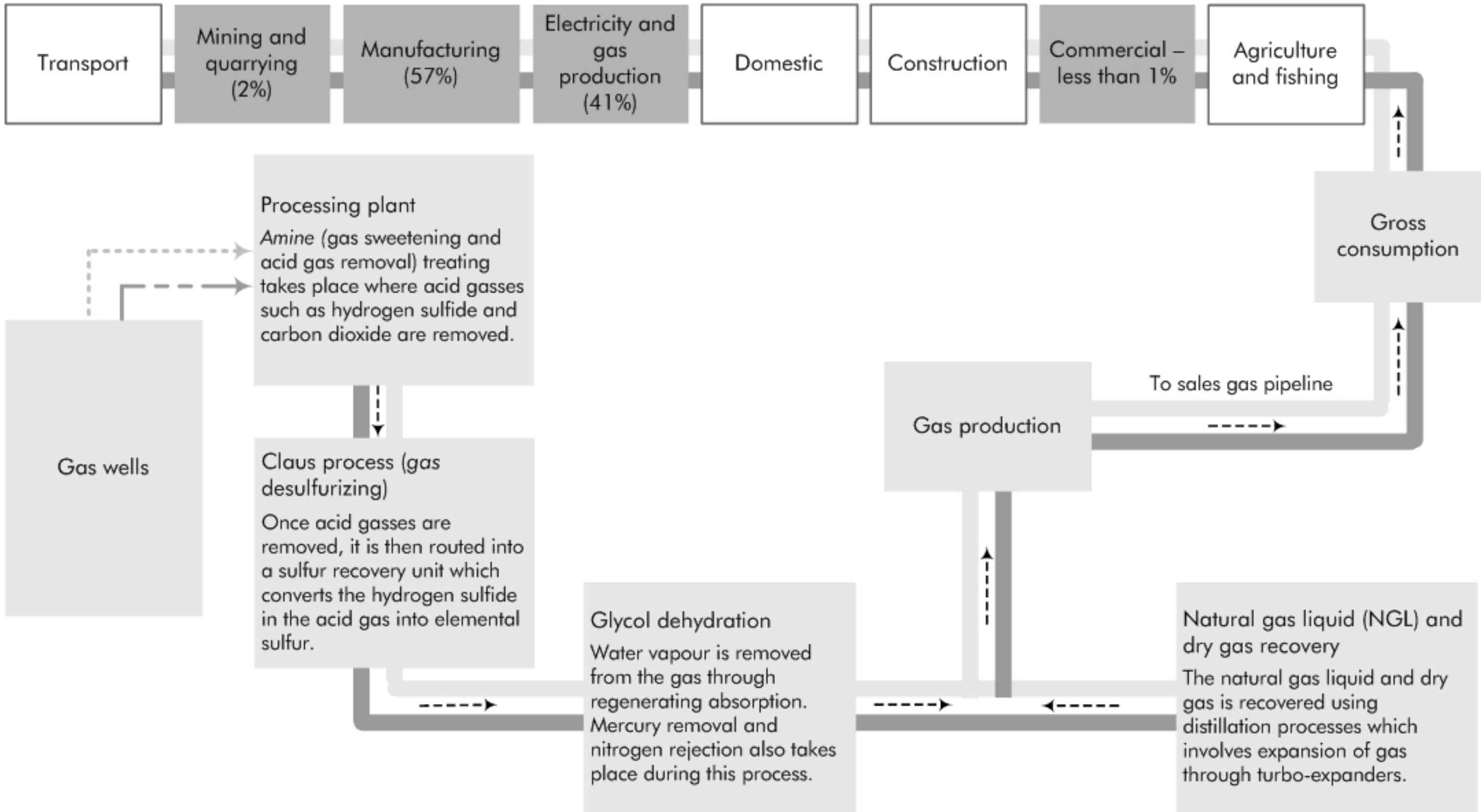
Source: Statistics South Africa, 2009.

Figure 7: Flow diagram for petroleum products – 2006



Source: Statistics South Africa, 2009.

Figure 8: Flow diagram for gas – 2006



Foot notes:
South Africa has small oil and gas fields situated south off the coast of Mosselbay, at Oribi, Oryx as well as Sable. Limited oil and gas is supplied by these fields while the majority is imported and the small gas fields supply the Mossgas. Condensate wells produce raw natural gas along with a very low density liquid hydrocarbon called *natural gas condensate*.
Data is based on the Energy Balances for South Africa, 2006

Sectors that used gas energy

Sectors that used no gas energy

Source: Statistics South Africa, 2009.

3.1.4 Renewable energy

Renewable energy sources, other than biomass, have not yet been exploited optimally in South Africa.

The DoE strengthened international relationships in this area through the support offered to partnerships established during the World Summit on Sustainable Development in 2002. Such partnerships will overcome market barriers and promote widespread use of sustainable energy solutions. These include the Global Village Energy Partnership and the Renewable Energy and Energy Efficiency Partnership.

Cabinet approved the White Paper on Renewable Energy in November 2003, which stipulates the following targets:

Renewable energy of 10 000 GWh contribution to final energy consumption by 2013, produced mainly from biomass, wind, solar and small-scale hydroelectricity. The renewable energy is to be used for power generation and non-electric technologies such as solar water heating and biofuels. This is equivalent to replacing two 660 MW units of Eskom's combined coal-fired power stations, or replacing 1 100 million litres of diesel (14%) with biodiesel. This is in addition to the estimated existing 8–9% renewable energy contribution mainly from fuel wood and waste.

A macroeconomic analysis of the targets in the White Paper concluded that:

The target is economically viable with government financial support and 'green' funding (e.g. CDM, 'green' premium, etc.). Achieving the target could add about 1 667 MW new renewable energy capacity with a net impact on GDP of as high as R1 071 million per year compared with coal-fired power stations, and additional government revenue of R299 million. Just over 20 000 new jobs would be created and water savings of 17 million kilolitres would be achieved, translating into a R27 million saving.

The study also highlighted the 10 000 GWh low-cost renewable energy technologies and applications to be implemented first, based on the level of commercialisation of the technology and the natural resource availability.

These technologies include:

- Sugar cane bagasse for cogeneration (59%);
- Landfill gas extraction (6%);
- Mini-hydroelectric schemes (10%);
- Commercial and domestic solar water heaters (23%);
- Wind energy (1%); and
- Biomass pulp and paper (1%).

The White Paper addresses four key strategic areas, namely:

- Financial instruments to promote the implementation of sustainable renewable energy through the establishment of appropriate financial instruments;
- Legal instruments to develop, implement, maintain and continuously improve an effective legislative system to promote the implementation of renewable energy;
- Technology development to promote, enhance and develop technologies for the implementation of sustainable renewable energy; and
- Building capacity and education to develop mechanisms to raise awareness of the benefits and opportunities that renewable energy offers.

Technological feasibility studies will be conducted for possible implementation in the medium to longer term. These include:

- Grid-connected wind farms;
- Wind farm/pumped storage as a means of addressing peak loads on the national electricity grid; and
- Domestic and commercial solar water heating.

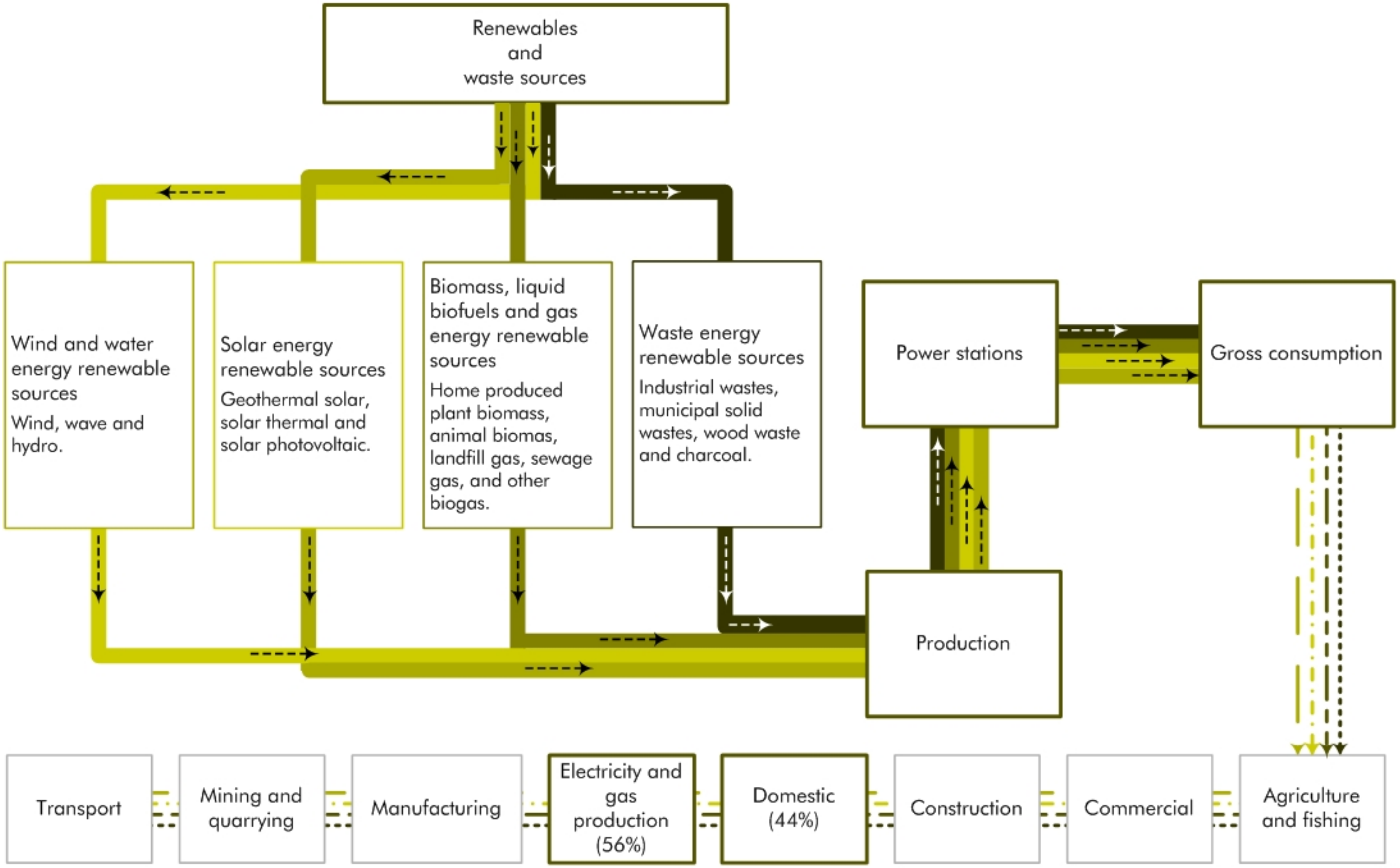
Solar thermal power generation is a collaborative programme with Eskom. It also involves the SolarPACES Programme of the International Energy Agency (IEA), and includes:

- Small-scale hydropower;
- Landfill gas exploitation; and
- Rural water supply and sanitation.

Biomass power

Renewable energy comprises biomass and natural processes that are replenishable as an energy source. Biomass is used commercially in pulp and paper mills and sugar refineries by burning bulk from logs, black liquor and bagasse to produce process heat. The energy produced is used by those industries to meet their needs. In future, some of this energy could be sold to the national grid (depending on electricity prices and environmental regulations). However, given the limited potential for agricultural expansion due to a lack of water and arable land, it is unlikely that this could make a major contribution. In households, biomass is used for cooking and heating.

Figure 9: Flow diagram for renewable energy – 2006



Footnotes:
Data is based on Energy Balances for South Africa, 2006.

Source: Statistics South Africa, 2009.

Solar power

Most areas in South Africa average more than 2 500 hours of sunshine per year, and average daily solar radiation levels range between 5 and 7 kilowatt-hour per square metre (kWh/m^2) in one day.

The southern African region, and in fact the whole of Africa, is well endowed with sunshine all year round. The annual 24-hour global solar radiation average is about 220 watt per square metre (W/m^2) for South Africa, compared with about 150 W/m^2 for parts of the United States of America, and about 100 W/m^2 for Europe and the United Kingdom. This makes the local resource one of the highest in the world. The solar resource is the most readily accessible in South Africa. It lends itself to a number of potential uses.

The country's solar equipment industry is developing. Annual photovoltaic (PV) panel assembly capacity totals 5 MW, and a number of companies in South Africa manufacture solar water heaters.

Solar power is increasingly being used for water pumping through the rural water provision and sanitation programme of the Department of Water Affairs (DWA) (prior to July 2009 called the Department of Water Affairs and Forestry). Solar water heating is used to a certain extent. Current capacity installed includes domestic (330 000 m^2) and swimming pools (327 000 m^2), commerce and industry (45 000 m^2) and agriculture (4 000 m^2).

Three cooperatives with over 10 permanent employees each have been started in the Eastern Cape to maintain 8 000 solar home systems installed under the previous electrification programme.

Wave power (ocean energy)

Ocean energy could potentially be derived from the various characteristics of the sea. For example, the rise and fall of the waves could be converted into hydraulic pressure by mechanical compression devices. Such pressure could drive a turbine generator to produce electricity, while the tidal variation, sea current and different thermal layers in the ocean could also be used.

The main reason why this energy resource is not currently being harnessed is that no reliable technology exists that can generate electricity from this resource. Various companies are testing systems internationally to develop technically viable solutions. Once technical reliability has been proven, cost effectiveness in relation to other solutions will have to be established.

Eskom has continued with resource surveys of the Agulhas current on the east coast of South Africa and of wave energy, in partnership with the DEA Marine and Coastal Management, and the Bayworld Centre for Research and Education.

Wind power

Eskom's Klipheuwel, just north of Cape Town, is the first large wind turbine facility in sub-Saharan Africa. The pilot phase of the Klipheuwel research and demonstration project ran from August 2002 to the end of 2005. During that time, the Klipheuwel pilot wind farm generated more than 12 GW/h of electricity, thus reducing carbon dioxide emissions by 11 000 tonnes (t). The three wind turbines operated at an average availability of 90%. The project's research phase has been completed and this pilot wind farm will be operated commercially for its anticipated 20-year lifespan as calculated from 2006.

Pending approvals and licensing processes, Eskom has decided to build a 100 MW wind facility. The choice of location and technology to be used is based on information obtained from the Klipheuwel pilot wind project.

In August 2006, the City of Cape Town signed a 20-year agreement to buy 'clean' electricity from Darling Wind Farm. Local and foreign investors, government and the community of Darling, a small town north-west of Cape Town, will collaborate to make South Africa's first commercial wind-farm venture operational.

The R70 million pilot commercial wind energy project was expected to start operating in 2007. The Darling Wind Farm is expected to feed the national power grid by using four giant wind turbines to generate an estimated 13 GW/h of 'clean' electricity a year. It will be 'wheeled' through the grid and on to suppliers who have chosen to pay a 25c per KWh surcharge for a 'green' power supply.

With growing concern over global warming, Cape Town expects to sell the electricity on to an initially small, but willing, market that will include businesses whose 'green credentials' will help them market their products in South Africa and abroad. The project is the result of a partnership between the national government, the Danish government, the Central Energy Fund (CEF) and the Darling Independent Power Producing Company. The agreement enabled Darling Wind Power to secure the necessary investment to finance the purchase of the initial four wind turbines comprising 17-storey-high towers with massive blades powering 42 t engine rooms at the top of the towers. Another six wind turbines will be added later, followed by another 10 in the longer term.

3.1.5 Nuclear power

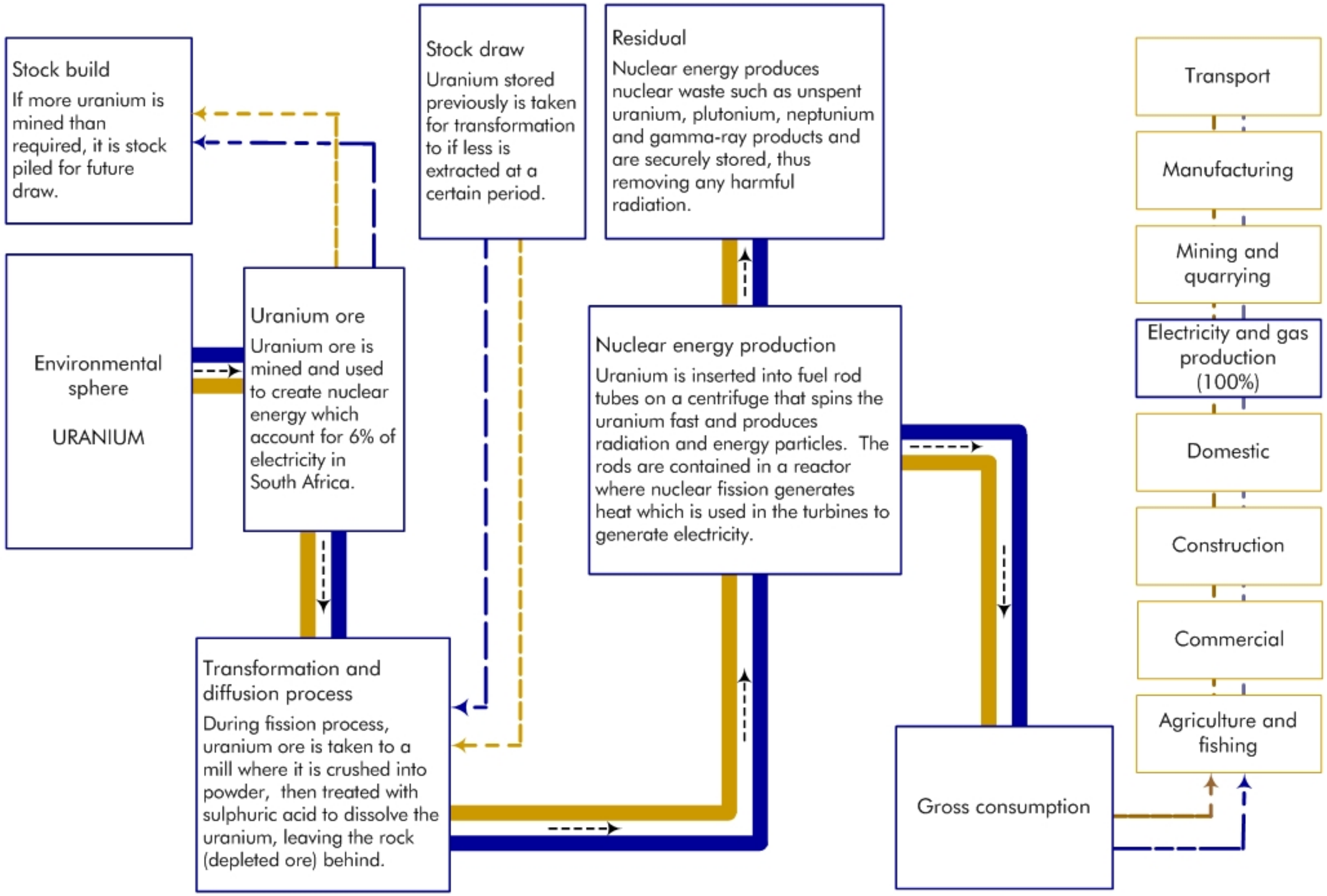
The nuclear sector in South Africa is mainly governed by the Nuclear Energy Act, 1999 (Act No. 46 of 1999), and the National Nuclear Regulator (NNR) Act, 1999 (Act No. 47 of 1999). The DoE administrates these acts. The Department of Health administrates the Hazardous Substances Act, 1973 (Act No. 15 of 1973), related to groups III and IV hazardous substances.

Approval of the Nuclear Energy Policy and Strategy is expected to result in the creation of many jobs and a boost to the economy. The document proposes the increased use of nuclear energy to supplement current energy sources. Nuclear energy is likely to contribute 15% of South Africa's energy in the next 30 years. If the strategy is approved, an extra 10 000 MW could be added to the current 39 000 MW in 10 years. This would entail recapitalising certain nuclear agencies, financing others and setting up new ones.

The draft document sets out a phased approach to creating a nuclear industry. Infrastructure would be maintained and upgraded until 2010. Thereafter, up to 2015, new nuclear power plants will be constructed and will become operational in 2025. The document also proposes that enriched uranium be sold internationally, allowing the country to compete in the global nuclear market.

South Africa has two nuclear reactors generating 6% of its electricity. Its first commercial nuclear power reactor began operating in 1984. The government's commitment to the future of nuclear energy is strong. Budget approval to proceed with a demonstration Pebble Bed Modular Reactor was given in 2004. The South African nuclear sector employs about 2 700 people[1].

Figure 10: Flow diagram for nuclear power – 2006



Footnotes:
South Africa is currently having one conventional nuclear station in Koeberg in the Western Cape, which contributes about 1 800 MW to the national grid (Eskom).
Data is based on Energy Balances for South Africa, 2006.

Sectors that used nuclear energy

Sectors that used no nuclear energy

Source: Statistics South Africa, 2009.

3.1.6 Hydroelectric power

An assessment conducted by the DoE, the Baseline Study on Hydropower in South Africa, indicated that specific areas in the country show significant potential for developing all categories of hydropower in the short and medium term.

Eastern Cape and KwaZulu-Natal are endowed with the best potential for developing small, i.e. less than 10 MW hydropower plants. The advantages and attractiveness of these plants are that they can either be stand-alone or can exist in a hybrid combination with other renewable energy sources.

Advantage can be derived from the association with other uses of water (e.g. water supply, irrigation, flood control, etc.), which are critical to the future economic and socio-economic development of South Africa.

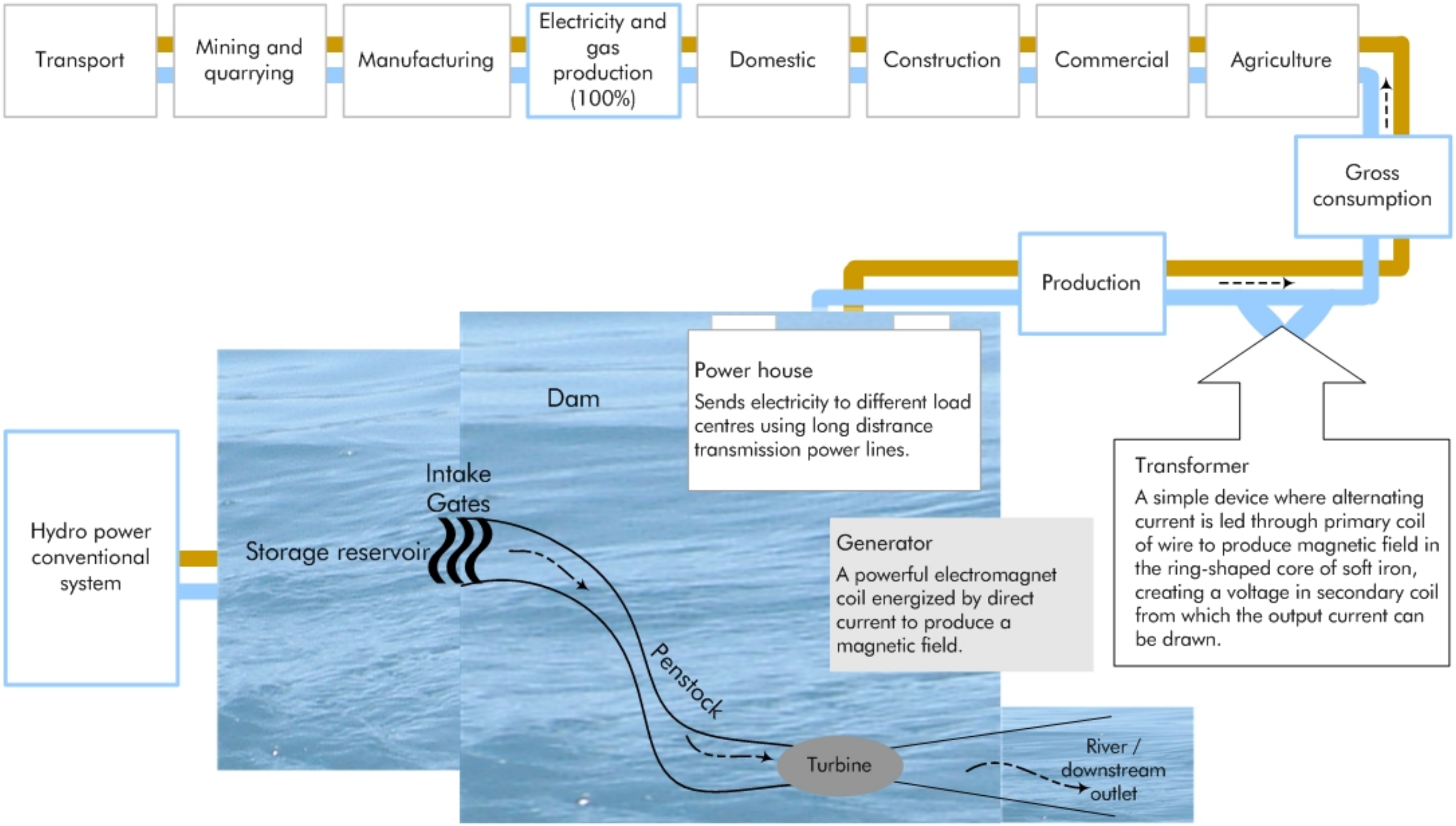
Eskom has started the construction of the Ingula pumped storage scheme (1 332 MW) near Van Reenen, KwaZulu-Natal. It is expected that the first unit will be operational in 2012. Preliminary work for the design and construction of a second pumped storage scheme in Mpumalanga has commenced. As peak demand for electricity continues to grow, Eskom will continue to explore the development of new hydroelectric and pumped storage schemes.

The South African Power Pool (SAPP) allows for the free trading of electricity between members of the Southern African Development Countries (SADC), providing South Africa with access to the vast hydropower potential in the countries to the north, notably the significant potential in the Congo River (Inga Falls). The main project outside South Africa's borders is Westcor. It entails a five-way intergovernmental memorandum of understanding signed between the utilities of the Democratic Republic of the Congo, Angola, Namibia, Botswana and South Africa. Westcor will tap into some of the potential in the Democratic Republic of the Congo. The first project is Inga III, a 3 500 MW hydro plant on the Congo River.

At the same time, the countries to the north could benefit through access to the coal-fired power resources in the south. Such an arrangement should stabilise the energy requirements of the region well into this century. Exploitation of the vast hydropower resources will constitute a significant infusion of renewable energy resources into the energy economy of the region over the medium to long term. The Lesotho Highlands Water Project can contribute some 72 MW of hydroelectric power to the system in the short term.

Global pressures regarding the environmental impact and displacement of settlements by huge storage dams are likely to limit the exploitation of hydropower on a large scale. Irrespective of the size of installation, any hydropower development will require authorisation in terms of the National Water Act, 1998 (Act No. 36 of 1998).

Figure 11: Flow diagram for hydroelectric power – 2006



Footnotes:
South Africa has two hydro power systems in operation, i.e. the conventional system and the pumped storage systems.
Data is based on Energy Balances for South Africa 2006.

Source: Statistics South Africa, 2009.

3.2 Sectors concerned with energy use

For the purpose of energy use, the South African economy can be divided into the following sectors: industrial, residential and transport. Each of these sectors is discussed in more detail below.

The table below shows the main users of electricity, excluding electricity, gas and steam production.

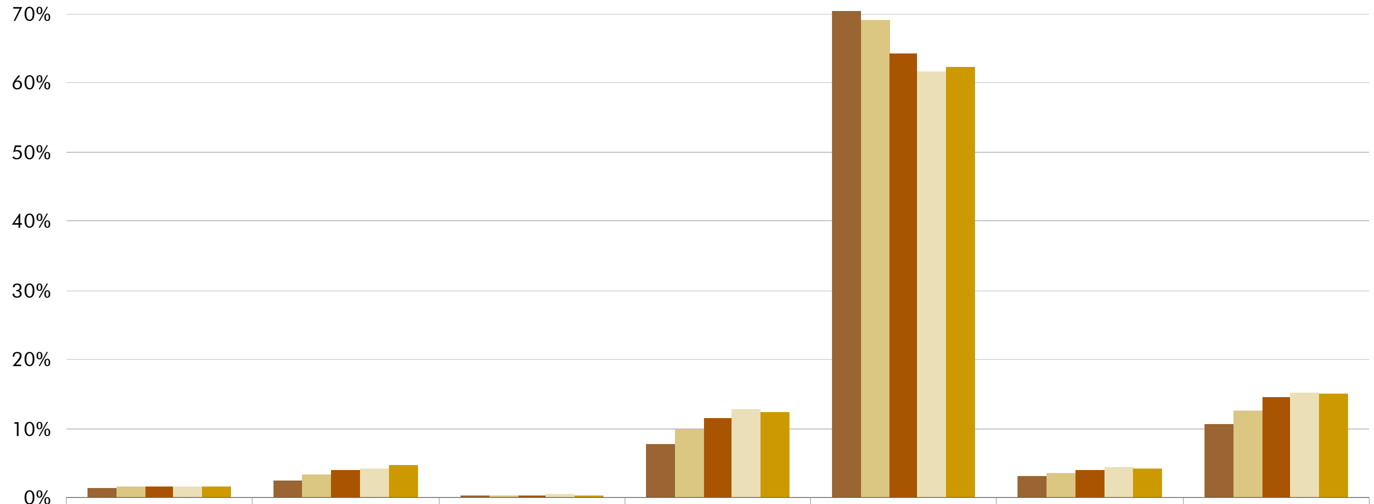
Table 1: Main users of energy in South Africa, 2002–2006

	Terajoules				
Intermediate consumption by main users	2002	2003	2004	2005	2006
Agriculture and fishing	72 904	74 998	77 988	71 534	70 385
Commercial	143 597	171 599	194 992	197 644	224 133
Construction	15 816	16 939	15 982	16 535	15 665
Domestic	459 920	510 980	552 888	592 930	601 305
Manufacturing	4 462 893	3 602 037	3 109 626	2 888 487	3 036 673
Mining and quarrying	183 795	180 699	190 274	204 592	201 982
Transport, storage and communication	636 332	656 520	698 552	710 943	726 596
Total sector use in TJ	5 975 257	5 213 772	4 840 301	4 682 665	4 876 738

	Terajoules				
Intermediate consumption by main users	2002	2003	2004	2005	2006
Agriculture and fishing	1.2%	1.4%	1.6%	1.5%	1.4%
Commercial	2.4%	3.3%	4.0%	4.2%	4.6%
Construction	0.3%	0.3%	0.3%	0.4%	0.3%
Domestic	7.7%	9.8%	11.4%	12.7%	12.3%
Manufacturing	74.7%	69.1%	64.2%	61.7%	62.3%
Mining and quarrying	3.1%	3.5%	3.9%	4.4%	4.1%
Transport, storage and communication	10.6%	12.6%	14.4%	15.2%	14.9%
Total sector use (%)	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Department of Energy, Energy Balances, 2002–2006.

Figure 12: Percentage distribution of energy to the main users in South Africa, 2002–2006



	Agriculture and fishing	Commercial sector	Construction	Domestic	Manufacturing	Mining and quarrying	Transport, storage and communication
2002	1.2%	2.4%	0.3%	7.7%	74.7%	3.1%	10.6%
2003	1.4%	3.3%	0.3%	9.8%	69.1%	3.5%	12.6%
2004	1.6%	4.0%	0.3%	11.4%	64.2%	3.9%	14.4%
2005	1.5%	4.2%	0.4%	12.7%	61.7%	4.4%	15.2%
2006	1.4%	4.6%	0.3%	12.3%	62.3%	4.1%	14.9%

Source: Department of Energy, Energy Balances, 2002–2006.

3.2.1 Residential sector

The residential sector used less than 15% of electricity from 2002 to 2006 (see Figure 12). The sector is subdivided into urban and rural areas. Different types of households use energy mainly for cooking, water heating, space heating as well as lighting. Most people in urban areas rely on the use of electricity; however, residents in rural areas might use mainly wood for their energy source. Residential energy falls into three categories:

- Traditional fuels, consisting of wood, dung and bagasse;
- Transitional fuels, consisting of coal, paraffin and liquefied petroleum gas (LPG); and
- Modern fuels, consisting of electricity.

It is expected that in the future the trend from traditional fuels through transitional fuels to electricity is likely to continue, based on previous experiences. Electricity allows for more efficient energy use than coal, wood and paraffin although more energy can get consumed for water heating. It is also expected that there will be a growth in demand for energy for non-essential appliances such as televisions. Residential energy use is expected to grow at the same rate as the population[8].

3.2.2 Industrial sector

In South Africa, the industrial sector is the largest user of energy. The sector is divided into sub-sectors including agriculture and fishing, commercial, construction, manufacturing, mining and quarrying, and transport (see Figure 13 below).

Commercial sector

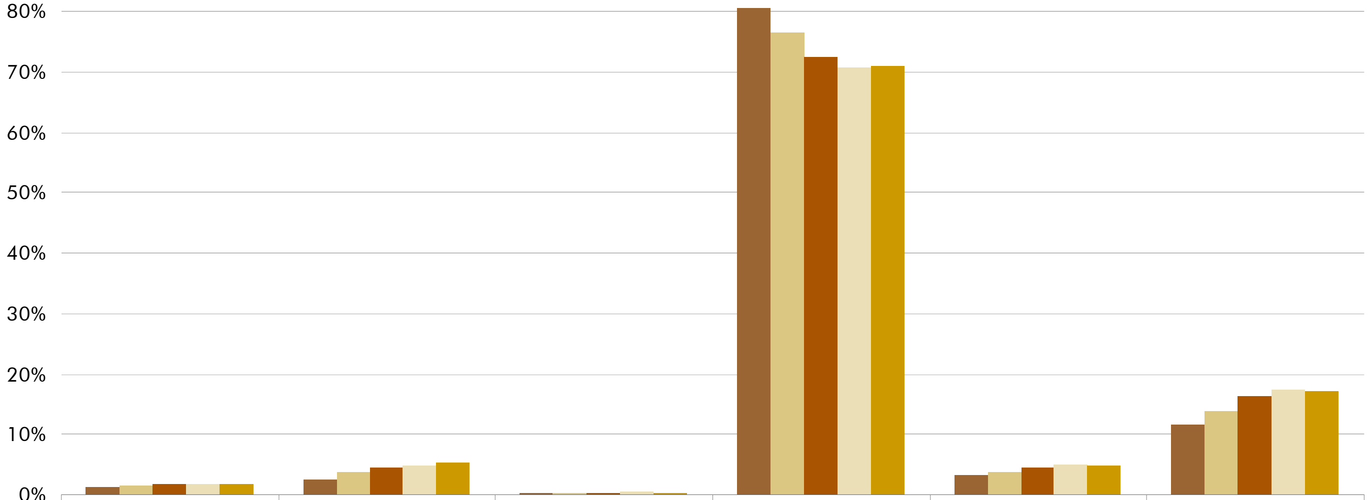
The commercial sector is very small (see Figure 13), even though it is growing at a fast rate. This sector consists of government, office buildings, financial institutions, shops, and recreation and education.

Energy in this sector is used mainly for lighting, heating and air-conditioning but, office machines such as computers, fax machines and printers are starting to play a bigger role as energy users. Electricity contributes the most to the commercial sector's energy use. Electricity is likely to take an even bigger share of energy for this sector in future.

Agricultural sector

The agricultural sector is smaller than the commercial sector in terms of electricity consumption (see Figure 13). The fuels used in the agricultural sector included electricity, petroleum and gas. As economies mature, agriculture forms a smaller share of the national employment, large farms replace smaller ones and agriculture produces a smaller fraction of GDP. However, with land reform, many new small farms are likely to arise, and these will almost certainly use traditional farming methods on small plots, including the use of vegetable wastes for energy. On the other hand, globalisation and commercialisation of farming are likely to lead to fewer commercial farmers with bigger farms and increased exports and imports. This will lead to a search for more energy efficiency. The latter trend is almost certain to prevail for agricultural energy demand and it is expected that the importance of diesel and electricity will increase, while that of vegetable wastes will decline.

Figure 13: Percentage distribution of energy to the industrial sub-sectors* in South Africa, 2002–2006



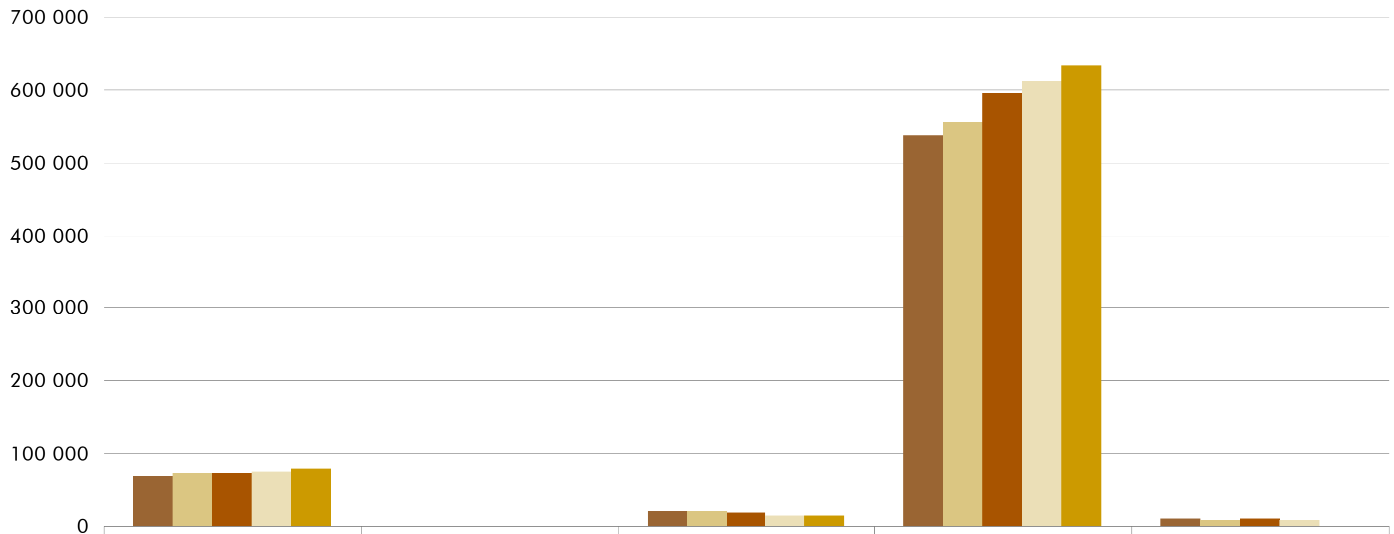
	Agriculture and fishing	Commercial sector	Construction	Manufacturing	Mining and quarrying	Transport, storage and communication
2002	1.3%	2.6%	0.3%	80.9%	3.3%	11.5%
2003	1.6%	3.6%	0.4%	76.6%	3.8%	14.0%
2004	1.8%	4.5%	0.4%	72.5%	4.4%	16.3%
2005	1.7%	4.8%	0.4%	70.6%	5.0%	17.4%
2006	1.6%	5.2%	0.4%	71.0%	4.7%	17.0%

*Excluding domestic.
Source: Department of Energy, Energy Balances, 2002–2006.

Transport sector

The transport sector deals with transport of people and goods by land, sea and air. Energy for transport is completely dominated by liquid fuels, such as petrol, diesel and jet fuel. It is very difficult to switch from fossil fuels to other sources of energy in this sector. Land transport is dominated by petrol and diesel with some electricity used by trains. Air transport uses jet fuel for gas turbine engines and aviation gas for piston engines. There are however, very few piston engines in the air these days and marine engines are nearly entirely diesel. Figure 14 below shows the energy consumption by various sub-sectors in the transport sector.

Figure 14: Energy consumption in terajoules per transport sub-sector from 2002–2006



	Air	Transport via pipeline	Rail	Road	Non-specified
2002	68 517	221	21 340	536 128	10 126
2003	72 615	278	20 667	555 363	7 596
2004	72 323	290	19 726	596 076	10 136
2005	75 931	284	14 726	612 564	7 439
2006	79 049	284	14 702	632 560	1

Source: Department of Energy, Digest of South African Energy Statistics, 2006.

4. Supply and use tables for energy for South Africa

Physical energy accounts should be constructed as extended supply and use tables. Usually the energy supply and use accounts will include both the monetary as well as the physical units. The energy accounts for South Africa are only presented in physical units at this time, the reason being that the accounts are based on the Energy Balances compiled by the DoE and are presented in physical units only. The DoE follows the IEA framework when compiling the Energy Balances. According to the Energy Statistics Manual (2005), the main aim of the Energy Balances (measured in physical units) is to serve as indicators of energy consumption and energy efficiency. This is done at a national level for every energy commodity in use, with the aim to make comparisons to the outside world. The IEA framework uses the International System of Units (SI) (i.e. modern metric system) that is used by all countries compiling Energy Balances. The SI converts to one unit of measure, e.g. terajoule, to energy commodities which makes it easy to understand and comparable, especially if correct conversions are applied. This section presents the energy supply and use accounts for South Africa from 2002–2006.

The main energy resources used in South Africa are listed in the columns and the sectors are given in the rows of the tables. Energy supply has to equal energy use in the column totals in order for the accounts to balance. All of the resources used are expressed in terajoules (TJ).

Supply of products is defined as domestic production plus import of the various energy commodities, whereas total product use is defined by the intermediate use by industries, household consumption, inventory changes and exports. The use table shows the use of natural resources, for example the use of coal, gas and oil extracted by the mining industries.

An important distinction has to be made between primary energy sources, classified into fossil fuels and renewable energy sources (such as water power and solar energy), and secondary energy sources such as electricity and refined petroleum products which have been produced from the transformation of a primary energy source. Use of a product refers to the consumption of the product by various industries and households. Exports, losses in distribution and statistical differences are included in the use table.

One should keep in mind that the energy accounts should include both primary and secondary energy sources. There is thus double counting in the sense that both primary energy (e.g. coal) and the converted energy (e.g. electricity produced by coal and other primary resources) are included. This is not different from other monetary and physical supply and use tables for products in which both raw materials and finished products appear. Tables 2 to 11 are the supply and use tables that include data from the Energy Balances, 2002–2006.

Table 2: Energy supply table for South Africa, 2002

	Terajoules								
	Coal	Crude oil	Electricity	Gas	Hydroelectric	Nuclear	Petroleum	Renewable energy and waste	Total energy supply
a. Domestic production	5 515 609	10 589	752 919	127 137	8 485	130 811	2 428 027	426 467	9 400 045
b. Imports	49 054	1 447 465	34 186	0	0	0	67 946	0	1 598 650
c. Total supply (a+b)	5 564 663	1 458 054	787 105	127 137	8 485	130 811	2 495 973	426 467	10 998 695

Source: Department of Energy, Energy Balances, 2002–2006.

Table 3: Energy use table for South Africa, 2002

	Terajoules								
	Coal	Crude oil	Electricity	Gas	Hydroelectric	Nuclear	Petroleum	Renewable energy and waste	Total energy use
a. Intermediate consumption by industries	3 513 139	1 453 533	567 234	127 137	8 485	130 811	1 957 354	236 067	7 993 761
Agriculture and fishing	*2 455*	*0*	*16 719*	*0*	*0*	*0*	*53 730*	*0*	*72 904*
Commercial	*45 524*	*0*	*65 618*	*293*	*0*	*0*	*32 162*	*0*	*143 597*
Construction	*0*	*0*	*415*	*0*	*0*	*0*	*15 401*	*0*	*15 816*
Electricity, gas and steam production	*2 015 364*	*0*	*3 933*	*83 764*	*8 485*	*130 811*	*0*	*236 067*	*2 478 424*
Manufacturing	*1 410 577*	*1 453 533*	*342 132*	*42 636*	*0*	*0*	*1 214 014*	*0*	*4 462 893*
Mining and quarrying	*39 218*	*0*	*115 933*	*412*	*0*	*0*	*28 231*	*0*	*183 795*
Transport, storage and communication	*0*	*0*	*22 485*	*31*	*0*	*0*	*613 816*	*0*	*636 332*
b. Inventory changes	21 216	0	0	0	0	0	0	0	21 216
c. Private consumption, total	89 564	0	144 048	0	0	0	35 909	190 400	459 920
Heating, use of electricity, etc.	*89 564*	*0*	*144 048*	*0*	*0*	*0*	*35 909*	*190 400*	*459 920*
d. Exports	1 940 743	4 520	26 071	0	0	0	502 711	0	2 474 046
e. Losses in distribution	0	0	49 752	0	0	0	0	0	49 752
f. Total use (a+b+c+d+e)	5 564 663	1 458 054	787 105	127 137	8 485	130 811	2 495 973	426 467	10 998 695

Source: Department of Energy, Energy Balances, 2002–2006.

Table 4: Energy supply table for South Africa, 2003

	Terajoules								
	Coal	Crude oil	Electricity	Gas	Hydroelectric	Nuclear	Petroleum	Renewable energy and waste	Total energy supply
a. Domestic production	5 796 818	5 144	784 879	99 062	2 890	138 142	2 255 901	430 427	9 513 263
b. Imports	49 171	732 330	29 498	0	0	0	41 398	0	852 397
c. Total supply (a+b)	5 845 989	737 474	814 378	99 062	2 890	138 142	2 297 299	430 427	10 365 660

Source: Department of Energy, Energy Balances, 2002–2006.

Table 5: Energy use table for South Africa, 2003

	Terajoules								
	Coal	Crude oil	Electricity	Gas	Hydroelectric	Nuclear	Petroleum	Renewable energy and waste	Total energy use
a. Intermediate consumption by industries	3 689 010	737 455	548 539	99 062	2 890	138 142	1 908 121	240 027	7 363 246
Agriculture and fishing	*3 322*	*0*	*18 515*	*0*	*0*	*0*	*53 162*	*0*	*74 998*
Commercial	*52 259*	*0*	*75 856*	*95*	*0*	*0*	*43 389*	*0*	*171 599*
Construction	*0*	*0*	*479*	*0*	*0*	*0*	*16 460*	*0*	*16 939*
Electricity, gas and steam 0production	*2 214 718*	*0*	*14 460*	*50 218*	*2 890*	*138 142*	*0*	*240 027*	*2 660 454*
Manufacturing	*1 381 877*	*737 455*	*308 339*	*46 415*	*0*	*0*	*1 127 950*	*0*	*3 602 037*
Mining and quarrying	*36 835*	*0*	*110 857*	*2 334*	*0*	*0*	*30 673*	*0*	*180 699*
Transport, storage and communication	*0*	*0*	*20 034*	*0*	*0*	*0*	*636 486*	*0*	*656 520*
b. Inventory changes	49 346	0	0	0	0	0	0	0	49 346
c. Private consumption, total	103 027	0	177 915	0	0	0	39 637	190 400	510 980
Heating, use of electricity etc.	*103 027*	*0*	*177 915*	*0*	*0*	*0*	*39 637*	*190 400*	*510 980*
d. Exports	2 004 606	19	36 947	0	0	0	349 541	0	2 391 112
e. Losses in distribution	0	0	50 976	0	0	0	0	0	50 976
f. Total use (a+b+c+d+e)	5 845 989	737 474	814 378	99 062	2 890	138 142	2 297 299	430 427	10 365 660

Source: Department of Energy, Energy Balances, 2002–2006.

Table 6: Energy supply table for South Africa, 2004

	Terajoules								
	Coal	Crude oil	Electricity	Gas	Hydroelectric	Nuclear	Petroleum	Renewable energy and waste	Total energy supply
a. Domestic production	5 840 254	206 292	890 631	120 862	2 890	145 801	1 058 263	430 427	8 695 420
b. Imports	52 106	1 006 341	35 345	6 981	0	0	82 675	0	1 183 446
c. Total supply (a+b)	5 892 359	1 212 633	925 976	127 842	2 890	145 801	1 140 938	430 427	9 878 867

Source: Department of Energy, Energy Balances, 2002–2006.

Table 7: Energy use table for South Africa, 2004

	Terajoules								
	Coal	Crude oil	Electricity	Gas	Hydroelectric	Nuclear	Petroleum	Renewable energy and waste	Total energy use
a. Intermediate consumption by industries	3 919 385	1 212 607	661 668	127 842	2 890	145 801	819 042	240 027	7 129 263
Agriculture and fishing	*3 155*	*0*	*22 172*	*0*	*0*	*0*	*52 661*	*0*	*77 988*
Commercial	*60 791*	*0*	*89 963*	*310*	*0*	*0*	*43 928*	*0*	*194 992*
Construction	*0*	*0*	*187*	*0*	*0*	*0*	*15 796*	*0*	*15 982*
Electricity, gas and steam production	*2 360 170*	*0*	*15 790*	*77 172*	*2 890*	*145 801*	*0*	*240 027*	*2 841 850*
Manufacturing	*1 456 283*	*1 212 607*	*392 687*	*48 049*	*0*	*0*	*0*	*0*	*3 109 626*
Mining and quarrying	*38 987*	*0*	*118 180*	*2 312*	*0*	*0*	*30 795*	*0*	*190 274*
Transport, storage and communication	*0*	*0*	*22 689*	*0*	*0*	*0*	*675 863*	*0*	*698 552*
b. Inventory changes	-53 861	0	0	0	0	0	0	0	-53 861
c. Private consumption, total	121 581	0	197 629	0	0	0	43 278	190 400	552 888
Heating, use of electricity etc.	*121 581*	*0*	*197 629*	*0*	*0*	*0*	*43 278*	*190 400*	*552 888*
d. Exports	1 905 254	25	47 714	0	0	0	278 618	0	2 231 611
e. Losses in distribution	0	0	18 965	0	0	0	0	0	18 965
f. Total use (a+b+c+d+e)	5 892 359	1 212 633	925 976	127 842	2 890	145 801	1 140 938	430 427	9 878 867

Source: Department of Energy, Energy Balances, 2002–2006.

Table 8: Energy supply table for South Africa, 2005

	Terajoules								
	Coal	Crude oil	Electricity	Gas	Hydroelectric	Nuclear	Petroleum	Renewable energy and waste	Total energy supply
a. Domestic production	5 793 803	282 359	832 538	124 505	4 199	123 193	1 190 715	430 427	8 781 738
b. Imports	57 616	772 180	39 884	45 383	0	0	102 500	0	1 017 563
c. Total supply (a+b)	5 851 419	1 054 539	872 422	169 888	4 199	123 193	1 293 215	430 427	9 799 301

Source: Department of Energy, Energy Balances, 2002–2006.

Table 9: Energy use table for South Africa, 2005

	Terajoules								
	Coal	Crude oil	Electricity	Gas	Hydroelectric	Nuclear	Petroleum	Renewable energy and waste	Total energy use
a. Intermediate consumption by industries	3 516 383	1 054 319	587 528	169 888	4 199	123 193	821 749	240 027	6 517 286
Agriculture and fishing	*379*	*0*	*19 871*	*0*	*0*	*0*	*51 284*	*0*	*71 534*
Commercial	*68 155*	*0*	*97 572*	*326*	*0*	*0*	*31 592*	*0*	*197 644*
Construction	*0*	*0*	*188*	*0*	*0*	*0*	*16 347*	*0*	*16 535*
Electricity, gas and steam production	*1 962 168*	*0*	*14 988*	*82 976*	*4 199*	*123 193*	*0*	*240 027*	*2 427 551*
Manufacturing	*1 428 615*	*1 054 319*	*321 523*	*84 029*	*0*	*0*	*0*	*0*	*2 888 487*
Mining and quarrying	*57 066*	*0*	*113 425*	*2 557*	*0*	*0*	*31 543*	*0*	*204 592*
Transport, storage and communication	*0*	*0*	*19 961*	*0*	*0*	*0*	*690 982*	*0*	*710 943*
b. Inventory changes	197 741	0	0	0	0	0	0	0	197 741
c. Private consumption, total	135 343	0	227 766	0	0	0	39 420	190 400	592 930
Heating, use of electricity etc.	*135 343*	*0*	*227 766*	*0*	*0*	*0*	*39 420*	*190 400*	*592 930*
d. Exports	2 001 951	219	48 319	0	0	0	432 045	0	2 482 535
e. Losses in distribution	0	0	8 809	0	0	0	0	0	8 809
f. Total use (a+b+c+d+e)	5 851 419	1 054 539	872 422	169 888	4 199	123 193	1 293 215	430 427	9 799 301

Source: Department of Energy, Energy Balances, 2002–2006.

Table 10: Energy supply table for South Africa, 2006

	Terajoules								
	Coal	Crude oil	Electricity	Gas	Hydroelectric	Nuclear	Petroleum	Renewable energy and waste	Total energy supply
a. Domestic production	5 788 411	287 766	856 008	125 797	9 895	109 375	991 004	430 427	8 598 682
b. Imports	57 428	926 356	38 246	52 202	0	0	135 264	0	1 209 496
c. Total supply (a+b)	5 845 839	1 214 122	894 255	177 998	9 895	109 375	1 126 267	430 427	9 808 178

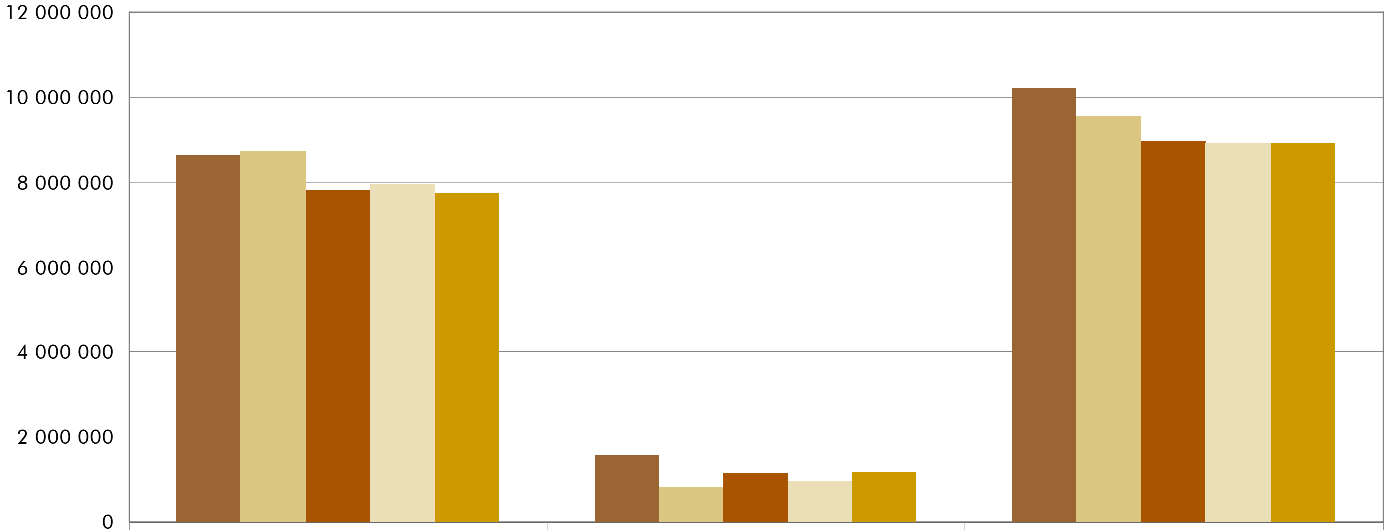
Source: Department of Energy, Energy Balances, 2002–2006.

Table 11: Energy use table for South Africa, 2006

	Terajoules								
	Coal	Crude oil	Electricity	Gas	Hydroelectric	Nuclear	Petroleum	Renewable energy and waste	Total energy use
a. Intermediate consumption by industries	3 568 553	1 193 284	601 218	177 998	9 895	109 375	853 589	240 027	6 753 939
Agriculture and fishing	*763*	*0*	*21 029*		*0*	*0*	*48 592*	*0*	*70 385*
Commercial	*76 399*	*0*	*103 798*	*864*	*0*	*0*	*43 071*	*0*	*224 133*
Construction	*0*	*0*	*194*	*0*	*0*	*0*	*15 470*	*0*	*15 665*
Electricity, gas and steam production	*2 032 129*	*0*	*14 766*	*72 314*	*9 895*	*109 375*	*0*	*240 027*	*2 478 506*
Manufacturing	*1 405 978*	*1 193 284*	*335 491*	*101 920*	*0*	*0*	*0*	*0*	*3 036 673*
Mining and quarrying	*53 282*	*0*	*113 412*	*2 900*	*0*	*0*	*32 388*	*0*	*201 982*
Transport, storage and communication	*0*	*0*	*12 527*	*0*	*0*	*0*	*714 069*	*0*	*726 596*
b. Inventory changes	197 741	0	0	0	0	0	424	0	198 165
c. Private consumption, total	152 604	0	219 435	0	0	0	38 867	190 400	601 305
Heating, use of electricity etc.	*152 604*	*0*	*219 435*	*0*	*0*	*0*	*38 867*	*190 400*	*601 305*
d. Exports	1 926 942	20 838	48 920	0	0	0	233 387	0	2 230 088
e. Losses in distribution	0	0	24 682	0	0	0	0	0	24 682
f. Total use (a+b+c+d+e)	5 845 839	1 214 122	894 255	177 998	9 895	109 375	1 126 267	430 427	9 808 178

Source: Department of Energy, Energy Balances, 2002–2006.

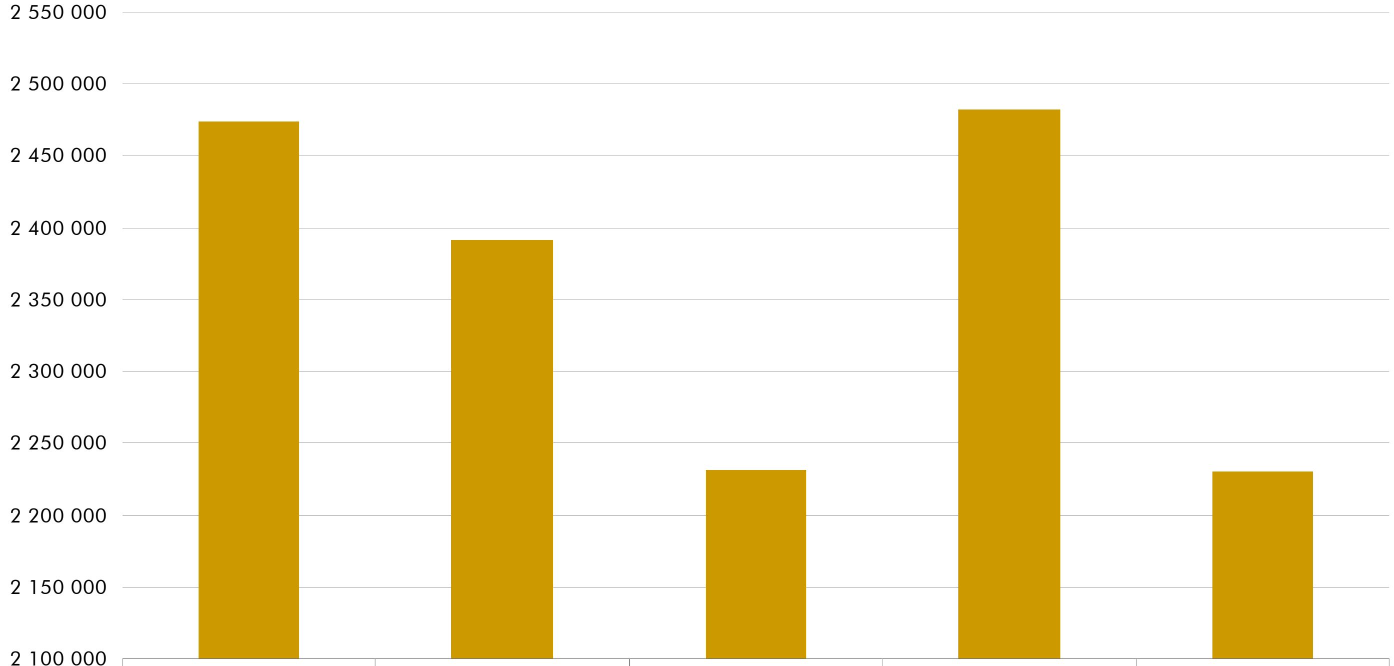
Figure 15: Total primary* energy supply in South Africa in terajoules, 2002–2006



	Domestic production	Imports	Total supply
2002	8 647 126	1 564 465	10 211 590
2003	8 728 384	822 899	9 551 282
2004	7 804 789	1 153 948	8 958 737
2005	7 949 201	977 679	8 926 879
2006	7 742 673	1 171 250	8 913 923

*Electricity production as a secondary supplier is not included.
Source: Department of Energy, Energy Balances, 2002–2006.

Figure 16: Total energy exported from South Africa in terajoules, 2002–2006



	2002	2003	2004	2005	2006
■	2 474 046	2 391 112	2 231 611	2 482 535	2 230 088

Source: Department of Energy, Energy Balances, 2002–2006.

5. South Africa's energy intensity and economic growth

South Africa's economic growth as measured by the growth in GDP was 4% for the period 2002 to 2006. The total primary energy supply decreased from 8 647 petajoules (PJ) in 2002 to 7 742 PJ in 2006 – a decrease of 10% over the five years. The energy intensity for the individual years is shown in Table 12 and Figure 17.

The ratio of aggregate energy use to GDP, often called 'energy intensity' or the 'energy ratio', is not an ideal indicator of energy efficiency, sustainability of energy use, or technological development. The aggregate ratio depends as much on the structure of the economy as on the energy intensities of sectors or activities, and changes in the ratio over time are influenced almost as much by changes in the structure of the economy as by changes in sector energy intensities. Measurement and interpretation of energy intensities are complicated by differences among products within a category, such as size (automobile weight or refrigerator capacity), features (power steering and automatic transmission in cars, freezer compartments in refrigerators), and utilisation (hours per year a stove is used, and vehicle occupancy if passenger-km is the measure of output). Total energy use should ideally be disaggregated into components, by sector (manufacturing, transportation, residential, commercial/services, industry, agriculture, construction, etc.) or sub-sector. For each sector or sub-sector, energy use can be related to a convenient measure of output to provide sector or sub-sector energy intensity. Examples include energy use for steel-making relative to tonnes of steel produced; energy consumption by passenger vehicles relative to passenger-kilometres or vehicle-kilometres; energy consumption in buildings relative to their floor area. The energy intensity of a process (energy consumed per unit of output) is the inverse of the 'energy efficiency' of the process (output per unit energy consumed). Due to resource constraints, this energy measurement would only be incorporated in future energy accounts.

Table 12: Energy intensity per gross domestic product, 2002–2006

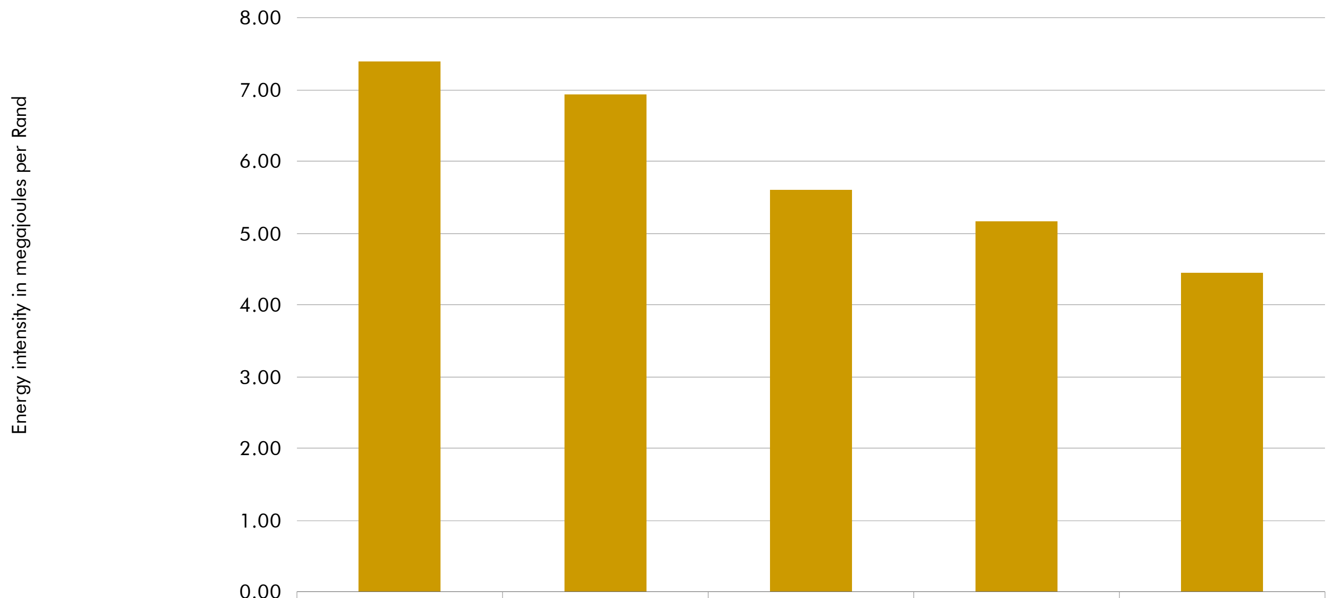
Year	Gross domestic product at market prices (R millions)	Primary energy supply in TJ*	Energy intensity in megajoules (MJ) per Rand
2002	1 168 699	8 647 126	7.40
2003	1 260 693	8 728 384	6.92
2004	1 395 369	7 804 789	5.59
2005	1 543 975	7 949 201	5.15
2006	1 745 219	7 742 673	4.44

*Excludes imports; includes coal, crude oil, gas, hydro, nuclear, petroleum products, and renewables and waste.

Sources: Department of Energy, Energy Balances, 2002-2006. Statistics South Africa, Quarterly Gross Domestic Product, Second quarter: 2009, Statistical release P0441.

High energy intensities indicate a high price or cost of converting energy into GDP. Low energy intensities indicate a lower price or cost of converting energy into GDP. Since 2002 the price of converting energy into GDP has steadily decreased. The lower energy intensities could thus be an indicator of higher economic productivity.

Figure 17: Energy intensity in megajoules per rand, 2002–2006



	2002	2003	2004	2005	2006
Energy intensity in megajoules per Rand	7.40	6.92	5.59	5.15	4.44

Sources: Department of Energy, Energy Balances, 2002–2006. Statistics South Africa, Quarterly GDP, Second quarter: 2009, Statistical release P0441.

6. Real gross domestic product and energy use change

South Africa's real GDP annualised changes as shown in Tables 13 and 14 are presented below. The change in energy use from 2002 to 2006 does not necessarily reflect the change in real GDP in the period 2002 to 2006.

Table 13: Real gross domestic product, percentage change at seasonally adjusted annualised rates, 2001–2006

	Primary sector		Secondary sector			Tertiary sector	
	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas and water	Construction	Wholesale and retail trade; hotels and restaurants	Transport, storage and communication
2001	-3.3%	-0.1%	3.2%	-3.7%	4.9%	1.9%	5.9%
2002	6.5%	1.0%	2.8%	3.5%	5.8%	2.3%	9.0%
2003	-2.1%	4.0%	-1.4%	1.9%	6.9%	6.5%	5.9%
2004	1.4%	1.3%	4.7%	3.0%	11.1%	5.9%	4.7%
2005	5.4%	2.2%	4.6%	1.7%	12.4%	7.3%	5.3%
2006	-7.2%	-0.3%	4.9%	2.8%	13.5%	7.2%	6.6%

2002	↗	↗	↘	↗	↗	↗	↗
2003	↘	↗	↘	↘	↗	↗	↘
2004	↗	↘	↗	↗	↗	↘	↘
2005	↗	↘	↘	↘	↗	↗	↗
2006	↘	↘	↗	↗	↗	↘	↗

Sources: Statistics South Africa, Gross Domestic Product, Second quarter: 2009, Statistical release P0441. South African Reserve Bank, Quarterly Bulletins, 2002–2007.

Table 14: Energy use in terajoules by the industrial sector, 2001–2006

	Energy use in terajoules (TJ)						
	Primary sector		Secondary sector			Tertiary sector	
	Agriculture and fishing	Mining and quarrying	Manufacturing	Electricity, gas & steam production	Construction	Commercial sector	Transport, storage and communication
2001	70 003	183 744	2 691 680	2 112 434	15 044	134 447	226 497
2002	72 904	183 795	4 462 893	2 478 424	15 816	143 597	636 332
2003	74 998	180 699	3 602 037	2 660 454	16 939	171 599	656 520
2004	77 988	190 274	3 109 626	2 841 850	15 982	194 992	698 552
2005	71 534	204 592	2 888 487	2 427 551	16 535	197 644	710 943
2006	70 385	201 982	3 036 673	2 478 506	15 665	224 133	726 596

2002	↗	↗	↗	↗	↗	↗	↗
2003	↗	↘	↘	↗	↗	↗	↗
2004	↗	↗	↘	↗	↘	↗	↗
2005	↘	↗	↘	↘	↗	↗	↗
2006	↘	↘	↗	↘	↘	↗	↗

Sources: Department of Energy, Energy Balances 2002–2006. Statistics South Africa, Supply and Use Tables, Energy Accounts for South Africa, 1995–2001 and 2002–2006.

Primary sector

Agriculture

The real value added by the agricultural sector increased in 2002, due to an increase in field crop production – particularly maize and sugar. Similarly energy use by the agricultural sector increased in 2002. In 2003 most of the country was affected by poor weather conditions having an adverse effect on livestock and field crop production and real value added by the agricultural sector declined in 2003. Energy use by the agricultural sector increased in 2003. Following the decline in 2003, the real value added by the agricultural sector increased mainly on account of higher field crop production and an increase in the output of livestock farmers in 2004. Energy use in 2004 by the agricultural sector also increased. In 2005 livestock production continued to edge higher, showing an increase in the real value added by the agricultural sector, but energy use declined. The rate of decline in real value added by the agricultural sector in 2006 was a reflection of the continued deterioration in the production of field crops, despite an improvement in the wheat crop production. Energy use by the agricultural sector declined in 2006.

Mining

In 2002 as a whole the real value added by the mining sector declined. A weak demand influenced production volumes of diamond mining, and the global demand for platinum was slow-moving. An improvement in the real output from the gold-mining sector counteracted the weak display from the non-gold mining sector with volume of gold output showing the first increase since 1993. Energy use in the mining sector increased in 2002. Real mining output increased in 2003 due to buoyant activities in diamond and coal mining, supported by stable growth in platinum production. Energy use in 2003 by the mining sector declined. The contraction in the mining sector in 2004 was mainly due to a decline in the real value added by the gold and platinum sectors. The increase in coal mining production could not offset the decline in the real value by the other mining sub-sectors. Export earnings came under pressure in 2004 as a result of the strong exchange rate. Energy use by the mining sector increased in 2004. The notable contraction in 2005 was mainly due to the decline in the real value added by the platinum mining sector, which was adversely affected by scheduled smelter maintenance. The dampening effect of the stronger rand on export earnings might have constrained mining production somewhat. In 2005 energy use by the mining sector increased. Although platinum increased in real value added in 2006, gold mining declined showing an overall decline in the mining sector. Energy use by the mining sector declined in 2006.

Secondary sector

Manufacturing

Growth in real manufacturing output for 2002 was due to the improved price competitiveness which South African producers enjoyed in export markets as a result of the lower exchange value of the rand for the greater part of 2002. The manufacturing sector showed an increase in energy use in 2002. Real manufacturing output for 2003 contracted due to reduced exports, inability to take advantage of strong domestic demand, and lagging translation of global growth into South African exports. Energy use by the manufacturing sector declined in 2003. An improvement in the manufacturing sector was shown in 2004 due to the continued strength of the domestic demand; local manufacturing proximity to and flexibility in dealing with the domestic market; well-contained and in some cases declining input costs; and strong international demand. The energy use by the manufacturing sector declined in 2004. The decline in the real value added by the manufacturing sector in 2005 occurred in a number of sub-sectors, namely manufactured food and beverages, petroleum, chemical and plastic products as well as electrical machinery. Plant conversion related to the change-over from leaded to unleaded and lead replacement fuel adversely affected production in the petroleum and chemical products sub-sector for 2005. Cheaper exports made it difficult for local manufacturers to capitalise on the buoyant domestic demand for consumer goods. In 2005 energy used by the manufacturing sector declined. In 2006 the sub-sector that manufactures petroleum, chemical products, rubber and plastic rebounded strongly. Throughout 2006 a continued high level of business confidence and a sustained high level of domestic demand continued, while manufacturing exports expanded. As a result manufacturing experienced an increase in the utilisation of production capacity in 2006. The manufacturing sector showed an increase in energy use in 2006.

Electricity, gas and water supply

The real value added by the electricity, gas and water supply sector accelerated in 2002 due to a higher domestic production. Electricity, gas and steam production showed an increase in 2002. The real output by the electricity, gas and water supply sector in 2003 declined due to lower imports from neighbouring countries. An increase was shown by electricity, gas and steam production in 2003. Higher volumes of electricity exported in 2004 boosted growth in the real value added by the sector supplying electricity, gas and water. An increase was shown by electricity, gas and steam production in 2004. Growth in the real value added by the sector supplying electricity, gas and water was slowed in 2005 by an exceptionally mild winter which weighed on electricity consumption. Electricity, gas and steam production showed a decline in 2005. An increase in demand, both domestically and abroad, resulted in growth in the real value added by the sector supplying electricity, gas and water in 2006. Electricity, gas and steam production showed a decline in 2006.

Construction

The real value added by the construction sector in 2002 was due to the expansion in residential areas, specifically high security developments. The construction sector increased its energy use in 2002. Growth in the real value added by the construction sector accelerated in 2003, mostly from the addition and modernisation of retail space. The construction sector increased its energy use in 2003. The real value added by the construction sector increased in 2004, underpinned by robust activity in the residential building sector. Relatively low interest rates and rising household incomes provided impetus to the demand for new residential buildings. The demand for retail and entertainment space increased in 2004, showing a substantial improvement. The construction sector showed a decline in energy use in 2004. Buoyancy of residential and non-residential building activity kept the construction sector accelerating in 2005. Provincial governments stepped up the pace of civil construction works, adding to the increase in 2005. The construction sector increased its energy use in 2005. A surge in the construction of non-residential buildings and further increased activity in the construction of residential buildings attributed to an increase in growth in real value added in 2006 for the construction sector. The construction sector showed a decline in energy use in 2006.

Tertiary sector

Commerce

For the year 2002 real value added by the commerce sector increased due to a solid performance by the retail sector. The commerce sector accelerated in 2003 mainly due to lively activity in the retail trade and catering and accommodation sectors. Strong consumer demand for furniture and household equipment, semi-durable and non-durable goods prevailed and the tourism industry flourished. The commerce sector decelerated slightly in 2004, although the demand for durable goods remained strong. In 2005 the retail and motor trade showed brisk performance against the backdrop of consumer confidence, real spending on durable goods that lifted the real value added in the commerce sector. Growth in the commerce sector slowed in 2006 mainly reflected by slower output growth in the wholesale and retail sectors. The commercial sector showed a continued increase of energy use between 2002 and 2006.

Transport, storage and communication

Growth in the real value added by the transport, storage and communication sector slowed down in 2003. A slight decline in the transport, storage and communication sector is shown in 2004 due to volumes of imports and exports. In 2005 the sustained high level of domestic demand which led to an increase in the usage of land freight transport added to the growth in the real value added to the transport, storage and communication sector. In 2006 the mainstay activity in the communication sector was increased cellular communication where increased competition and number portability supported real output. The brisk increase in road transport comfortably offset slower growth in real value added by air transport. As a result of these developments the real value added by the transport, storage and communication sector rose in 2006. The transport, storage and communication sector showed increased energy use from 2002 to 2006.

7. Conclusion

The main energy resources in the South African economy are coal, oil, gas, nuclear power, hydropower and renewable sources such as wind, solar, biomass and wave power. The South African economy, for our purpose, is divided into six sub-sectors, namely the residential sector; the commercial sector; the agricultural sector; the transport sector; the industrial sector; and other sectors.

The environmental economic accounts are crucial in a sense that they reflect how significant our environment is as a provider of resources in the economy. In South Africa, energy is sourced from the natural resources being coal, therefore the supply and use (in physical units) of energy should be reflected in a way that is understandable from its raw production to the residuals.

The energy supply and use tables can therefore provide us with answers to the following questions:

- What is the level of energy consumption?
- What is the level of energy input (both direct and indirect) into the various categories of final demand (private household consumption, exports, etc.)?
- What is the energy intensity of particular industries, taking into account both direct and indirect energy inputs?

For the sake of future predictions, these accounts can also provide information on changes in the energy requirements of particular industries in relation to their output. These accounts will be updated periodically, based on data availability from Energy Balances compiled by the DoE. It will be important to publish future energy accounts as official statistics and for the DoE and Stats SA to embark on the process of verification of input data into the energy balances.

8. Glossary

Term	Description
Anaerobic digesters	Anaerobic digestion is a series of processes in which micro-organisms break down biodegradable material in the absence of oxygen. It is widely used to treat wastewater sludges and organic waste because it provides volume and mass reduction of the input material. As part of an integrated waste management system, anaerobic digestion reduces the emission of landfill gas into the atmosphere. Anaerobic digestion is a renewable energy source because the process produces a methane and carbon dioxide rich biogas suitable for energy production helping replace fossil fuels. Also, the nutrient-rich solids left after digestion can be used as fertiliser. The digestion process begins with bacterial hydrolysis of the input materials in order to break down insoluble organic polymers such as carbohydrates and make them available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. Acetogenic bacteria then convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Methanogens are finally able to convert these products to methane and carbon dioxide.
Account	An account is a tool which records, for a given aspect of economic life, (a) the uses and resources or (b) the changes in assets and the changes in liabilities and/or (c) the stock of assets and liabilities existing at a certain time; the transactions accounts include a balancing item which is used to equate the two sides of the accounts (e.g. resources and uses), and which is a meaningful measure of economic performance.
Biomass	Biomass is the quantity of living material of plant or animal origin, present at a given time within a given area.
Biomass power	Biomass is plant material either raw or processed and includes agricultural residues, wood waste, paper trash, municipal solid waste, energy crops and methane captured from landfill sites. Unlike fossil fuels, biomass is renewable in the sense that only a short period of time is needed to replace what is used as an energy source. This biomass can be used to generate electricity, heat or liquid fuels.
Biota	Refers to the flora and fauna of a specific region or country.
Coal	An accumulation of carbonaceous material derived from vegetation.
Consumption	Consumption is an activity in which institutional units use up goods and services. It can be either intermediate or final.

Term	Description
Crude oil	A mineral oil consisting of a mixture of hydrocarbons of natural origins, yellow to black in colour and of variable viscosity.
Ecological footprint	An ecological footprint is the land (and water) area of the planet or particular area required for the support either of humankind's current lifestyle or the consumption pattern of a particular population. It is the inverse of the carrying capacity of a territory.
Energy balances	Materials and energy balances are accounting tables that provide information on the material input into an economy delivered by the natural environment, the transformation and use of that input in economic processes (extraction, conversion, manufacturing, consumption) and its return to the natural environment as residuals (wastes). The accounting concepts involved are founded on the first law of thermodynamics, which states that matter (mass/energy) is neither created nor destroyed by any physical process.
Energy intensity	Energy intensity is a measure of the energy efficiency of a nation's economy. It is calculated as units of energy per unit of GDP. • High energy intensities indicate a high price or cost of converting energy into GDP. • Low energy intensity indicates a lower price or cost of converting energy into GDP. Many factors influence an economy's overall energy intensity. It may reflect requirements for general standards of living and weather conditions in an economy. It is not atypical for particularly cold or hot climates to require greater energy consumption in homes and workplaces for heating (furnaces, or electric heaters) or cooling (air conditioning, fans, refrigeration). A country with an advanced standard of living is more likely to have a wider prevalence of such consumer goods and thereby be impacted in its energy intensity than one with a lower standard of living. Energy efficiency of appliances and buildings (through use of building materials and methods, such as insulation), fuel economy of vehicles, vehicular distances travelled (frequency of travel or larger geographical distances), better methods and patterns of transportation, capacities and utility of mass transit, energy rationing or conservation efforts, 'off-grid' energy sources, and stochastic economic shocks such as disruptions of energy due to natural disasters, wars, massive power outages, unexpected new sources, efficient uses of energy or energy subsidies may all have an overall impact on the energy intensity of a nation. Thus, a nation that is highly economically productive, with mild and temperate weather, demographic patterns of work places close to home, and uses fuel-efficient vehicles, supports carpools, mass transportation or walks or rides bicycles, will have a far lower energy intensity than a nation that is economically unproductive, with extreme weather conditions requiring heating and

Term	Description
	cooling, long commutes, and extensive use of generally poor fuel-economy vehicles. Paradoxically, some activities that may seem to promote high energy intensities, such as long commutes, could in fact result in lower energy intensities by causing a disproportionate increase in GDP output.
Energy sources	Energy sources are all solid, liquid and gaseous fuels; electricity; uranium; steam and hot water; and the traditional fuels such as fuel wood, charcoal, and vegetable and animal wastes.
Energy supply	Total primary energy domestic supply (sometimes referred to as energy use) is calculated by the International Energy Agency as production of fuels + inputs from other sources + imports - exports - international marine bunkers + stock changes. It includes coal, crude oil, natural gas liquids, refinery feed stocks, additives, petroleum products, gases, combustible renewables and waste, electricity and heat. Domestic supply differs from final consumption in that it does not take account of distribution losses. The supply and use of energy commodities are converted to kilogramme oil equivalent using standard coefficients for each energy source.
Environmental accounting	Under the SEEA framework, environmental accounting refers to the combination of natural resource accounts, which consist of stock and flow accounts in physical terms, and the monetary valuation of these accounts.
Gross domestic product	A measure of the total economic activity occurring within the national boundary of a country.
Hydropower	Hydropower is electricity generation using the power of falling water.
Intermediate consumption	Intermediate consumption consists of the value of the goods and services consumed as inputs by a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital. The goods and services may be either transformed or used up by the production process. Some inputs re-emerge after having been transformed and incorporated into the outputs. Other inputs are completely consumed or used up. Intermediate consumption includes the rentals paid on the use of fixed assets.
Joules	One joule is the amount of energy required to perform the following physical actions: • The work done by a force of one Newton travelling through a distance of one metre. • The work required to move an electric charge of one coulomb through an electrical potential difference of one volt; or one coulomb volt, with the symbol C·V. • The work done to produce the power of one watt continuously for one second or one watt second

Term	Description
	(compare kilowatt-hour), with the symbol W·s. Thus a kilowatt-hour is 3 600 000 joules.
Micro-hydropower	Micro-hydropower is a technically and economically feasible remote area power supply technology option at suitable sites. A typical micro-hydropower scheme diverts water from a river using a dam or weir.
Natural gas	Consists mainly of methane occurring naturally in underground deposits. It may be associated or free gas.
Natural resource accounting	An accounting system that deals with stocks and flows of natural assets, comprising biota (produced or wild); subsoil assets (proved reserves); and water and land with their aquatic and terrestrial ecosystems. The term is used frequently in distinguishing physical accounting from monetary (environmental) accounting. However, the terms 'natural resource accounting' and 'environmental accounting' are often used interchangeably.
Natural resources	Natural assets (raw materials) occurring in nature that can be used for economic production or consumption.
Non-renewable natural resources	Exhaustible natural resources such as mineral resources (coal or uranium) that cannot be regenerated after exploitation.
Nuclear power plant	A nuclear power plant is a facility that converts atomic energy into usable power. In a nuclear electric power plant, heat produced by a reactor is generally used to drive a turbine which in turn drives an electric generator.
Photovoltaics	Photovoltaics is the field of technology and research related to the application of solar cells for energy by converting sun energy (sunlight or sun ultra violet radiation) directly into electricity.
Physical accounting	Natural resource and environmental accounting of stocks and changes in stocks in physical (non-monetary) units, for example weight, area or number. Qualitative measures, expressed in terms of quality classes, types of uses or ecosystem characteristics, may supplement quantitative measures.
Solar power	Solar radiation exploited for hot water production and electricity generation by: • Flat plate collectors, mainly of the thermosyphon type, for domestic hot water or for the seasonal heating of swimming pools. • Photovoltaic cells. • Solar thermal-electric plants.

Term	Description
System of Environmental and Economic Accounting (SEEA)	The SEEA was developed by the United Nations Statistical Division, as a satellite system to the System of National Accounts (SNA), for the incorporation of environmental concerns (environmental costs, benefits and assets) in the national accounts. The SEEA is intended to be a system with global application and standards, suitable for all countries and all aspects of the environment.
System of National Accounts (SNA)	An international accounting framework consisting of a coherent, consistent and integrated set of macro-economic accounts, balance sheets and tables based on a set of internationally agreed concepts, definitions, classifications and accounting rules. It provides a comprehensive accounting framework within which economic data can be compiled and presented in a format that is designed for the purposes of economic analysis, and decision and policy-making.
Wave power	Waves are a free and sustainable energy resource created as wind blows over the ocean surface. The greater the distances involved, the higher and longer the waves will be. Energy is stored in this way until it reaches the shallows and beaches of coasts where it is released.
Wind power	Wind power is the conversion of wind energy into a useful form, such as electricity, using wind turbines.

Table 15: International System of Units – multiples for joule

SI multiples for joule (J)					
Submultiples			Multiples		
Value	Symbol	Name	Value	Symbol	Name
10^{-1} J	dJ	decijoule	10^{1} J	daJ	decajoule
10^{-2} J	cJ	centijoule	10^{2} J	hJ	hectojoule
10^{-3} J	mJ	millijoule	10^{3} J	kJ	kilojoule
10^{-6} J	µJ	microjoule	10^{6} J	MJ	megajoule
10^{-9} J	nJ	nanojoule	10^{9} J	GJ	gigajoule
10^{-12} J	pJ	picojoule	10^{12} J	TJ	terajoule
10^{-15} J	fJ	femtojoule	10^{15} J	PJ	petajoule
10^{-18} J	aJ	attojoule	10^{18} J	EJ	exajoule
10^{-21} J	zJ	zeptojoule	10^{21} J	ZJ	zettajoule
10^{-24} J	yJ	yoctojoule	10^{24} J	YJ	yottajoule

9. Endnotes

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Annexure 1

According to the SEEA 2003, there are four types of physical flows included for energy accounts, namely:

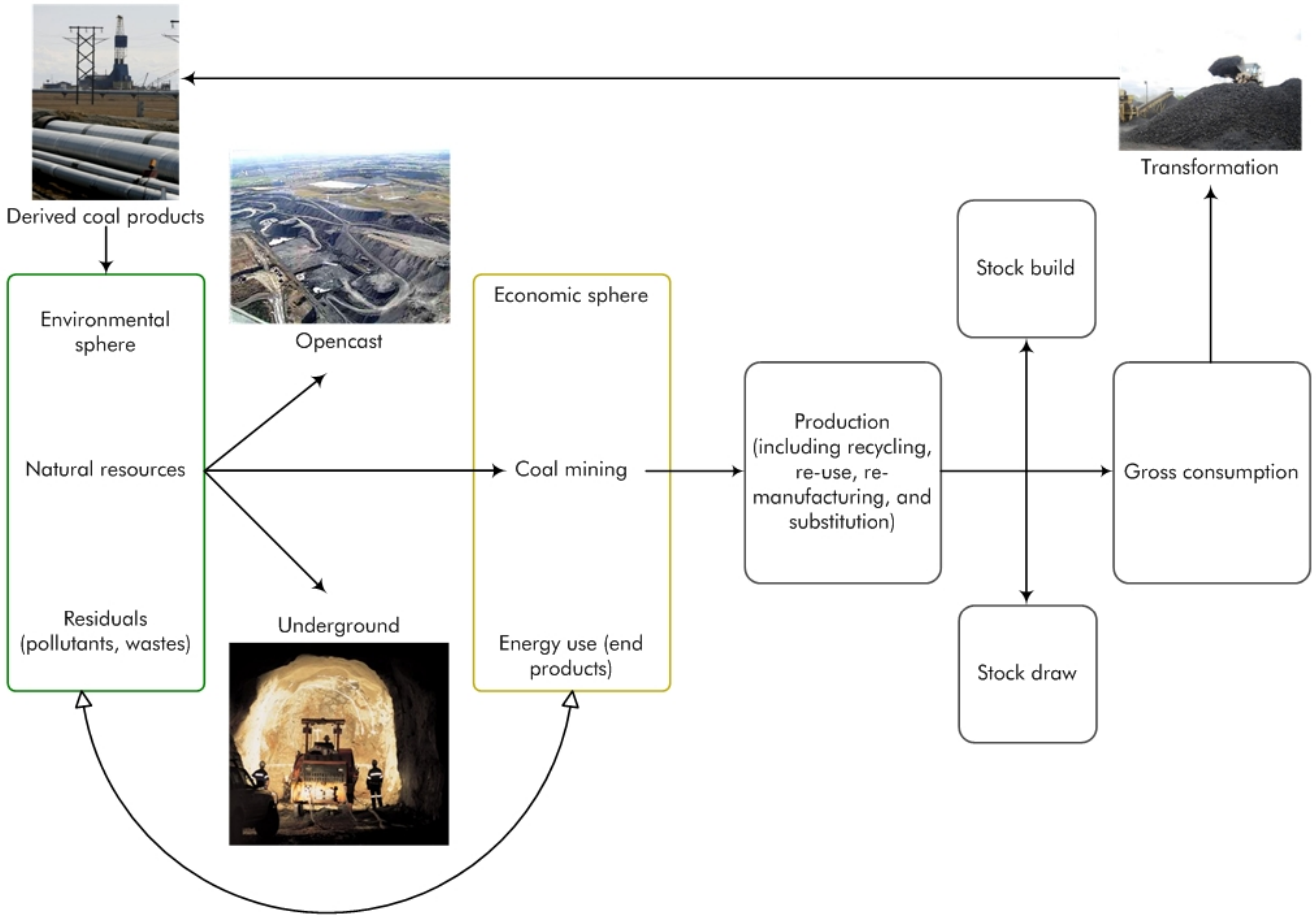
- Natural resource extraction (coal, crude oil, and natural gas);
- Ecosystem inputs (oxygen combustion);
- Products (energy fuels such as petrol, diesel, etc.); and
- Residuals generated by the use of fossil fuels (emissions to air and other residuals such as ashes are dealt with separately in emission accounts).

The scope of the energy accounts is summarised below:

Figure 1.1 indicates the physical flows of coal from extraction to the end products. From the chart it is easy to understand the process which coal undergoes before it produces secondary products such as electricity.

In South Africa, energy accounts are assembled in the form of supply and use tables. The energy supply and use accounts include both the monetary as well as the physical units. These physical units are converted to terajoules (TJ) to give total energy use and total energy supply, since the monetary values are not easily available.

Figure A1.1: Scope of energy accounts in the case of coal



Source: Adapted from United Nations Statistic Division, System of Integrated Environmental and Economic Accounting, 2003 and Energy Statistics Manual, 2005.

Energy supply table

The supply of products is defined as the addition of both domestic production and imports of the various energy commodities. The two main sources used to obtain data on the supply of energy are production statistics and foreign trade statistics. It is important that the nomenclatures of these two sources be absolutely compatible. Both the production and the foreign trade statistics will normally provide data on the monetary value as measured in basic prices of the energy commodities, both produced domestically and imported, as well as the corresponding physical quantities thereof.

However, some energy types are not commodities in the narrow sense of the word; many renewable resources are not tradable, for example wind. The physical supply of such renewables is thus determined by the total use, while the supply in monetary terms is determined either by the unit value of relevant substitutes (or some other 'rule of thumb') or set to zero, depending on the corresponding market prices. Foreign trade statistics are used as a source of information for imports and exports of the different energy commodities. An example of the energy supply table used by Denmark, which was published in SEEA 2003, is shown below:

Table A1.1: Sample supply table for energy

	Crude oil	Natural gas	Coal and lignite	Petroleum products	Gas to users	Electricity	Steam and water	Wood, straw and waste	Total energy use	
	1 000 tons	million m^3	1 000 tons	1 000 tons	million m^3	TWh	PJ	1 000 tons	PJ	Billion DKK
a. Domestic production										
b. Imports										
c. Total supply (a+b)										

Source: United Nations Statistics Division, System of Integrated Environmental and Economic Accounts, 2003.

Energy use table

The total product use is defined by the intermediate use by industries, household consumption, inventory changes and exports. Natural resources, for example the use of coal, gas and oil extracted by the mining industries are shown in the use table.

An important distinction has to be made between primary energy sources, separated into fossil fuels and renewable energy sources (such as water power and solar energy), and secondary energy sources such as electricity and refined petroleum products which have been produced from the transformation of a primary energy source.

Compiling a comprehensive view of the energy use table therefore typically involves combining all sorts of data together with assumptions (for example, estimating private transport to be equal to 75% of total transport) and well-defined calculation procedures. Often definitive information is available at an aggregate or semi-aggregate level and this data is used as control totals in determining entries at a lower level of aggregation.

To determine the use of the different energy commodities by industries and households, the first group of data consists of information from surveys explicitly concerned with energy consumption. In many countries, including South Africa, these are conducted regularly (in South Africa, normally every three years) for manufacturing, hereby providing industry-specific data on the use of a number of energy products. Surveys on service industries and households are also conducted in some countries, including South Africa. If not conducted yearly, the data must be projected or estimated using various indices and other supporting data according to the SEEA 2003.

In some cases the survey data includes information in both physical quantities and monetary values. If not, accounting data may give more or less detailed information on the amount spent on energy by industry, measured in monetary terms, thus providing important information on the value dimension of the industry-specific control totals. This, together with information on price statistics, can help to determine a control total in physical terms also. Best use of both physical and monetary data should be made in populating the use table, typically making use of the one dimension in determining the other in a supplementary way. The energy use table used by Denmark, which was published in SEEA 2003, is shown below:

Table A1.2: Sample use table for energy

	Crude oil	Natural gas	Coal and lignite	Petroleum products	Gas to users	Electricity	Steam and hot water	Wood, straw and waste	Total energy use	
	1 000 tons	million m³	1 000 tons	1 000 tons	million m³	TWh	PJ	1 000 tons	PJ	Billion DKK
a. Intermediate consumption by industries										
Agriculture, fishing and quarrying										
Manufacturing										
Electricity, gas and water supply										
Construction										
Wholesale and retail traders										
Transport, storage and communication										
Financial intermediation										
Public and personal services										
b. Inventory changes										
c. Total private consumption										
Own account transportation by cars										
Heating, use of electricity, etc.										
d. Exports										
e. Losses in distribution										
f. Total use (a+b+c+d+e)										

Source: United Nations Statistics Division, System of Integrated Environmental and Economic Accounts, 2003.

Bringing the system into balance means that for any commodity the total supply must equal to the total use, and for any industry the sum of its uses of each of the energy commodities must equal some given level (which might be one of the control totals).

As the whole system tends to be rather large, it often pays to balance smaller blocks of the system separately before putting the whole system together. The balancing has to be done by first filling out the parts, which are known with a fair degree of certainty, and then determining the remainder of the system using progressively less hard data and more assumptions.

All of the resources used are expressed in their own specific physical units. These units are then converted to petajoules (PJ) in order to calculate total energy use. In the Energy Balances – Republic of South Africa, which is the main data source, terajoules (TJ) are used instead of petajoules, so the energy accounts for South Africa are also expressed in TJ. A distinction is made between primary and secondary energy sources. Primary sources are in the form in which they appear in the environment and thus synonymous with natural resources. Secondary sources are in the form in which they are finally consumed in the economy and are thus products. Crude oil, natural gas, coal, wood and straw could be shown as natural resources flowing from the environment to the extraction industries of the economy, but for the purpose of this account are shown as products; that is, as outputs of the economy.

For petroleum products, gas to users, electricity, and steam and hot water, the domestic production is a result of the conversion of primary energy types into final energy types. Thus, there is a double counting in the sense that both primary energy (for example, coal) and the secondary energy (for example, electricity produced by coal) are included. This, however, is not different from other monetary and physical supply tables for products in which both raw materials and finished products appear.

The use table for energy has exactly the same headings as the supply table. For each group the total use is equal to the total supply. However, one additional entry, 'losses in distribution, etc.', is included in the use table in order to take explicit account for the losses that take place when the energy is distributed from supplier to user by pipe, wire, ship, truck or other means of transportation. As an alternative to the explicit accounting, the physical losses in distribution should be allocated to the users of the energy.

Electricity data collection

Electricity data is collected by the Trade and Industry division in Stats SA through the Electricity Generated and Available for Distribution Survey, statistical release P4141. The Survey follows the regulation stated under section 16 of the Statistics Act, 1999 (Act No. 6 of 1999), and the requirement of the information is compulsory to all energy sectors. Data is collected on a monthly basis (in physical units), using a questionnaire that is sent via post or fax, and returned not later than ten days within the month concerned.

Data is collected from a sample of 22 industries following the SIC. Electricity, Gas and Water supply are categorised under SIC code 4. Electricity data is collected for SIC 41111 (generation of electricity) and 41113 (distribution for own use) respectively.

Table A1.3: Standard Industrial Classification of all Economic Activities (SIC)

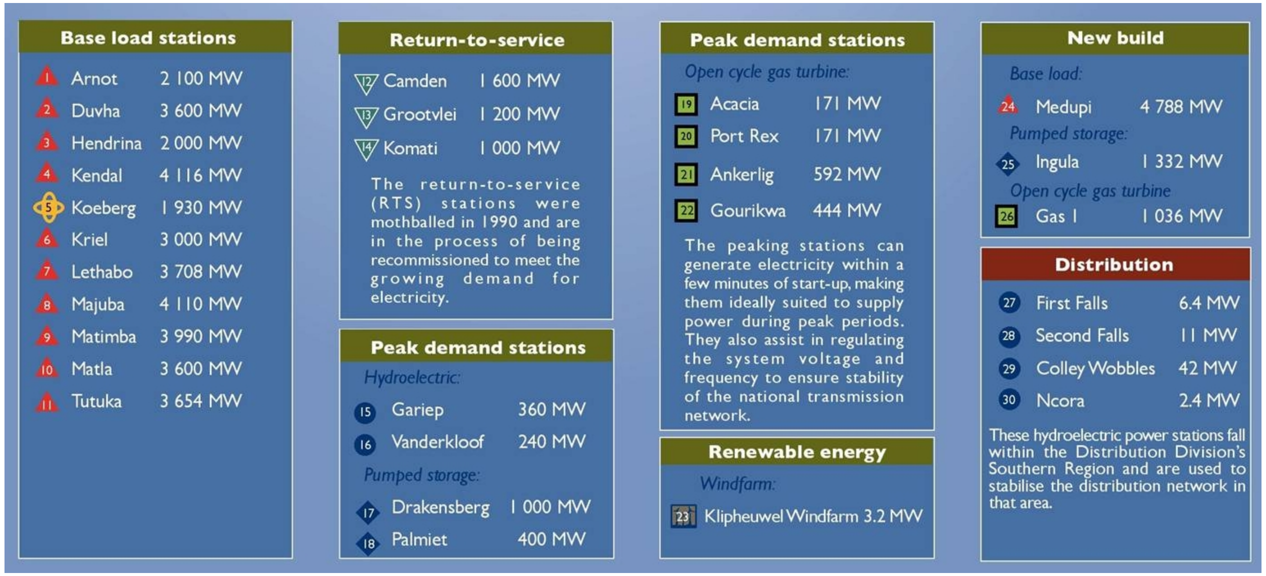
SIC codes		Classification
Major Division	4	Electricity, gas and water supply (1-digit level)
Division	41	Electricity, gas, steam and hot water supply (2-digit level)
Major Group	411	Production, collection and distribution of electricity (3-digit level)
Group	4111	(4-digit level)
Subgroup	41111	Generation (5-digit level)
	41112	Distribution of purchased electric energy only (5-digit level)
	41113	Generation for own use (5-digit level)

Questions used when collecting electricity information

1. Electricity generated in kilowatt-hours (kWh).
2. Electricity consumed in power station(s) and energy storage systems in kWh.
3. Net quantity of electricity generated and sent out from power station(s).
4. Purchases outside the Republic of South Africa, e.g. Mozambique (specifying supplier).
5. 'Consumed in synchronous condenser (CSO), DWA and Assets' (applicable to Eskom).

The main source of electricity data (95% of total power generation) is Eskom, followed by municipal power stations, manufacturers in the sugar, paper and petroleum industries, as well as one mine (5% of power generated as an additional activity to their main activity).

Figure A1.2: Map of power stations in South Africa



Source: Eskom, 2008.

The following industries (power stations) participate in the survey and make up the electricity sector:

Arnot	Koeberg	Matla
Camden	Kriel	Tutuka
Duvha	Lethaba	Other (hydroelectric, gas and pumped storage)
Hendrina	Majuba	
Kendal	Matimba	

State energy company Eskom is one of the largest utilities in the world and generates 95% of South Africa's electricity as well as two-thirds of the electricity for the African continent. It owns and operates the national transmission system. Eskom has 36 200 megawatts (MW) of net generating capacity, which is primarily coal fired (32 100 MW). Eskom's network is made up of more than 300 000 km of power lines, 27 000 km of which constitute the national transmission grid.

Since the bulk of South Africa's electricity is produced from coal, the main generating stations are located in Mpumalanga, where there are vast coal reserves. In addition, Eskom operates the nuclear power station at Koeberg (1 800 MW), two gas turbine generators (340 MW), six conventional hydroelectric plants (600 MW), and two hydroelectric pumped-storage stations

(1 400 MW). Eskom has been producing adequate electricity for domestic use and export of surplus power to Botswana, Lesotho, Mozambique, Namibia, Swaziland, and Zimbabwe. Additional electricity is generated by South African municipalities (2 400 MW), and private companies (800 MW).

Data compilation

The supplier of the Energy Balances is the DoE, who conforms to the international standards by following the framework of the IEA.

Table A1.4: Energy commodities and its source covered by the Department of Energy

Data source	Type of data or energy commodity
Department of Energy (DoE)	Information on wind, solar, natural gas liquid, natural gas, and all data related to coal except coking coal imports which are either from South African Revenue Service (SARS) or Mittal Steel.
Oil companies	Electricity used in petrochemical industry and by oil refineries.
South African Coal and Oil (SASOL)	Petroleum products from non-crude sources and gas works.
Electricity Supply Commission (Eskom)	Electricity production and consumption figures excluding the 5% electricity produced by municipalities.
National Energy Regulator of South Africa (NERSA)	• Export of electricity; • Imports of electricity; • Own use in electricity; • Electricity used in pumped storage; • Distribution losses; • Electric output from public plants and auto-producing electric plants; • Electricity from pumped storage; and • Electricity production and consumption for the whole country, including Eskom and municipalities.
South African Revenue Services (SARS)	Imports and exports of oil and coal data.
Mittal Steel	Imports of coking coal, production and consumption of blast furnace gas from iron and steel.
South African Petroleum Industry Association (SAPIA)	Oil consumption or sales data by sector.

Data capturing and calculation

There is no specific format for supplying data. The DoE receives data electronically or by fax, after which it is then captured into Excel spreadsheets that are labelled with the specific year the data applies to. These spreadsheets are then used to compile the Energy Balances. There are no complex mathematical calculations employed in the compilation of Energy Balances; only simple arithmetic rules are used.

Table A1.5: Conversion tables used by the Department of Energy

Fuel type	Calorific values Calorific value	Units	Density
Avgas	37.0	MJ/l	0.730
Bagasse (wet)	7.0	MJ/kg	
Bagasse fibre (dry)	14.0	MJ/kg	
Biomass (wood dry typical)	17.0	MJ/kg	
Blast furnace gas	3.1	MJ/m^3	
Coal (coking)	30.1	MJ/kg	
Coal (Eskom - average 1994)	24.3	MJ/kg	
Coal gas (Sasol - methane rich)	38.0	MJ/m^3	
Coal gas (Sasol)	18.0	MJ/m^3	
Coke	27.9	MJ/kg	
Coke oven gas	17.3	MJ/m^3	
Diesel	41.6	MJ/l	0.839
Electricity	3.6	MJ/kWh	
Heavy furnace oil (HFO)	20.1	MJ/kg	0.984
Illuminating paraffin	37.5	MJ/l	0.788
Jet fuel	38.1	MJ/l	0.793
Liquefied petroleum gas (LPG)	34.2	MJ/l	0.541
Natural gas	41.0	MJ/m^3	
Petrol	33.9	MJ/l	0.723
Power Paraffin	34.3	MJ/l	0.813
Refinery gas (estimate)	20.0	MJ/m^3	