

**SOUTH AFRICA**



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## 1. GENERAL INFORMATION

### 1.1. General Overview

The Republic of South Africa occupies the southernmost part of the African continent (see Figure 1), stretching latitudinally from 22° to 35° S and longitudinally from 17° to 33° E. Its surface area is 1 219 090 km<sup>2</sup>. It has common boundaries with the republics of Namibia, Botswana and Zimbabwe, while the Republic of Mozambique and the Kingdom of Swaziland lie to the northeast (Figure 2). Completely enclosed by South African territory in the southeast is the mountain Kingdom of Lesotho.



FIG. 1. African Continent

To the west, south and east, South Africa borders on the Atlantic and southern Indian oceans. Isolated, 1 920 km southeast of Cape Town in the Atlantic, lie Prince Edward and Marion islands, which became part of South Africa in 1947.

South Africa has a lengthy coastline of about 3 000 km. This coastline is swept by two major ocean currents – the warm south-flowing Mozambique-Agulhas current and the cold Benguela. The

former skirts the east and south coasts as far as Cape Agulhas while the Benguela current flows northwards along the west coast as far as southern Angola. The contrast in temperature between these two currents partly accounts for important differences in climate and vegetation between the east and west coasts of South Africa. It also causes big differences in marine life, the cold waters of the west coast being much richer in oxygen, nitrates, phosphates and plankton than those of the east coast.



FIG. 2. Map of South Africa

The coastline itself is an even, closed one with few bays or indentations naturally suitable for harbors. Most river mouths are unsuitable for use as harbours because large sand banks block the entry for most of the year. Only the largest rivers, such as the Orange and Limpopo, maintain narrow permanent channels through the banks. For much the same reasons, the country has no navigable rivers.

The surface area of South Africa falls into two major physiographic features: the interior plateau, and the land between the plateau and the coast. Forming the boundary between these two areas is the Great Escarpment, the most prominent and continuous relief feature of the country. Its height above sea level varies from approximately 1 500 m in the southwest to a height of 3 482 m in the KwaZulu Natal Drakensberg in the east.

Inland from the Escarpment lies the interior plateau, which is the southern continuation of the great African plateau stretching north to the Sahara Desert. The plateau itself is characterized by wide plains with an average height of 1 200 m above sea level. Surmounting the plateau in places are a number of well-defined upland blocks. The dissected Lesotho plateau, which is more than 3 000 m above sea level, is the most prominent. In general, the Escarpment forms the highest parts of the plateau. Between the Great Escarpment and the coast lies an area which varies in width from 80 to 240 km in the east and south to a mere 60 to 80 km in the west. At least three major subdivisions can be recognized: the eastern plateau slopes, the Cape folded belt and adjacent regions, and the western plateau slopes.

The subtropical location, on either side of 30° S, accounts for the warm temperate conditions so typical of South Africa. The country also falls squarely within the subtropical belt of high pressure, making it dry, with an abundance of sunshine. The wide expanses of ocean on three sides of South Africa have a moderating influence on its climate. More apparent, however, are the effects of the warm Agulhas and cold Benguela currents along the east and west coasts respectively. While Durban (east coast) and Port Nolloth (west coast) lie more or less on the same latitude, there is a difference of at least 6°C in their mean annual temperatures. Gale-force winds are frequent on the coasts, especially in the south-western and southern coastal areas.

South Africa has an average annual rainfall of 464 mm, compared with a world average of 860 mm. About 20% of the country has a total annual rainfall of less than 200 mm, 48% between 200 and 600 mm, while only about 30% records more than 600 mm. In total, 65% of the country has an annual rainfall of less than 500 mm – usually regarded as the absolute minimum for successful dry-land farming. In Cape Town, the capital city of the Western Cape province, the average rainfall is highest in the winter months, while in the capital cities of the other eight provinces, the average rainfall is highest during summer. South Africa's rainfall is unreliable and unpredictable. Large fluctuations in the average annual figure are the rule rather than the exception in most areas of the country. Years where a below-average figure is recorded are more common than years with an above-average total. South Africa is periodically afflicted by drastic and prolonged droughts, which often end in severe floods.

Temperature conditions in South Africa are characterized by three main features. Firstly, temperatures tend to be lower than in other regions at similar latitudes, for example North Africa and Australia. This is due primarily to the greater elevation above sea level of the subcontinent. Secondly, despite a latitudinal span of 13 degrees, average annual temperatures are remarkably uniform throughout the country. Owing to the increase in the height of the plateau towards the north-east, there is hardly any increase in temperature from south to north as might be expected. The third feature is the striking contrast between temperatures on the east and west coasts. Temperatures above 32°C are fairly common in summer, and frequently exceed 38°C in the lower Orange River valley and the Mpumalanga Lowveld.

Frost often occurs on the interior plateau during cold, clear winter nights, with ice forming on still pools and in water pipes. The frost season is longest (from April to October) over the eastern and southern plateau areas bordering on the Escarpment. Frost decreases to the north, while the coast is virtually frost-free. Average annual relative humidity readings show that, in general, the air is driest over the western interior and over the plateau. Along the coast, the humidity is much higher and at times may rise to 85%. Low stratus clouds and fog frequently occur over the cool west coast, particularly during summer. The only other area that commonly experiences fog is the 'mist belt' along the eastern foothills of the Escarpment.

The capital of South Africa is Pretoria, however, Cape Town is the legislative center and Bloemfontein the judicial center. South Africa has 9 provinces: Eastern Cape, Free State, Gauteng, KwaZulu-Natal, Mpumalanga, North-West, Northern Cape, Northern Province and Western Cape (Figure 3).



FIG. 3. South African Provinces

According to Census '96 figures, there were 40.58 million people in South Africa. Estimates by Statistics South Africa are that the country's mid-1999 population stood at 43.054 million, of which women constituted some 22 million. It thus has a low average population density in the order of 330 to 350 persons per thousand hectares. However the population density varies extensively between rural and urban areas. The population is increasing at a rate of 2.3% per annum though with a decreasing rate (Table 1). The predicted population growth rate from 2000 to 2010 is estimated to be 39.1%.

TABLE 1. POPULATION INFORMATION

	1960	1970	1980	1990	1999	2000	Growth rate (%) 1980 to 2000
Population (millions)	17.4	22.1	27.6	34.0	43.0	40.7	2.3
Population density (inhabitants/km <sup>2</sup> )	14.2	18.1	22.6	27.9	32.8	33.3	
Urban population as % of total	47	48	48	49	50	50	
Area (1000 km <sup>2</sup> )	1221.0						

Source: IAEA Energy and Economic Database; Data and Statistics/The World Bank; National Data.

South Africa is a country with a dual socio-economic composition - a large industrial base with a good infra structure (the best in Africa), but with a large third world component. For instance, South Africa is a large electricity producer but one-third of its population still does not have access to electricity.

The country has gone through a major political change since 1994, during which the policy of apartheid was replaced by a democratic form of government. After a long, bumpy negotiation process, marked by much opportunistic violence from the right wing and its surrogates and in some instances sanctioned by elements of the State, South Africa held its first democratic election in April 1994 under an Interim Constitution.

The African National Congress (ANC) led Government embarked on a programme to promote the reconstruction and development of the country and its institutions. This called for the simultaneous pursuit of democratization and socio-economic change, as well as reconciliation and the building of a consensus founded on commitment to improving the lives of all South Africans, in particular the poor.

Converting democratic ideals into practice required, amongst other things, initiating a radical overhaul of the machinery of the government at every level, towards service delivery, openness and a culture of human rights.

## 1.2. Economic Indicators

South Africa's is classed as a developing country. Its economy with a GNP per capita of 18,203 Rand (US\$ 3,034 at 6 Rand/US\$) in 1999, is placed in the upper middle-income bracket for developing countries (Table 2). For a developing country in Africa, it is highly industrialized with industry contributing 39.3% to total Gross Domestic Product (GDP). The economy includes a modern financial and industrial sector, supported by a well-developed infrastructure, operating alongside a subsistence informal sector.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

	1995	1996	1997	1998	1999
GDP at market prices (current billion US\$)	151	144	148	134	131
GDP growth (annual %)	3.12	4.15	2.52	0.63	1.23
GDP per capita (current US\$/cap)	3,862	3,609	3,636	3,237	3,034
Agriculture, value added (% of GDP)	3.86	4.22	4.06	3.8	3.85
Industry, value added (% of GDP)	34.81	33.54	32.89	32.03	32.45
Services, etc., value added (% of GDP)	61.33	62.24	63.05	64.17	63.7

Source: Data and Statistics/The World Bank.

The agricultural sector contributes only 4% of the gross domestic product (GDP). The mining sector played an important role in the development of the South African economy, but its importance has declined in the last decade and currently accounts for about 6% of GDP. The manufacturing sector accounts for approximately one-fifth of South Africa's GDP. The contribution of financial services and business increased from about 12% to nearly 18% during the nineties and given the high level of banking and commercial activities in South Africa, this share is expected to expand even further. Tourism activity is also expanding its relative size and further increases in the contribution of the tertiary sector to GDP are expected.

The economic growth rate during the worst years of the apartheid era was running at 3.3% per annum (GNP) and 1.3% per annum (Gross Domestic Product (GDP)) (1980 to 1991). By the second half of 1999, real gross domestic production was growing from quarter to quarter at annualized rates of more than 3%. Real GDP is expected to grow by about 3.5% on average in the next three years.

## 1.3. Energy Situation

The country has very large coal deposits, small hydro potential and very small deposits of gas. South Africa has large uranium deposits associated with its gold-bearing ores (Table 3). Hence South Africa's indigenous energy resource base is dominated by coal.

TABLE 3. ESTIMATED ENERGY RESERVES

	Exajoule					
	Solid	Liquid	Gas	Uranium <sup>(1)</sup>	Hydro <sup>(2)</sup>	Total
Total amount in place	1319.69	0.13	0.83	147.31	0.00	1467.96

<sup>(1)</sup> This total represents essentially recoverable reserves.

<sup>(2)</sup> For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 1998) by a factor of 10.

Source: IAEA Energy and Economic Data Base; Country Information.

### Coal

Many of the coal deposits can be exploited at extremely favorable costs and results in 91% of primary energy being based on coal. The country ranks as the world's fifth largest coal producer. In addition to the extensive use of coal in the domestic economy, large amounts are exported, South Africa being the second-largest exporter of steam coal. South African coal for local electricity production is among the cheapest in the world. The beneficiation of coal, particularly for export, results in more than 60 Mt of discards being produced annually. Thirty per cent of raw coal mined for the export market and between 15% and 25% of the raw coal mined for local demand (excluding power-station coal) is not marketable and therefore discarded.

### Gas and oil

Apart from limited gas and oil reserves in the Mossel Bay area (southern coastal area), South Africa does not have significant commercially exploitable gas or crude oil reserves. Most petroleum must therefore be imported. During the period, when world sanctions were applied because of the country's apartheid policies, the Government undertook the construction of a vast oil-from-coal facility (Sasol) and a smaller oil-from-gas facility (Mossgas). At peak production these two facilities produced 30% and 10% respectively of local oil.

### Biomass

Fuel wood, which comes mainly from natural woodlands, is the primary source of energy used by households in most rural areas for the purposes of cooking and heating. In some areas this is already almost completely depleted and in others it is under heavy pressure. The total annual sustainable supply of wood from natural woodlands in communal rural areas is estimated at about 12 Mt. However, probably no more than half of it is usable as fuel wood. In addition to these sources, residues from commercial forestry total about 4.2 Mt per year. Much of this, as well as wood from bush clearing on commercial farmland, is being used increasingly as fuel. To be effective, planning for a sustainable fuel wood supply thus requires decentralization, understanding of local conditions and flexibility. Supply-side interventions focus on satisfying a range of local needs and the realization that community forestry does not involve only the planting of trees and that community participation is central to all activities. Planning must ensure their integration into broader rural development, land use, natural resources management, and agricultural and energy planning. Interventions should build on the best indigenous practices identified.

### Renewables

Renewable energy sources, other than biomass, have not yet been exploited to the full in South Africa, and there are a number of initiatives to expand their use.

### Solar

Most areas in South Africa average more than 2 500 hours of sunshine per year, and average daily solar radiation levels range between 4,5 and 6,5 kWh/m<sup>2</sup>. The country's solar equipment industry is developing. Annual photovoltaic (PV) panel assembly capacity totals 4 MW, and a number of companies in South Africa manufacture solar water-heaters. In February 1999, former President Nelson Mandela launched the world's largest solar-powered rural electrification project in Bipa in the Eastern Cape. The Eskom-Shell Solar Rural Electrification Project will eventually provide 50 000 solar home systems, while 16 000 schools and 2 000 clinics will benefit. The project will cost some R150 million. The use of solar power for water pumping is increasing rapidly through the rural water



provision and sanitation programme of the Department of Water Affairs and Forestry. Solar water heating is already being used to a certain extent. Current capacity installed: domestic 330 000 m<sup>2</sup> and swimming pools 327 000 m<sup>2</sup> (middle to high income); commerce and industry 45 000 m<sup>2</sup>; agriculture 4 000 m<sup>2</sup>. Improved thermal efficiency of housing stock through solar passive design techniques has been introduced in the national housing programme and is aimed at ameliorating the high levels of indoor air pollution resulting from the extensive use of coal for heating in winter.

### Wind

Wind power potential is generally good along the entire coast, with mean annual speeds greater than 4 m/s, and there are localized areas where speeds exceed 6 m/s. These latter areas are potentially attractive as wind power sites, and Eskom and the Department of Minerals and Energy are investigating the use of wind power for large-scale electricity generation. Wind power is primarily used for water pumping, with about 300 000 windmills being used for watering livestock and supplying communities. About 400 kW of small wind turbines for power generation have been installed. The implementation of hybrid systems that make use of wind power is being investigated by the Department.

### Hydro

South Africa can be classified as a generally dry country, and thus has very little perennial hydropower potential. The current total installed large-scale hydropower generation capacity (larger than 10 MW), including pumped storage schemes, is 2 222 MW. The installed capacity of plants smaller than 10 MW totals some 65 MW.

The historical energy data are given in Table 4.

TABLE 4. ENERGY STATISTICS

	1960	1970	1980	1990	1999	2000	Exajoule	
							Average annual growth rate (%)	
							1960 to 1980	1980 to 2000
Energy consumption								
- Total <sup>(1)</sup>	0.97	1.44	2.91	4.22	5.84	6.01	5.63	3.70
- Solids <sup>(2)</sup>	0.99	1.60	3.12	4.07	5.32	5.47	5.90	2.85
- Liquids					0.29	0.28	13.47	-1.24
- Gases				0.07	0.05	0.05		
- Primary electricity <sup>(3)</sup>			0.01	0.09	0.18	0.22	24.33	16.90
Energy production								
- Total	0.99	1.60	3.02	4.22	5.82	5.97	5.73	3.47
- Solids	0.99	1.60	3.01	4.07	5.32	5.47	5.71	3.03
- Liquids					0.31	0.31		
- Gases				0.07	0.05	0.05		
- Primary electricity <sup>(3)</sup>			0.01	0.09	0.15	0.15	24.33	14.56

<sup>(1)</sup> Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.

<sup>(2)</sup> Solid fuels include coal, lignite and commercial wood.

<sup>(3)</sup> Primary electricity = Hydro + Geothermal + Nuclear + Wind.

Source: IAEA Energy and Economic Database.

## 1.4. Energy Policy

The *White Paper on Energy Policy 1998* gives an overview of the South African energy sector's contribution to GDP, employment, taxes and the balance of payments. It concludes that the sector can greatly contribute to a successful and sustainable national growth and development strategy. The Energy Policy contains 5 key policy objectives, which form the foundation for South Africa's energy policy:

### *Increasing access to affordable energy services*

- Government will promote access to affordable energy services for disadvantaged households, small businesses, small farms and community services.

### *Improving energy governance*

- Governance of the energy sector will be improved. The relative roles and functions of the various energy governance institutions will be clarified, the operation of these institutions will become more accountable and transparent, and their membership will become more representative, particularly in terms of participation by blacks and women.
- Stakeholders will be consulted in the formulation and implementation of new energy policies, in order to ensure that policies are sympathetic to the needs of a wider range of stakeholder communities.
- Co-ordination between government departments, government policies, and the various spheres of government will be improved in order to achieve greater integration in energy policy formulation and implementation.
- Government capacity will be strengthened in order to better formulate and implement energy policies.

### *Stimulating economic development*

- Government will encourage competition within energy markets.
- Where market failures are identified government will intervene through transparent, regulatory and other carefully defined and for time delineated mechanisms, to ensure effective delivery of energy services to consumers.
- Government policy is to remove distortions and encourage energy prices to be as cost-reflective as possible. To this end prices will increasingly include quantifiable externalities.
- If subsidies are required these should be implemented transparently based on agreed criteria.
- Energy taxation will continue to remain an option within government's fiscal policy, but will be exercised with more consideration for the economic and behavioural impacts of such policies.
- Government will work towards an investor-friendly climate in the energy sector through good governance, stable, transparent, regulatory regimes and other appropriate policy instruments.

### *Managing energy-related environmental and health impacts*

- Government will promote access to basic energy services for poor households, in order to ameliorate the negative health impacts arising from the use of certain fuels.
- Government will work towards the establishment and acceptance of broad national targets for the reduction of energy-related emissions that are harmful to the environment and to human health.
- Government will ensure a balance between exploiting fossil fuels and maintenance of acceptable environmental requirements.

### *Securing supply through diversity*

- Given increased opportunities for energy trade, particularly within the Southern African region, government will pursue energy security by encouraging a diversity of both supply sources and primary energy carriers.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the electricity sector.

The National Electricity Regulator (NER) is the regulatory authority over the electricity supply industry (ESI) in South Africa. It is a statutory body, established in terms of the Electricity Act, No 41 of 1987, as amended by the Electricity Amendment Acts of 1994 and 1995. The NER was established on 1 April 1995 as the successor to the Electricity Control Board.

The Minister of Minerals and Energy appoints board members, but, once appointed, the NER acts independently and reports to parliament. The Board of the NER consists of a chairperson, a Chief Executive Officer and seven other members, all of whom are knowledgeable and experienced in broader electricity supply industry issues. Members do not act as representatives of stakeholder interests but serve in their individual capacities. The Board is supported by a small, full-time support staff, which includes functional experts in technical, financial, economics, customer and support services areas. The NER is funded from a levy imposed on generators of electricity, which is passed on to all customers of electricity. Customers of electricity therefore pay for the protection that they receive from the NER, and the general body of taxpayers is relieved of this obligation.

The NER's role is to license generators, transmitters and distributors of electricity, to approve the prices at which electricity is sold and to set minimum standards for quality of supply and service. The NER also resolves disputes between suppliers of electricity and their customers, as well as between suppliers. The NER operates under the mandate given by the Minister of Minerals and Energy to be "the custodian and enforcer of regulatory framework to monitor and ensure that the interests and needs of present and future customers of electricity are respectively safeguarded and met, having regard to the efficiency, effectiveness and long term sustainability of the electricity supply industry".

In September 1999, the NER unveiled its restructuring plan, outlining a new structure and several key strategic regulatory issues. These include a regulatory framework for independent power producers, involvement in the restructuring of the distribution sector, further developing the wholesale electricity tariff and helping to set up customer forums.

At present there are 14 generation licensees. Generation licences are issued by the NER to all generators who sell more than 500 GW·h of electricity per annum, in accordance with the Electricity Act. Apart from Eskom, some municipalities and some co-generators, the NER has also recently licensed the first two independent power producers. The following business sectors participate in electricity generation: Eskom (95.9%), Local Government/Municipalities (1.0%) and the private sector (3.1%).

Electricity is generated at 53 licensed power generation stations. The total energy sent out by these power stations amounted to 197 TW·h in 2000 (190 TW·h in 1999). The net electricity sent out by generators in the year 2000 was 187.7 TW·h. The difference is due to own use of co-generators and the use of pumped storage schemes. The majority of generation comes from coal fired generation (87.3%). Other forms of generation are nuclear (5.1%), hydro (1.8%), pumped storage (4.7%) and gas turbines (1.1 %).

The South African energy utility, Eskom, supplies more than 95% of South Africa's electricity and more than 60% of the electricity consumed throughout Africa. In global terms, Eskom is among the top seven utilities in terms of size and sales, and is the cheapest electricity producer in the world. It has the world's biggest dry cooling power station. Eskom, also owns and operates the national high voltage electricity transmission network. Although Eskom is a public corporation, it is financed by net financial market liabilities and investments as well as reserves, and is run on business principles for the benefit of its customers.

The distribution of electricity is undertaken by Eskom and about 415 municipalities. The municipalities collectively service about 60% of total customers by number, and about 40% of total customers by sales volume. Municipal electrical departments generally supply to consumers in their local government areas. The municipal distributors differ greatly in customer density, size and type of customer base, geographic spread, financial base and effectiveness.

The Southern African Power Pool was formally started in 1996, when the 12 member states of the Southern African Development Community (SADC) signed an enabling memorandum for the formation of the pool. The southern African region has good hydroelectric generation potential, all of which is outside South Africa, with an estimated total of 125 GW in the SADC region. Five interconnectors, with a transfer capacity of 1.66 GW, are already operational between SADC states, and an additional three, with a transfer capacity of 2.2 GW, have been approved or are under construction.

In August 1999, the first phase of a 400 MW power line linking South Africa and Namibia was inaugurated by President Thabo Mbeki and Namibian President Sam Nujoma. Initiated by Eskom and Namibia's Nampower, the line will supply power to Namibia and possibly Angola in future.

## **2.2. Decision Making Process**

The Government regards an accelerated and sustainable electrification programme as being of the utmost importance. The Government's original electrification initiative was expressed in the targets set for the Reconstruction and Development Programme (RDP) in terms of which 2.5 million new connections were to be made during the period 1994 to 1999. Eskom committed itself to 70% of the target and the balance was to be achieved by Local Governments. 2.74 million connections were completed within the prescribed time limit, thus exceeding the RDP target. The result was that approximately 66% of households in South Africa enjoyed the benefits of electricity in their homes at the end of 1999 as opposed to little more than 40% at the beginning of the RDP period.

From 1997 to date, the NER has co-ordinated the funding earmarked for the electrification projects of Local Governments. In addition, the NER has audited these electrification projects. In compliance with the Electricity Act of 1987, the NER monitors the overall electrification programme, keeps statistics on salient data and reports annually on the performance of the ESI in respect of electrification.

The majority of connections were made in the urban areas that are the easiest and the cheapest to electrify due to their proximity to the network, the high density of houses and relatively high consumption. The result is that 80% of households in urban areas, and 46% in rural areas were electrified at the end of 1999. The principal reasons for this state of affairs in the rural areas are inter alia: rural areas are considerably more expensive to electrify with grid electricity; consumption levels in rural areas are lower due to lower income levels; and there are generally no major anchor electricity customers in the rural areas. The new challenge for the electrification programme is to address this backlog in a sustainable manner.

With a view to give effect to the issues raised in the White Paper on Energy Policy, the Minister of Minerals and Energy established the National Electrification Co-ordinating Committee (NECC) in April 1999. The role of the NECC is to advise the Minister on transitional matters concerning the current electrification programme based on the RDP as well as on the integrated, post-RDP National Electrification Programme (NEP). Key issues under consideration by the NECC relate to the development of strategies for the integration of electrification into the planning processes of local government, electrification planning, technologies, funding, implementation, monitoring and evaluation.

The price of electricity is an important factor in economic growth. Eskom undertook to reduce the real price of electricity by 15% between 1995 and 2000, following a reduction of 20% between 1992 and 1998. Eskom is currently one of the lowest cost producers of electricity in the world.

## 2.3. Main indicators

Table 5 shows the historical electricity production and the installed capacity and Table 6 the main energy and electricity related ratios.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

	1960	1970	1980	1990	1999	2000	Average annual growth rate (%)	
							1960 to 1980	1980 to 2000
Electricity production (TW·h)								
- Total <sup>(1)</sup>	24.37	50.79	89.64	165.39	193.58	194.31	6.73	3.94
- Thermal	24.35	50.77	88.63	156.32	178.45	178.97	6.67	3.58
- Hydro	0.01	0.03	1.01	0.62	1.66	2.35	24.33	4.30
- Nuclear				8.45	13.47	12.99		
Capacity of electrical plants (GWe)								
- Total	5.14	10.51	18.38	26.39	35.54	35.54	6.58	3.35
- Thermal	5.13	10.50	17.84	24.04	33.13	33.13	6.43	3.14
- Hydro	0.01	0.01	0.55	0.55	0.61	0.61	21.57	0.55
- Nuclear				1.80	1.80	1.80		

<sup>(1)</sup> Electricity losses are not deducted.

Source: IAEA Energy and Economic Database.

TABLE 6. ENERGY RELATED RATIOS

	1960	1970	1980	1990	1999	2000
Energy consumption per capita (GJ/capita)	56	65	105	124	146	148
Electricity per capita (kW·h/capita)	1,401	2,150	3,248	4,468	4,908	4,960
Electricity production/Energy production (%)	24	29	29	35	32	31
Nuclear/Total electricity (%)				6	7	7
Ratio of external dependency (%) <sup>(1)</sup>	N/A	N/A	N/A	N/A	N/A	N/A
Load factor of electricity plants						
- Total (%)	54	55	56	72	62	62
- Thermal	54	55	57	74	61	62
- Hydro	13	20	21	13	31	44
- Nuclear				54	85	82

<sup>(1)</sup> Net import / Total energy consumption

Source: IAEA Energy and Economic Database.

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

South Africa has large reserves of coal and most of its electricity has been traditionally generated from coal. However the coal fields are situated on the Highveld some 1500 kilometres from some of the further load centres such as Cape Town. Investigating the potential for alternative generation capacity for such areas in the early 1970's, it was determined that nuclear capacity of around 2000 MW would be cheaper than building a coal-fired plant in the Cape and railing coal from the Highveld area, or to transmit the power to the Cape via 400 kV transmission lines.

It was decided in the mid-1980's to build the Koeberg Nuclear Power Plant on the coast at Duinefontein, 35 kilometres north of Cape Town. The plant was commissioned in 1984. The plant

consists of two Pressurized Water Reactors and was built by Framatome. Fissile fuel was obtained from overseas but at the height of the sanctions period there were fears that nuclear fuel could be embargoed and the then Atomic Energy Board (now the South African Nuclear Energy Corporation – NECSA) was asked by the Government to design, build and operate an enrichment plant to provide power plant enriched fuel. Later this was expanded to manufacture the fuel locally. However, since sanctions are no longer applied against South Africa, it is now possible for Eskom to obtain nuclear fuel on the international market. Hence the conversion, enrichment and fuel element fabrication facilities have recently being closed.

### 3.2. Status and Trends of Nuclear Power

Eskom, the South African energy utility, owns and operates South Africa's only nuclear plant, the twin reactor Koeberg Power Station near Cape Town, at the South-West tip of the country (see Figure 4 and Table 7). Koeberg operating parameters are shown in Table 8.



FIG. 4 Koeberg NPP

TABLE 7. STATUS OF NUCLEAR POWER PLANTS

Station	Type	Capacity	Operator	Status	Reactor Supplier
KOEBERG-1	PWR	900	ESKOM	Operational	FRAM
KOEBERG-2	PWR	900	ESKOM	Operational	AA

  

Station	Construction Date	Criticality Date	Grid Date	Commercial Date	Shutdown Date
KOEBERG-1	01-Jul-76	14-Mar-84	04-Apr-84	21-Jul-84	
KOEBERG-2	01-Jul-76	07-Jul-85	25-Jul-85	09-Nov-85	

Source: IAEA Power Reactor Information System as of 31-Dec-1999.

TABLE 8. KOEBERG OPERATING PARAMETERS

Type	Pressurized Water Reactors
Number of reactors	2
Rated station output	1840 MW
Nuclear Island Contractor	Framatome
Cooling	Seawater

Source: Country Information.

South Africa does not anticipate building new large nuclear power plants of the Koeberg type in the near future. However, investigations into small modular high temperature gas cooled reactor technology (the Pebble Bed Modular Reactor) are being undertaken to determine whether this type of nuclear technology could be included in the energy supply system for the future.

### 3.3. Current Policy Issues

In early 2000, revised nuclear legislation came into effect, the Nuclear Energy Act of 1999 (Act No. 46 of 1999) and the National Nuclear Regulator Act of 1999 (Act No 47 of 1999). In terms of this latter Act, revised and new regulations are being developed by the National Nuclear Regulator (NNR).

The Government is also awaiting the results of Eskom's investigations into high temperature gas cooled reactor (pebble bed modular reactor) technology, including the required independent environmental impact assessment and nuclear licensing of this technology prior to taking decisions on the future role of this nuclear technology in South Africa. The Government has appointed international review teams to provide independent assessment of this technology.

The Nuclear Energy Act of 1999 vests the authority to manage radioactive waste with the Minister of Minerals & Energy:

- (1) The authority over the management and discarding of radioactive waste and the storage of irradiated nuclear fuel vests in the Minister;
- (2) The Minister, in consultation with the Minister of Environmental Affairs and Tourism and the Minister of Water Affairs and Forestry, may make regulations prescribing the manner of management, storage and discarding of radioactive waste and irradiated nuclear fuel.

In May 2000, the Department of Minerals & Energy initiated a process to develop a national policy for the management of radioactive waste. A working group was established, with initial objective to establish a Status document on radioactive waste in South Africa, which would serve as a basis for drafting a Policy document and a Strategy document on radioactive waste management. The draft policy document was issued for public comment at the end of 2000. A draft national strategy has been developed. Public workshops on the draft policy and strategy will be scheduled prior to the finalisation of these documents in 2002.

### 3.4. Organizational Chart

The Nuclear Energy Act of 1999 assigns responsibility to the Minister of Minerals & Energy for the production of nuclear energy, the management of radioactive waste, as well as South Africa's international commitments. Both the National Electricity Regulator and the National Nuclear Regulator functions report to the Minister of Minerals & Energy.

The National Electricity Regulator (NER) is the regulatory authority over the electricity supply industry (ESI) in South Africa. It is a statutory body, established in terms of the Electricity Act, No 41 of 1987, as amended by the Electricity Amendment Acts of 1994 and 1995.

The National Nuclear Regulator (NNR) (previously the Council for Nuclear Safety - CNS) is the national authority responsible for exercising regulatory control over the safety of nuclear installations, radioactive waste, irradiated nuclear fuel, and the mining and processing of radioactive ores and minerals. The primary function of the NNR is to protect workers and members of the public from the harmful effects (i.e. nuclear damage) arising from exposure to ionising radiation.

The NNR is an independent statutory organisation whose powers are defined in the National Nuclear Regulator Act of 1999 (Act No 47 of 1999). The NNR comprises a Board of Directors appointed by the Minister of Minerals and Energy, which overviews and monitors the policies and progress of the Executive.

The Koeberg nuclear power plant is owned and operated by Eskom, the South African energy utility established in terms of the Eskom Act of 1987, as amended by the Eskom Amendment Act of 1998. The sole shareholder of Eskom is the South African Government, represented by the Minister of Public Enterprises.

The South African Nuclear Energy Corporation (NECSA) (previously the Atomic Energy Corporation – AEC), established in terms of the Nuclear Energy Act of 1999, operates and manages the National Radioactive Waste Repository for low and intermediate level radioactive waste, at Vaalputs in the Northern Cape Province on behalf of the State. Although NECSA previously performed conversion, enrichment and fuel manufacturing services for Koeberg, these facilities have recently been closed.

#### 4. NUCLEAR POWER INDUSTRY

##### 4.1. Supply of NPP

South Africa has one nuclear power station - Koeberg - situated near Cape Town.

Client:	ESKOM
Contractors:	
Nuclear Island:	Framatome
Conventional Island:	Alstom Atlantique
Civil Works:	Spie Batignolles
Coordination:	Framateg

##### 4.2. Operation of NPP

Koeberg Power Station is owned, operated and maintained by Eskom. Engineering and maintenance support contracts have been signed with a number of original equipment manufacturers.

##### 4.3. Fuel Cycle, Spent Fuel and Waste Management

In late 1951, a South African company Calcined Products (Pty) Ltd [Calprods] was formed with the objective of processing uranium rich slurries produced as a by-product of gold mining operations. In 1967 Calprods was replaced by the Nuclear Fuels Corporation of South Africa (Pty) Ltd [NUFCOR], a private company, whose board of directors comprised representatives from all gold mining groups that were members of the South African Chamber of Mines. The uranium contracts existing at that time, being managed by the South African Chamber of Mines Uranium Sales Organisation, were transferred to NUFCOR.

In 1998, NUFCOR's share holding was re-structured and the company is now 100% owned by AngloGold Limited. NUFCOR's year 2000 production of approximately 2.2 million pounds is anticipated to increase and stabilize between 2.5 and 3 million pounds U3O8 per annum. In 1999, Nufcor International Limited was established as a joint-venture company between AngloGold and



First Rand International, each holding 50% of the company's share holding. NIL assumed marketing responsibility on behalf of NUFCOR.

From 1967 to the present day, NUFCOR's Head Office main activities have included the marketing of uranium under long-term contracts with international and local utilities (ore recently, London-based Nufcor International Limited has assumed this marketing function) and the transporting of uranium products in accordance with international hazardous materials regulations. NUFCOR's processing facility is located in Westonaria and its main activity is the processing of uranium rich slurries into uranium oxide powder. These slurries are collected from current producing mines owned by AngloGold and Palabora Mining Company.

In 1995, NUFCOR formed a subsidiary company RaDPRO (Pty) Ltd providing services in radiological protection, decontamination and waste management. RADPRO was formed initially as a joint venture company established at the end of 1995 by NUFCOR and BNFL Engineering Limited, a wholly owned subsidiary of British Nuclear Fuels plc (BNFL). In 1999 RADPRO became a wholly owned subsidiary of NUFCOR.

RADPRO provides a comprehensive range of radiation protection, waste management and related services, including: Radiation protection consulting; plant decontamination and recycling; radiometric instrumentation and measurement services; analytical services. RADPRO has an operational base at NUFCOR's processing facility in Westonaria for decontamination services and research and development.

Eskom is responsible for its own fuel procurement. Eskom procures conversion, enrichment and fuel element manufacturing services on the international market.

Low and intermediate level waste from Koeberg is disposed of in metal drums steel and concrete containers respectively at the National Radioactive Waste Repository Vaalputs, some 600 km north of Cape Town, in trenches (see Figure 5). Vaalputs is operated by the South African Nuclear Energy Corporation (NECSA) – previously known as the Atomic Energy Corporation, on behalf of the State. Regulation of the site is done by the National Nuclear Regulator.



*FIG. 5a. National Radioactive Waste Repository Vaalputs  
Low-level Radioactive Waste Disposal*

Spent fuel is stored on site at Koeberg, most of it in wet storage in spent fuel pools, although some is stored on site in dry casks while the spent fuel pools are being modified to increase their storage capacity.



*FIG. 5b. National Radioactive Waste Repository Vaalputs  
Intermediate-level Radioactive Waste Disposal*

#### **4.4. Research and Development Activities**

Research and Development in the nuclear energy field is performed mainly by the South African Nuclear Energy Corporation (NECSA), who carries out a variety of research projects, for example into the application of radioactive techniques in industry, the treatment of foodstuffs using radioactive sources, the development of medical radio-isotopes.

Research using accelerators is also carried out by a number of universities and associated institutes, for example the Schonland Research Centre for Nuclear Sciences at the University of the Witwatersrand, as well as by the National Accelerator Centre in the Western Cape.

Eskom initiated the development of a high temperature gas cooled reactor technology – the so-called Pebble Bed Modular Reactor – in 1993. This development work has been extended to the development of the pebble bed fuel. A demonstration plant is planned to start construction in 2002/2003 subject to an economic feasibility study and the required licensing and approval processes, including that of an environmental impact assessment, and approval from the South African Government being successful.

### **5. REGULATORY FRAMEWORK**

#### **5.1. Safety Authority and the Licensing Procedure**

The National Nuclear Regulator (NNR) (previously the Council for Nuclear Safety - CNS) is the national authority responsible for exercising regulatory control over the safety of nuclear installations, radioactive waste, irradiated nuclear fuel, and the mining and processing of radioactive ores and minerals. The primary function of the NNR is to protect workers and members of the public from the harmful effects (i.e. nuclear damage) arising from exposure to ionising radiation.

In terms of the National Nuclear Regulator Act of 1999, the licence holder is required to provide the NNR with whatever information the NNR considers necessary to demonstrate that the licensed site is acceptably safe.

The nuclear licence is a set of requirements drawn up by the NNR expanding on the conditions of the act with requirements specific to the site in question, relating to the plant, the site and environs, licensee organization and processes, and safety related documentation. These requirements essentially amount to three types, namely on the documented safety case (including supporting documentation and operational programmes), implementation of compliance assurance related processes, and reporting requirements.

## 5.2. Main National Laws and Regulations

Legislation on nuclear energy dates back to 1948 when the predecessor of the present South African Nuclear Energy Corporation (NECSA), namely the Atomic Energy Corporation, was created by the Atomic Energy Act. This Act was amended over the years to keep pace with developments in nuclear energy. A major addition in this field came about in 1963 when the Nuclear Installations Act came into force. This made provision for the licensing of Nuclear Installations by the Atomic Energy Board. The Uranium Enrichment Corporation was created in 1970 by the Uranium Enrichment Act. This allowed the enrichment of uranium by a State Corporation separate from the Atomic Energy Board and subject to licensing by the latter. A major change took place in 1982 when the AEC was created and made responsible for all nuclear matters, including uranium enrichment. This came about through the Nuclear Energy Act of 1982. This Act was amended several times in subsequent years. A major amendment created the autonomous Council for Nuclear Safety (CNS), responsible for nuclear licensing and separate from the AEC, in 1988 (Nuclear Energy Amendment Act, Act 56 of 1988). The old Nuclear Energy Act was replaced by a new Act in 1993 (Nuclear Energy Act 131 of 1993). This maintained the autonomous character of the CNS but made provision for the implementation of the Safeguards Agreement with the IAEA pursuant to the requirements of the Nuclear Non-Proliferation Treaty to which South Africa acceded in June 1991. This Act has been superseded by two Acts, the Nuclear Energy Act of 1999 and the National Nuclear Regulator Act of 1999.

Nuclear activities are also subject to numerous other legislation, for example the Environmental Impact Assessment Regulations promulgated in 1997 terms of the Environment Conservation Act of 1989, and the disclosure of information in terms of the Promotion of Access to Information Act of 2000.

### *FINANCING FOR DECOMMISSIONING AND WASTE DISPOSAL*

In general, the financing for decommissioning and waste disposal follows the rule "polluter pays" although this has led, in some cases, to uncertainty of who the "polluter" is. The Government has initiated a process to establish a National Radioactive Waste Policy that will also address the accountability for the financing of waste disposal. Decommissioning and waste disposal is currently taking place in the following areas:

- i) ongoing radioactive waste from hospitals, general industry and from the NECSA's own activities is disposed of at Thabana, a low and medium active waste disposal site on its Pelindaba site. The financing for this operation is dealt with through NECSA's annual State allocation for operating activities;
- ii) low and medium active waste from Koeberg is disposed of in shallow land-fill trenches at Vaalputs, the National Radio-active Waste Repository operated by the NECSA and situated about 600 km north of Cape Town. Although the State financed the initial development costs of the site, Eskom pays the interest on the initial capital and the operational costs;
- iii) decommissioning and waste disposal of NECSA's two enrichment plants (the Y and Z plants) are undertaken by NECSA itself and the financing is carried by the State through the annual State allocation for operational funds;
- iv) decommissioning of disused mine equipment (primarily in the gold, copper, phosphate and beach sands operations) are currently undertaken. The mining companies finance the decommissioning costs themselves and subcontract the operations out to specialized agencies.

## 5.3. International, Multilateral and Bilateral Agreements

### *AGREEMENTS WITH THE IAEA*

- NPT related agreement                                      Entry into force:                                      16 September 1991

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- |  |                   |              |
|--|-------------------|--------------|
| • Additional Protocol  | Not signed        |              |
| • Improved procedures for designation of safeguards inspectors             | Accepted          | 19 July 1995 |
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | -            |
| • AFRA   | Entry into force: | 18 May 1992  |
| 2 <sup>nd</sup> extension  | Entry into force: | 4 April 2000 |
| • Agreement on privileges and immunities                                   | Entry into force: | Non-Party    |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

- |   |                   |                   |
|---|-------------------|-------------------|
| • NPT   | Entry into force: | 10 July 1991      |
| • Convention on physical protection of nuclear material   | Signature:        | 18 May 1981       |
| • Convention on early notification of a nuclear accident  | Entry into force: | 10 September 1987 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency                | Entry into force: | 10 September 1987 |
| • Convention on civil liability for nuclear damage and joint protocol                                 | Non-Party         |                   |
| • Joint protocol  | Non-Party         |                   |
| • Protocol to amend the Vienna convention on civil liability for nuclear damage                       | Not signed        |                   |
| • Convention on supplementary compensation for nuclear damage   | Not signed        |                   |
| • Convention on nuclear safety  | Entry into force: | 24 March 1997     |
| • Joint convention on the safety of spent fuel management and on the safety of radio waste management | Not signed        |                   |
| • ZANGGER Committee   | Member            |                   |
| • Nuclear Export Guidelines   | Not adopted       | (observer status) |
| • Acceptance of NUSS Codes  | No reply          |                   |
| • Partial Test-Ban Treaty   | Entry into force: | 10 October 1963   |
| • Nuclear Suppliers Group   | Member            |                   |

- African Nuclear-Weapon-Free Zone Treaty.

#### *BILATERAL AGREEMENTS*

- Agreement between the Government of South Africa and the Government of the USA on Nuclear Co-operation.
- Agreement between the Government of South Africa and the Government of the France on Co-operation on Molecular Laser Isotope Enrichment.

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- [7] National Nuclear Regulator, [www.nnr.co.za](http://www.nnr.co.za).
- [8] Pebble Bed Modular Reactor, [www.pbmr.co.za](http://www.pbmr.co.za).

## Appendix

### DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

#### *NATIONAL ATOMIC ENERGY AUTHORITY*

South African Nuclear Energy Corporation  
Ltd. (NECSA)  
PO Box 582  
Pretoria 0001  
South Africa

Tel: +27-12-305-4911  
Fax: +27-12-305-4111  
Telex: 322948 SA; 322448 SA  
Cable: ISOTOPE PRETORIA  
<http://www.aec.co.za/>

#### *OTHER NUCLEAR ORGANIZATIONS*

National Nuclear Regulator (NNR)  
PO Box 7106  
Hennopsmeer 0046, South Africa

Tel: +27-12 663-5500  
Fax: +27-12 663-5513  
<http://www.nnr.co.za/>

Koeberg Nuclear Power Station  
Private bag X10  
Kernkrag 7440, South Africa

Tel: +27-21-550 4921  
Fax: +27-21-550 5900  
<http://www.eskom.co.za/nuclear/>

Eskom Enterprises  
Pebble Bed Modular Reactor (Pty) Ltd.  
PO Box 9396  
Centurion 0046, South Africa

Tel: +27-12-677 9400  
Fax: +27-12-663 3052  
<http://www.pbmr.co.za>

Nuclear Fuels Corporation  
of South Africa Pty.Ltd. (NUFCOR)  
PO Box 2655  
Rivonia 2128, South Africa

Tel: +27-11-807-5675  
Fax: +27-11-807 5658  
e-mail: [nufcor@nufcor.co.za](mailto:nufcor@nufcor.co.za)

#### *NUCLEAR RESEARCH INSTITUTES*

Schonland Research Centre  
for Nuclear Sciences  
University of the Witwatersrand  
Private Bag 3  
Johannesburg 2050, South Africa

Tel: +27-11-717-6923  
Fax: +27-11-339-2144  
e-mail : [srcns@src.wits.ac.za](mailto:srcns@src.wits.ac.za)  
<http://www.src.wits.ac.za/>

National Accelerator Centre (NAC)  
PO Box 72  
Faure, 7131  
South Africa

Tel: +27-21-843 1000  
Fax: +27-21-843 3525  
e-mail: [director@nac.ac.za](mailto:director@nac.ac.za)  
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#### *OTHER ORGANIZATIONS*

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<http://www.eskom.co.za/>