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Minerals, energy and geology

The Department of Minerals and Energy is responsible for ensuring exploration, development, processing, utilisation and management of South Africa's mineral and energy resources.

The department's Electricity and Nuclear Branch is responsible for electricity and nuclear-energy affairs. The Hydro Carbons and Energy Planning Branch is responsible for coal, gas, liquid fuels, energy efficiency, renewable energy and energy planning, including the energy database.

The objective of the Mineral Development Branch is to transform the minerals and mining industry and to promote the sustainable development of the industry for the benefit of all South Africans.

The Mine Health and Safety Inspectorate (MHSI) is responsible for implementing mine health and safety legislation.

Policy

The Minerals and Petroleum Resources Development Act (MPRDA), 2002 (Act 28 of 2002), was promulgated in May 2004 and became law in May 2005. The Act recognises the State's sovereignty and custodianship over the country's mineral resources, provides for equitable access to mineral resources, opportunities for historically disadvantaged individuals (HDIs), economic growth, employment and socio-economic welfare, and security of tenure. Meaningful and substantial participation of HDIs in the mining sector is guided by principles contained in the Broad-Based Socio-Economic Empowerment Charter. A scorecard for the charter has been introduced to facilitate its application in terms of the requirements of the MPRDA, 2002, for the conversion of all the old-order rights into new rights.

The provisions of the MPRDA, 2002 have necessitated the establishment of the National Mining Promotion System (NMPS). This online system allows the department to improve mineral licensing administration, investment promotion and the registration of rights. The NMPS enables the department to improve on turnaround time when processing applications and to maintain the proper management and administration of mineral-related rights and permits.

By May 2005, the department had processed 57 conversions for both exploration and mining, of which 22 had been granted and 35 returned to applicants for further information.

The Mining Titles Registration Amendment Act, 2003 (Act 24 of 2003), was promulgated on 26 November 2003. The purpose of the Act is to re-regulate the registration of mineral and petroleum titles and related rights, to effect certain amendments that are necessary to ensure consistency with the MPRDA, 2002 and to amend the Deeds Registries Act, 1937 (Act 47 of 1937). This transfers the functions relating to the registration of minerals rights from the ambit of the Act into the duties and functions of the Director-General of the Department of Minerals and Energy.

The Precious Metals Bill and Diamond Amendment Bill were expected to be promulgated in 2005. In addition, incentives for the beneficiation of minerals and metals were being developed.

The Bills will assist in providing access to precious metals and diamonds to promote the culture of local value addition/beneficiation. This will also go a long way towards creating jobs, promoting skills development and increasing foreign direct investment and export earnings.

Mine environmental management

Mine environmental management forms an integral part of the management of mineral and petroleum resources. It focuses on the following national priority programmes:

- Strengthening enforcement to prevent mining legacies from occurring. This relates to the effective implementation of the MPRDA, 2002 and other short- and long-term strategies to strengthen environmental enforcement.



On 3 March 2005, Cabinet approved cleaner fuels for South Africa with effect from January 2006. This will see an end to lead being added to petrol and lower sulphur standards for diesel. This decision is part of a process that will see newly formulated fuels being introduced, which will contribute to the improvement of urban air quality.

- Identifying mine-pollution 'hot spots' and implementing regional closure strategies to direct operational mines in addressing and managing pollution and mining waste within these areas.
- Rehabilitating abandoned and ownerless mines in accordance with a priority ranking system and a dedicated database.

To address the water ingress and decanting problems within the Witwatersrand gold-mining area, which includes the central, eastern, western and far western basins, the Department of Minerals and Energy, in conjunction with the Council for Geoscience (CGS) and several other government departments, is developing a comprehensive strategy to prevent water ingress and to manage decant water in a sustainable way.

Such preventative measures will reduce safety hazards within operational mines underground and the impact on the receiving environment and will substantially decrease mining costs within the area.

For the prevention of water ingress, a programme aimed at implementing engineering interventions in the central and eastern mining basins was implemented in 2003/04. Engineering solutions such as limiting water losses through leaking water pipes to prevent ingress, and other water-management options such as building canals and tunnels to manage decanting water, are under consideration.

A phased work plan is also underway in terms of the rehabilitation of 75 abandoned and ownerless mine shafts, ventilation shafts and other mine-related openings.

Mining outcomes of the World Summit on Sustainable Development (WSSD)

Representatives from nearly 200 countries assembled at the WSSD in Johannesburg in September 2002 to reaffirm their commitment to sustainable development.

As a follow-up to the WSSD outcomes for mining, the Department of Minerals and Energy finalised a strategy with specific programmes, plans and time frames to achieve the objectives and priorities regarding the implementation of the Johannesburg Plan of Implementation (JPI).

The WSSD outcomes for mining include:

- poverty eradication
- changing unsustainable patterns of consumption and production
- protecting and managing the natural resource base for economic and social development
- globalisation
- initiatives for sustainable development in Africa.

Apart from the national processes being established to take the WSSD outcomes forward, international processes and structures such as the African Mining Partnership will be established to champion, among others, the New Partnership for Africa's Development's (NEPAD) mining and mineral-related initiatives. The Global Mining Dialogue was also established to promote WSSD mining outcomes in the international arena.

The dialogue has achieved its objective of bringing together interested governments to prepare for the launch of the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development.

The second preparatory meeting of the Global Dialogue on Mining/Metals and Sustainable Development took place in Geneva, Switzerland, in June 2004.

The JPI has implications for a number of national departments, because of its integrated nature to address poverty eradication, sustainable production and consumption, management of the natural resource base and socio-economic aspects. Many of the relevant national departments have been requested to submit follow-up action plans to the Department of Environmental Affairs and Tourism. The departments' input ranges from national to international actions as well as policy reform and priorities.

Mineral and Mining for Sustainable Development

An international initiative as well as a southern African initiative for sustainable development have been embarked on. The purpose of these initiatives is to undertake research into sustainable development through mining, to identify critical issues and priorities, and to make recommendations regarding the implementation of such initiatives.

The key challenges include:

- poverty alleviation through employment, job creation, skills development and training, and ensuring that communities benefit from the exploitation of natural resources
- addressing the social and environmental legacies of the past
- HIV and AIDS
- ensuring the viability of the mining industry on global, national and regional bases where markets for minerals must develop in a way that enables rather than limits the transition to sustainable development, notably in terms of internalising costs over time, while maintaining viable enterprises and rewarding good practice
- good governance and strengthening enforcement
- issues relating to market access and, in particular, the beneficiation of minerals.

A task team has been established, consisting of government departments, the mining industry, labour and non-governmental organisations. Its role is to determine how the recommendations emanating from the initiatives can be taken forward.

Sustainable development on the African continent

In support of the implementation of mining-related NEPAD issues, the department played an important role in conceptualising the African Mining Partnership, a mining ministers' partnership that drives the minerals and mining agenda of NEPAD.

During 2005/06, the department continued to participate in projects addressing beneficiation, small-scale mining, environment/sustainable development, human resource development, foreign investment and indigenous/local participation.

A collaborative programme among coastal states has been put in place under the auspices of the African Mining Partnership. The programme provides a platform for African coastal states to share expertise in compiling their respective submissions supporting their claims to extend their exclusive economic zones. The submission to the United Nations should be made by May 2009. The project is led by South Africa's CGS and Senegal.

The Intergovernmental Memorandum of Understanding (MoU) on the Western Power Corridor Project (WESTCO) was signed in October 2004. WESTCO is a NEPAD flagship programme intended to pilot hydroelectric energy of the Inga rapids site in the Democratic Republic of Congo (DRC). It will ensure security of supply in the Southern African Development Community (SADC). The participating utilities are those of Namibia, South Africa, the DRC, Botswana and Angola. A joint venture company has been formed to initiate studies determining the viability of the project and to build, own, and operate the infrastructure.

Rehabilitation of mines

About R120 million has been allocated over the 2005/06 to 2007/08 financial years towards the rehabilitation of ownerless and derelict mines. The cleaning up of abandoned and ownerless asbestos dump sites was the Department of Minerals and Energy's first rehabilitation priority. By mid-2005, 65% of the identified 578 sites, mainly in the Northern Cape and Limpopo, had been cleaned up.

The rehabilitation programme for 2005/06 included the following:

- Some R48 million was allocated to asbestos rehabilitation, which continues to be a priority as asbestos is a serious health hazard.
- In North West, Northern Cape and Mpumalanga, the CGS has identified about 490 abandoned shafts, which pose a severe safety risk to nearby communities.
- Some R18 million was allocated towards the rehabilitation of abandoned uranium mines in the Karoo and the Free State.



Gold panners from around the world gathered at Pilgrim's Rest in Mpumalanga for the eight-day World Gold Panning Championships in September 2005.

South Africa was the first country in Africa to host the championships.

The championships are held annually in one of 22 countries that are members of the World Gold Panning Association.

- Bids worth R104 million were expected to be published as part of the rehabilitation programme in 2005/06. Each of the rehabilitation projects will incorporate dedicated enterprise development and intensive job creation.

Excellence in Mining Environmental Management (EMEM) Award System

The EMEM Award System was implemented in March 2000 to motivate the mining industry to excel in environmental management and to recognise mining companies that have excelled in their field. The awards are presented to both regional and national companies.

Black Economic Empowerment (BEE)

The New Africa Mining Fund (NAMF), a private equity fund, was established in 2002 to exclusively finance exploration activities, while facilitating the entry of HDIs into the mining industry.

By June 2004, the NAMF had received 130 applications for funding. During 2004, eight BEE transactions to the value of R10 billion were finalised.

The Department of Minerals and Energy continues to support BEE suppliers in pursuance of the Liquid and Petroleum Charter. On 30 November 2004, the department and individual members of the Southern African Petroleum Industry Association signed an MoU aimed at the creation of the Supplier Development Agency. The agency opened its doors for trading on 1 April 2005.

The primary objectives of the agency are to source potential BEE suppliers, accredit the suppliers to combat fronting, develop suppliers to meet the performance levels of the industry, and source opportunities for BEE suppliers from industry.

Mining industry

Preliminary figures for 2004 indicate that South Africa's mining contributed R87,1 billion or 7,1% gross value added, an increase of R8,6 billion from the previous year. The trend where foreign revenue

earnings are dominated by platinum-group metals (PGMs) at US\$4,6 billion, followed by gold at US\$4,5 billion, also continued in 2004.

However, the gold sector has been declining due to the challenges of aging infrastructure in deep mines. The industry faces challenges of commodity price cycles and is also affected by the currency fluctuations and business models that are not aligned with current rand value.

The Department of Minerals and Energy, in collaboration with its partners, labour and business, is evolving a strategy to manage the decline of the sector and the impact on workers.

South Africa produces 14% of the world's gold, and has 41% of the world's known reserves. Solutions and new ways to mine the remaining gold will be investigated.

Over the last few years, South African mining houses have transformed into large focused mining companies that include Anglo Platinum, AngloGold, De Beers, Implats and Iscor.

The Government is the only shareholder of Alexkor, a diamond mine situated on the west coast of Namaqualand. Mining takes place on land and in certain sea concession areas.

The Alexkor Limited Amendment Act, 2001 (Act 29 of 2001), provides for the sale or disposal of shares held by the State.

Government is involved in the Alexkor Diamond Mine Board and Audit Committee.

In October 2003, the Constitutional Court returned the land and mineral rights owned by Alexkor to the Richtersveld community, which was forcibly removed from the land in the 1920s.

Negotiations regarding the future of the mine continue.

Mineworkers

Gold mining, with 45,7% of the mining industry's labour force, was the largest employer in 2003, followed by PGM mining with 28,8%. The coal industry employed 11% of the labour force in 2003.

Taking into account the multiplier effect of the supply and consumer industries, including dependants, many millions rely on the mining industry for their livelihood.

Employers and trade unions in the mining industry have agreed to establish measures that will help create jobs and alleviate poverty. The parties committed themselves to ensuring that skills development becomes a priority in the industry.

Mine health and safety

The MHSI, established in terms of the Mine Health and Safety Act (MHSA), 1996 (Act 29 of 1996), is responsible for protecting the health and safety of persons working at mines or affected by mining activities.

The activities of the MHSI are unequivocally focused towards achieving a safer and healthier mining industry for all.

The mining industry's safety performance improved in 2004. A fatality rate of 0,56 deaths per 1 000 employees was recorded compared with a fatality rate of 0,65 deaths per 1 000 employees in 2003. Regrettably, these rates correspond to 246 deaths in 2004 and 270 deaths in 2003. The reportable injury rates also improved from 10,32 per 1 000 employees in 2003 to 9,63 in 2004. These rates correspond to 4 254 injuries in 2004 and 4 301 injuries in 2003. Considering that the number of persons employed at mines increased by 24 952, from 416 660 in 2003 to 441 612 in 2004, a dedicated effort was required from all stakeholders to realise the improvement.

At the Mine Health and Safety Summit held in 2003, employers, labour and government agreed to work towards achieving national health and safety milestones. The following milestones necessitate steady improvement in occupational health and safety over the next decade (ending December 2013), including:

- Reducing the fatality and disabling injury rate by 20% in the industry as a whole (by 2% per year). Safety performance during 2004 was well within target and reflected an annual decrease of 14% in fatalities and 7% in disabling injuries.
- Reducing the fatality and disabling injury rate by 50% in the gold sector to achieve performance comparable with other internationally recognised levels in metalliferous underground mines (a reduction of 5% per year.) This target was

achieved during 2004 with a 24% annual decrease in fatalities, with disabling injuries realising a 4,5% decrease.

- Eliminating silicosis and noise-induced hearing loss by 2013. By mid-2005, work towards improving the quality of reporting, collecting and analysing occupational health and disease data was in progress and was expected to start yielding meaningful results in 2005/06.

The expansion in the platinum sector resulted in total labour at work increasing from 111 745 in 2003 to 140 287 in 2004. However, this resulted in an increase in fatalities from 58 to 64 respectively. This is a 12% improvement of fatality rates per 1 000 employees, from 0,52 in 2003 to 0,46 in 2004.

The Mine Health and Safety Council (MHSC) provides extensive advice to the minister on the continued development of a revised regulatory framework for the industry. These recommendations led to the

promulgation of new regulations and guidelines for mandatory codes of practice at mines. The following MHSA, 1996 regulations were promulgated in 2004/05:

- Underground Railbound Transport
- Survey, Mapping and Mine Plans
- Protection of the Surface and Workings.

The Chief Inspector of Mines issued guidelines for mandatory codes of practice dealing with slope stability-related accidents on surface mines.

The MHSI also prepared and published an internal guideline document on the enforcement of the MHSA, 1996, for use by inspectors.

There are five projects aimed at raising awareness on the prevention, treatment and care of HIV and AIDS in the mining industry. These include the:

- Powerbelt Project, which focuses on coal-mining areas
- Lesedi Project in Virginia, Free State
- Lechabille Project in Welkom
- Bambisanani Project in Lusikisiki, Eastern Cape
- Carletonville Home-Based Care Project, Gauteng.

The Chief Inspector of Mines also proposed a strategy on dealing with deaths associated with HIV and AIDS following a non-life threatening mine accident.

The Safety in Mines Research Advisory Committee has a programme to overcome barriers to improved occupational health and safety performance. The programme comprises the following nine major thrust areas:

- cultural change
- rockfalls
- rockbursts
- explosions and fires
- machinery and transport systems
- airborne pollutants
- physical hazards (noise, temperature, radiation, etc.)
- occupational diseases (effect of HIV and AIDS on tuberculosis and silicosis)
- special projects (surveys for quantifying risk prevalence).

South Africa's mineral reserves, 2004				
Commodity	Unit	Reserves	%	World ranking
Alumino-silicates	Kt	50	37	1
Antimony	t	250	6,4	3
Chrome ore	Mt	5 500	72,4	1
Coal	Mt	33,8	3,6	7
Copper	Kt	13	1,4	14
Fluorspar	Mt	80	17	2
Gold	t	36 000	40,7	1
Iron ore	Mt	1 500	0,9	9
Lead	Mt	3	2,1	7
Manganese ore	Kt	4 000	80,0	1
Phosphate rock	Kt	2 500	5	n/a
Platinum-group metals	Kg	70 000	87,7	1
Silver	t	10	1,8	9
Titanium minerals	Kt	244	29	2
Uranium	t	298	1,0	4
Vanadium	Kt	12 000	44,4	1
Vermiculite	Kt	14	40	1
Zinc metal	Kt	15	3,3	6
Zirconium minerals	Kt	14	19,4	2

Mt=megaton, Kt=kiloton, t=ton, n/a=not available, Kg=Kilogram

Source: Minerals Bureau

Mine Qualifications Authority (MQA)

The overall aim of the MQA is to facilitate the devel-

opment of appropriate knowledge and skills in the mining, minerals and jewellery sectors, to:

- enable the development and transformation of the sector
- contribute to the health, safety and competitiveness of the sector
- improve access to quality education and training for all
- redress past inequalities in education and training.

The MQA was established as a sector education and training authority under the leadership of the Department of Labour. The responsibilities of the MQA are to:

- develop and monitor the implementation of a sector skills plan
- register skills-development facilitators at workplaces within the sector
- approve work skills plans and annual training reports of companies in the sector
- develop unit standards and qualifications
- maintain the quality of standards, qualifications and learning provision in the sector
- establish, register, administer and promote learnerships
- administer existing apprenticeship systems
- administer and disburse skills-development levies.

Employment equity in the mining sector is supported through the following initiatives:

- The Mining Executive Preparation Programme specifically aims to address the needs of HDIs. Thirty-seven participants completed the course in 2004 and a further 41 started the course in February 2005.
- The MQA awarded bursaries to 196 students for scarce skills and tertiary-education assistance.
- In March 2004, 273 adult basic education and training practitioners started their learnerships. The second intake was planned for March 2005. The aim was to train 70% of these workers in basic literacy and numeracy skills by March 2005.
- By January 2005, 1 795 learners were registered in different skills programmes.

Chamber of Mines

Established in 1889, the Chamber of Mines consists of independent mining finance corporations, individual mines and mining companies. The members account for more than 85% of South Africa's mineral output.

The Chamber of Mines provides an advisory and service function to its members and to the industry on a co-operative basis. It covers areas such as industrial relations; education and training; security and healthcare; technical, legal and communication services; and the provision of statistical data.

The following services are provided by subsidiary companies to the South African mining industry and, in some instances, also to customers outside the mining industry: training, examination administration, visits to operational gold and diamond mines, the monthly newspaper *Mining News*, mine-rescue, environmental management, and centres for human development.

Other areas of industry networking include:

- The Employment Bureau of Africa (TEBA)
- TEBA-Bank, providing efficient and cost-effective banking services for mineworkers
- Rand Mutual Assurance, providing workers' compensation benefits for accidental injury or death arising out of and in the course of employment
- Rand Refinery Ltd, the world's largest gold refinery
- the Nuclear Fuels Corporation (NUFCOR)
- Colliery Technical Services, which includes the Colliery Training College
- Rescue Drilling Unit
- Collieries Environmental Control Services
- the Council for Scientific and Industrial Research's Mining Technology Division (Miningtek).

Junior and small-scale mining

The National Small-Scale Mining Development Framework assists small-scale miners with the challenges they face. The small-scale mining sector

makes a significant contribution to job creation in the mining industry.

It is estimated that about 1 000 jobs can be created for every seven to 10 sustainable small-scale mining projects assisted. Experience has shown that it is not enough just to provide institutional support. There is also a need to involve technical partners or business professionals to mentor the project to its completion.

The target market for assistance by the framework are:

- illegal or unacceptable operations to legalise and convert them into sustainable operations
- undercapitalised operations which require expansion or optimisation

- first-time entrepreneurs interested in greenfield projects.

The South African Small-Scale Mining Chamber (SASSMC) was launched in July 2005 in Kimberley in the Northern Cape.

The SASSMC represents the interests of small-scale miners nationally. Its objectives include positioning small-scale mining member companies to utilise available mining opportunities in and beyond South Africa's borders. It also aims to provide a model for small-scale mining that can be used as a basis to link up with the SADC and the African Mining Partnership.

The launch of the chamber supports government's objective to encourage and facilitate the sustainable development of small-scale mining, to ensure the optimal exploitation of small mineral deposits and to enable this sector to make a positive contribution to the economy.

South Africa's mineral production, 2004

Commodity	Unit	Production	%	World rank
Aluminium	Kt	866	2,6	10
Alumino-silicates	Kt	234,4	54,4	1
Antimony	t	4 967	3,1	3
Chrome ore	Mt	7,4		
Coal	Mt	243	4,7	5
Copper	Kt	102,6	0,7	18
Diamonds	Kcar	14 400	9	4
Ferrochromium	Mt	2,8		
Ferromanganese	Kt	907,8		
Ferrosilicon	Kt	131 555		
Fluorspar	Kt	–	–	–
Gold	t	340,2	13,8	1
Iron ore	Mt			
Lead	Kt	37,5	1,2	13
Manganese ore	Kt	4 206,7		
Nickel	Kt	40		
Phosphate rock	Kt	–	–	–
Platinum-group metals	Kg	286 733	57,8	1
Silicon metal	Kt	50 470		
Silver	t	72		
Titanium minerals	Kt	–	–	–
Uranium	t	887	2	4
Vanadium	Kt	27	41	1
Vermiculite	Kt	194,5	52,6	1
Zinc metal	Kt	105	1,2	22
Zirconium minerals	Kt	–	–	–

Mt=megaton, Kt=kiloton, t=ton, Kg=kilogram, K car=kilocarats

Source: Minerals Bureau

Mineral wealth

South Africa's mineral wealth is found in diverse geological formations, some of which are unique and extensive by world standards. Some of the country's minerals include:

- Gold – the unique and widespread Witwatersrand Basin yields some 96% of South Africa's gold output.
- Diamonds (in kimberlites, alluvial and marine) – the country is among the world's top producers.
- Titanium – heavy mineral-sand occurrences containing titanium minerals are found along the coasts.
- Manganese – enormous reserves of manganese are found in the sedimentary rocks of the Transvaal Supergroup.
- PGMs and chrome – these minerals occur in the Bushveld Complex in Mpumalanga, Limpopo and North West. More than half of the global reserves of chrome and platinum are found in this deposit.
- Coal and anthracite beds occur in the Karoo Basin in Mpumalanga, KwaZulu-Natal and Limpopo.
- Copper phosphate, titanium, iron, vermiculite and zirconium are found in the Phalaborwa Igneous Complex in Limpopo.

South Africa's reserves of five commodities rank highest in the world. These are:

- manganese
- chromium
- PGMs
- gold
- alumino-silicates.

Due to the small domestic market for most commodities, South Africa's mineral industry is export-orientated. Vanadium contributes 79% of world exports, antimony 26%, alumino-silicates 38%, ferrochromium 57%, chrome ore 57%, and manganese ore and ferromanganese 22% and 24% respectively.

South Africa is the world's largest exporter of these commodities, as well as of gold, zirconium and vermiculite. Other important export commodities include coal and titanium minerals.

Because of its vast mineral resource base, South Africa is, to a large degree, self-sufficient with respect to the supply of minerals.

However, some minerals and mineral products need to be imported.

South Africa's total primary minerals decreased by 12,6% to R117,7 billion in 2003. Total processed mineral sales increased by 10% from R30,9 billion in 2002 to R27,8 billion in 2003.

The combined total for primary and processed mineral sales is estimated to have decreased by 12,2% from R165,7 billion in 2002 to R145,5 billion in 2003.

Domestic primary mineral sales revenue increased in 2003 by 12,8% to R30,9 billion, from 27,4 billion in 2002.

The value of exports of primary minerals in 2003 decreased by 19,1% to R86,8 billion.

The Directorate: Mineral Economics (Minerals Bureau) of the Department of Minerals and Energy monitors and analyses all mineral commodities regarding South African and world supply and demand, marketing and market trends.

Gold

World demand for gold decreased by 7,2% to 3 851 tons (t) in 2004. The average gold price traded at a 15-year high of US\$409/oz.

World mine supply decreased by 128 t to 2 462 t, but South African gold production fell by 8,7% to 340,2 t in 2004. Provisional data for 2004 indicates that total gold sales increased by 4,1% to US\$4,55 billion.

Coal

In 2004, South African mines produced 242,82 megaton (Mt) of coal. Of this figure, 178,37 Mt was used locally, at a value of R13,6 billion, with export sales totalling 67,94 Mt, at a value of R14,47 billion.

South Africa has around 28,6 billion t of recoverable coal reserves, making it the seventh-largest holder of coal reserves in the world.

Platinum-group metals

South African PGM production increased by 7,7% to 286,7 t in 2004, while PGM revenue increased by 35,7% to US\$5,17 billion. The average platinum price for 2004 was 22,2% higher at US\$846/oz, while the average palladium price was 14,7% higher at US\$230/oz.

Non-ferrous minerals

Refined copper, nickel, cobalt, titanium and zirconium concentrates dominate this sector, with support from zinc, lead and arsenic concentrates. The sector contributes some 12% and 4% respectively to total primary local sales and total primary export sales. About 44% of total revenue is from local sales for further added-value operations.

Ferrous minerals

This sector consists of manganese and chrome, and is dominated by iron ore. It has been a leading performer in the primary minerals industry in recent years, with revenue in dollar terms growing at about 10,3% annually. Demand depends on the fortune of the world's steel and stainless steel industries.

Export earnings from ferrous minerals increased by 16,3% from R4,16 billion in 2003 to R4,84 billion in 2004, despite the fact that higher dollar earnings were severely discounted by a much higher average rand-dollar exchange rate ratio for 2004. Higher prices also affected total ferrous sales, which rose by 18,9% to R6,81 billion.

Industrial minerals

This sector comprises a wide variety of mineral products, from which over 80% of revenue is local sales. In dollar terms, domestic total sales increased by 25% in 2004 to US\$942 million. In rand terms, local sales increased by 15% to the value of R5 billion, and export sales decreased by 21% to R1 billion.

During 2004, 83% of local sales comprised aggregate and sand (38%), limestone and lime (24%), phosphate rock concentrate (data withheld) and sulphur (4%).

Exports were dominated by dimension stone (33%), vermiculite (14%), andalusite (20%), fluorspar (17%) and phosphate rock concentrate (data withheld).

Processed minerals

Ferro-alloys and aluminium dominate this sector, with solid support from titanium slag, phosphoric acid, vanadium, zinc metal and low-manganese pig-iron. Through investment in beneficiation, it has been the outstanding performer in the mineral industry over the last 20 years, with revenue in dollar terms growing by 6,3% annually.

International prices of processed minerals surged strongly during 2004 on the back of vigorous growth in demand in China and the East. As a result, export sales earnings were at an all-time high of US\$4,096 billion in 2004, up 42% from US\$2,889 billion in 2003.

Other minerals

This sector is dominated by diamonds, with support from hydrocarbon fuel, uranium oxide and silver.

Due to the strong Rand, revenue from these minerals slumped by 12,6% to R117,8 million in 2003.

New investment potential remains strong in this sector, which has recovered enormously through new investments in operations since 1994. This compensates for the rapid demise in the demand for uranium oxide in nuclear applications since the late 1980s.

Energy

The Department of Minerals and Energy's Energy Policy is based on the following key objectives:

- attaining universal access to energy by 2014
- accessible, affordable and reliable energy, especially for the poor
- diversifying primary energy sources and reducing dependency on coal
- good governance, which must also facilitate and encourage private-sector investments in the energy sector
- environmentally responsible energy provision.

Estimates suggest that R107 billion will be needed between 2005 and 2009 to meet the country's growing energy needs. Eskom will invest R84 billion over the next five years. The balance of R23 billion is reserved for independent power producer (IPP) entrants.

By May 2005, the department was in the process of procuring 1 000 megawatt (MW) through IPPs, which are expected to be commissioned in 2008.

The refurbishment of three power stations – Camden in Ermelo, Grootvlei in Balfour, and Komati in Middelburg – will result in an additional 3 800 MW to the system.

Eskom will spend about R12 billion (nominal rand) on the recommissioning of these stations. This is about 40% of the cost of a new station. About 10% of the costs will go towards improving environmental performance such as particulate emissions and water controls.

At least 36 000 jobs are expected to be created, directly and indirectly, until 2007, during both construction and operational phase activities.

Energy in the economy

Energy comprises about 15% of South Africa's gross domestic product (GDP), creating employment for about 250 000 people. The total electricity sales by Eskom in 2003 grew to 196 980 gigawatt-hour (GWh). The peak demand on the integrated system totalled 31 928 MW. Total liquid-fuels sales in 2001 grew by 0,3% to 20 934 million litres (ML). These figures demonstrate the growth of the South African economy and the importance of energy as a key driver of the country's economy.

This energy intensity is above average, with only 10 other countries having higher commercial primary energy intensities. It is largely a result of the

economy's structure, with dominating large-scale, energy-intensive primary mineral beneficiation and mining industries.

In addition, coal is relied on for the generation of most of the country's electricity and a significant proportion of its liquid fuels. Furthermore, South Africa's industry has not generally used the latest in energy-efficient technologies, mainly as a result of relatively low energy costs.

Government has been persistently engaging members of the Organisation of Petroleum Exporting Countries through diplomatic channels to increase production.

Energy efficiency

The Energy Efficiency Strategy, which was approved in March 2005, sets a national target for energy efficiency improvement of 12% by 2015.

South Africa has a history of overcapacity in electricity, which has made its power cheap and reliable. Electricity has been a contributor to the country's economic growth and service delivery to the poor.

The strategy includes Eskom's demand-side management. Municipalities are also implementing their own energy efficiency strategies. In addition, 32 large companies have joined forces with the Department of Minerals and Energy and Eskom by signing an energy-efficiency accord, committing themselves to targets contained in the department's strategy.

To assist households to be more energy efficient, the Department of Minerals and Energy initiated an appliance-labelling campaign. Labels on household appliances inform consumers how energy efficient their appliances are.

The department, in collaboration with the Department of Public Works and Eskom, is retrofitting government buildings to make them more energy efficient. This contributes a saving of about R600 000 in electricity bills per year.

Energy demand by the economic subsector

Households

Energy consumed by households represents some

17% of the country's net use. Most household energy is obtained from fuel wood (50% of net household energy), primarily in rural areas, with the remainder obtained from coal (18%), illuminating paraffin (7%) and a small amount from liquid petroleum gas.

Rural households comprise the majority of poor homes and are characterised by severe poverty. In terms of basic energy services, their energy 'poverty' is exacerbated by the increasingly widespread scarcity of fuel-wood resources. Wood and paraffin are their main energy sources, with few having access to electricity.

Coal

South Africa's indigenous energy resource base is dominated by coal. Internationally, coal is the most widely used primary fuel, accounting for about 36% of the total fuel consumption of the world's electricity production.

About 77% of South Africa's primary energy needs are provided by coal. This is unlikely to change significantly in the next two decades, owing to the relative lack of suitable alternatives to coal as an energy source.

Many of the deposits can be exploited at extremely favourable costs and, as a result, a large coal-mining industry has developed.

In addition to the extensive use of coal in the domestic economy, some 28% of South Africa's production is exported internationally, mainly through the Richards Bay Coal Terminal, making South Africa the fourth-largest coal exporting country in the world.

South Africa's coal is obtained from collieries ranging from among the largest in the world to small-scale producers. As a result of new entrants in the industry, operating collieries were increased to 64 during 2004. Of these, a relatively small number of large-scale producers supply coal primarily to electricity and synthetic fuel producers. About 51% of South African coal mining is done underground and about 49% is produced by opencast methods.

The coal-mining industry is highly concentrated, with five companies, namely Ingwe (BHP Billiton), Anglo Coal, Sasol, Eyesizwe and Kumba, accounting

for 85% of the saleable coal production. Production is concentrated in large mines, with 11 mines accounting for 70% of the output.

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 65 Mt of coal discards being produced annually.

Twenty-one percent of the run-of-mine coal produced is exported, and 21% is used locally (excluding power-station coal). The rest is not saleable and is discarded.

The remainder of South Africa's coal production feeds the various local industries: some 62% is used for electricity generation, 23% for petrochemical industries (Sasol), 8% for the general industry, 4% for the metallurgical industry (Mittal), and 4% is purchased by merchants and sold locally or exported.

The key role played by South Africa's coal reserves in the economy is illustrated by the fact that Eskom ranks first as steam coal user and seventh as electricity generator in the world. Sasol is the largest coal-to-chemicals producer.

South Africa's coal reserves are estimated at 28,6 billion t. With the present production rate, there should be more than 50 years of coal supply left.

By international standards, South Africa's coal deposits are relatively shallow with thick seams, which make them easier and, usually, cheaper to mine.

Coal is expected to maintain its share of the overall electricity generation market until 2020. Total discards on the surface could reach more than two billion tons by 2020, should none of this material be utilised. As a result, the Department of Minerals and Energy is investigating ways to promote and encourage the economic use of the discards.

Environmental concerns pose the main challenge to coal as energy source. Not only does the burning of coal cause air pollution, but the mining activities to extract coal also impact negatively on the environment. The department and the coal-mining industry are therefore fostering the introduction of clean coal technologies into the South African arena.

Nuclear

The nuclear sector in South Africa is mainly governed by the Nuclear Energy Act, 1999 (Act 46 of 1999), and the National Nuclear Regulator (NNR) Act, 1999 (Act 47 of 1999). These Acts are administered by the Department of Minerals and Energy; while part of the Hazardous Substances Act, 1973 (Act 15 of 1973), related to groups III and IV of hazardous substances, is administered by the Department of Health.

The main organisations directly involved in the nuclear sector are the following:

- The Department of Minerals and Energy plays a leading governance role regarding nuclear technology, non-proliferation and safety. The Minister of Minerals and Energy is the executive authority responsible for overseeing the Nuclear Energy Corporation of South Africa (Necsa) and the NNR.
- Necsa undertakes and promotes research and development in the fields of nuclear energy, radiation sciences and technology, medical-isotope manufacturing, nuclear liabilities management, waste management and decommissioning. Necsa's reactor-produced radioisotopes are exported to more than 50 countries.
- The NNR oversees safety regulation of nuclear installations at Necsa's Pelindaba site, Vaalputs Radioactive Waste Disposal Facility, the Koeberg Nuclear Power Station, certain mines and other small users. It is a public entity reporting to the Minister of Minerals and Energy.
- The Department of Health (Directorate: Radiation Control) issues licences for group III hazardous substances (electronic product generating X-rays, other ionising beams, electrons, neutrons or other particle radiation or non-ionising radiation) and group IV hazardous substances (radioactive material outside a nuclear installation, which does not form part of or is used or intended to be used in the nuclear fuel cycle, and which is used or intended to be used for medical, scientific, agricultural, commercial or industrial purposes).
- The Koeberg Nuclear Power Station is responsible for electricity generation. It is government-

owned through the public entity, Eskom, which reports to the Minister of Public Enterprises.

- iThemba Laboratories is responsible for medical isotopes and medical applications. This public entity falls under the Department of Science and Technology.
- NUCCOR is responsible for uranium-ore refinement and export. It is privately owned by AngloGold.

The South African nuclear sector employs about 2 700 people. The Koeberg Nuclear Power Station contributes about 6% of total electricity, and contributions to GDP are in excess of R1,5 billion from uranium exports (last five years) and Necsa's direct commercial sales of about R300 million per year.

Liquid fuels

The liquid fuels industry was, for the first time, licensed in 2005. The objectives of the licensing framework as detailed in the Petroleum Products Amendment Act, 2003 (Act 58 of 2003), include:

- promoting an efficient manufacturing, wholesaling and retailing petroleum industry
- facilitating an environment conducive to efficient and commercially justifiable investment
- promoting the advancement of HDIs
- creating employment opportunities and small businesses in the petroleum sector.

South Africa consumed 21 267 ML of liquid-fuel products in 2002 and 25 338 ML in 2003. Thirty-six percent of the demand is met by synthetic fuels (synfuels) produced locally, largely from coal and a small amount from natural gas. The rest is met by products refined locally from imported crude oil.

The petrol price in South Africa is linked to the price of petrol in United States (US) dollars in certain international petrol markets. This means that the domestic price is influenced by supply and demand for petroleum products in the international markets, combined with the Rand/Dollar exchange rate.

The National Petroleum, Gas and Oil Corporation of South Africa (PetroSA) was officially launched in Cape Town in October 2002.

PetroSA is responsible for exploring and exploiting oil and natural gas, as well as producing and

marketing synthetic fuels produced from offshore gas at the world's largest commercial gas-to-liquids plant in Mossel Bay, in the Western Cape.

Sasol

Sasol operates the world's only coal-based synthetic fuels facility, producing liquid petroleum gas (LPG) from low-grade coal. Sasol mines coal and converts it into synthetic fuels and chemicals through proprietary Fischer-Tropsch technologies. The company also has chemical manufacturing and marketing operations in Europe, Asia and the Americas. Its larger chemical portfolios include polymers, solvents, olefins and surfactants and their intermediates, waxes, phenolics and nitrogenous products.

Sasol produces crude oil in offshore Gabon, refines crude oil into liquid fuels in South Africa, and retails liquid fuels and lubricants through a growing network of retail centres and service stations. In the first quarter of 2004, Sasol started supplying Mozambican natural gas to customers and to its petrochemical plants in South Africa. The company is also developing two gas-to-liquids fuel joint ventures that will incorporate the proprietary Sasol Slurry Phase Distillate Process.

Sasol's focus is on the manufacturing, refining and marketing of automotive and industrial fuels



The 18th World Petroleum Congress (WPC) was held in Johannesburg from 25 to 29 September 2005.

For the first time in its 72-year history, the WPC was held on the African continent. Many African countries such as South Africa, Algeria, Angola, Libya and Nigeria are already major energy suppliers in world terms, while new energy powers such as Egypt and Equatorial Guinea are experiencing rapid growth. Hotspots such as Mauritania are emerging as exploration pushes new frontiers.

The WPC focused on the theme *Shaping the Energy Future: Partners in Sustainable Solutions*.

Delegates explored international business opportunities and threats; exchanged ideas on global issues; networked; and shared the latest information on technological, economical, environmental and social developments.

and oils, with a growing interest in gas. Its entry into hydrogen- and methane-rich gas production and exploration has extended into southern and West Africa.

In industry, Sasol provides premium fuels and lubricants that meet or exceed stringent specifications. It also produces jet fuel, fuel alcohol and illuminating kerosene.

Sasol is a signatory of Responsible Care, a worldwide initiative that strives to improve performance in safety, health and the environment.

Central Energy Fund (CEF)

The CEF is involved in the search for appropriate energy solutions to meet the future energy needs of South Africa, SADC and the sub-Saharan African region. This includes oil, gas, electrical power, solar energy, low-smoke fuels, biomass, wind and renewable energy sources. The CEF also manages the operation and development of the oil and gas assets and operations of the South African Government.

The CEF, through its integrated oil company subsidiary, PetroSA, is involved in the exploration for oil and gas onshore and offshore in South Africa and the rest of Africa. It is also involved in the production of environmentally friendly petroleum fuels and petrochemical products from gas and condensate at its synfuels refinery outside Mossel Bay and the management of oil-storage facilities. The Strategic Fuel Fund manages South Africa's strategic crude oil reserves.



Implementation of the Kyoto Protocol came into effect on 16 February 2005. Government established the Designated National Authority (DNA) in the Department of Minerals and Energy to handle clean development mechanism transactions. It opened its doors on 1 December 2004. The DNA is receiving a number of project proposals for review from the private sector. These projects will, by the year 2012, reduce South Africa's carbon dioxide emissions by 21 million tons and generate revenue of R618 million from sales of certified emission reductions.

CEF subsidiary company, Oil Pollution Control SA, provides oil prevention, control and clean-up services, mainly in South African ports and coastal areas, in terms of South Africa's National Environmental Management Act, 1998 (Act 107 of 1998).

Through its subsidiary, the Petroleum Agency of South Africa (PASA), the CEF manages the promotion and licensing of oil and gas exploration, development and production in South Africa and the coastal areas offshore, as part of creating a viable upstream oil industry in the country.

CEF subsidiary iGas acts as the official agent of the South African Government for the development of the hydrocarbon gas industry, comprising liquified natural gas and LPG in South Africa.

Indigenous oil and gas resources and production

The Department of Minerals and Energy is committed to the promotion of LPG, which is cleaner and safer and can serve as an efficient burning energy source. It is better-burning fuel for cooking and heating and does not generate smoke, dust and choking fumes like most other hydrocarbon fuels.

Government is committed to making it more affordable for cooking and heating to reduce the need for large investments in power generation. The LPG Association undertook to connect 250 000 low-income households by March 2005 and a further three million by 2008. However, only 23 000 households were connected by March 2005. Among the obstacles encountered was the price of LPG and the cost of cylinders. Once these become affordable, a large market will open up. The department is addressing these problems.

Eskom is supporting the initiative. By May 2005, the industry had donated 120 LPG cylinders to members of Parliament for use in their constituencies and homes to educate themselves and the public.

PASA has been successful in further encouraging international exploration companies to evaluate the country's oil and gas opportunities.

The EM gas-field complex off Mossel Bay started production in the third quarter of 2000. It will ensure sufficient feedstock to PetroSA to

maintain current liquid-fuel production levels at 36 000 barrels (bbls) of petroleum products a day until 2009.

Parallel exploration is being carried out in various other sections of the Bredasdorp Basin off the coast of Mossel Bay to locate reserves for PetroSA beyond 2009.

PetroSA's gas-to-liquid plant supplies about 7% of South Africa's liquid-fuel needs. The products are supplied to oil companies that market them under their own brand names.

PetroSA also produces anhydrous alcohols and speciality fuels that are exported and earn the company more than R500 million per year.

PetroSA's oilfield, Sable, situated about 150 km south off the coast of Mossel Bay, is expected to produce 17% of South Africa's oil needs.

The field, which came into operation in August 2003, was initially projected to produce 30 000 to 40 000 bbls of crude oil a day and 20 million to 25 million bbls in the next three years.

The net savings in foreign exchange to the country would be equivalent to PetroSA's bottom-line profit of between US\$10 million and US\$15 million a year.

PetroSA holds 60% working interest in Sable, while Dallas-based partner company Pioneer Natural Resources holds the remaining 40%.

Import and export of fuel products

The import of refined products is restricted to special cases where local producers cannot meet demand. It is subject to state control to promote local refinery utilisation.

When overproduction occurs, export permits are required and generally granted, provided that both South Africa's and other Southern African Customs Union members' requirements 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 55% of total liquid-fuel exports, South Africa is also the main supplier of all other liquid fuels to Botswana, Namibia, Lesotho and Swaziland.

Gas

In addition to coal gas and LPG, South Africa produced some 930 000 t of natural gas and 104 860 t of associated condensate in 2003.

The entire gas and condensate output is dedicated to PetroSA's liquid-fuel synthesis plant, and accounts for about 1,5% of total primary energy supply. Gas manufactured from coal accounted for 5% of net energy consumption, while LPG accounted for about 6%.

Natural and coal gas play separate roles in the energy system, with natural gas being used solely as a feedstock for the production of synthetic fuels, and coal gas as an industrial and domestic fuel.

However, current development of regional gas-fields will lead to natural gas becoming a more important fuel in South Africa.

Infrastructure

South Africa's gas infrastructure stretches from Sasolburg in the northern Free State, through the



In July 2005, the Minister of Minerals and Energy, Ms Lindiwe Hendricks, announced that the SAFARI-1 nuclear research reactor of the South African Nuclear Energy Corporation, located at Pelindaba, will be converted from using high enriched uranium (HEU) to low enriched uranium.

SAFARI-1 was commissioned in the 1960s as a material test reactor and is now mainly used for the production of radioisotopes for nuclear-medicine applications. The remaining HEU will generally be applied to the manufacturing of medical isotopes, mainly Molybdenum-99, which are used in nuclear-medicine diagnostics.

The conversion of SAFARI-1 ensures that the future of South African medical-isotope production can be guaranteed for a longer period.

The conversion will be undertaken over a period of about three years and will provide opportunities for young scientists to be engaged in new development projects.

The process will be regulated by the National Nuclear Regulator and monitored by the International Atomic Energy Agency.

industrial areas of Vereeniging, Johannesburg and the East Rand, and from Secunda to Witbank, Middelburg, Newcastle, Richards Bay and Durban.

Through the Sasol Gas Division, Sasol Oil markets industrial pipeline gas produced by Sasol Synthetic Fuels and Sasol Chemical Industries to about 700 industrial customers. These customers are mostly situated in the greater Johannesburg-Pretoria region and the industrial areas of Witbank-Middelburg and Durban. Its pipeline network consists of about 1 500 km of underground pipelines.

Most of the remaining 10% of gas sales in South Africa is on selling of Sasol gas by Metro Gas in Johannesburg, which owns 1 300 km of distribution pipe, and supplies 12 000 domestic and 3 000 industrial customers.

The privatisation of Metro Gas was completed in 2000. It is now owned by Egoli Gas (Pty) Ltd, a joint venture company owned by Cinergy Global Power Inc. Egoli Gas intends to invest R276 million in Metro Gas.

Petronet owns and operates a gas pipeline, known as the Lily Line. It is about 600 km long and transports methane-rich gas from Sasol's Secunda plant as far as the Durban area. Easigas (Shell) has a small LPG/air pipe network in Port Elizabeth. A privately owned company in Port Elizabeth distributes a small amount of LPG/air blend by pipe.

Industrial customers use 87% of the gas, and domestic consumers the rest. The supply of cost-competitive pipeline gas is complemented by the fuel oils range of low-sulphur residual and distillate fuel oils derived from coal and other synthesised forms, as well as crude oil.

PASA markets offshore gas exploration and exploitation.

The Gas Act, 2001 (Act 48 of 2001), aims to:

- promote the orderly development of the piped gas industry
- establish a national regulatory framework
- establish the National Gas Regulator as the custodian and enforcer of the national regulatory framework.

To facilitate the movement of gas across international borders, a cross-border gas trade agreement was signed with Mozambique.

Electricity

South Africa supplies two-thirds of Africa's electricity and is one of the four cheapest electricity producers in the world. Almost 90% of South Africa's electricity is generated in coal-fired power stations. Koeberg, a large nuclear station near Cape Town, provides about 5% of capacity. A further 5% is provided by hydroelectric and pumped storage schemes. In South Africa there are few, if any, new economic hydro sites that could be developed to deliver significant amounts of power. Generation is currently dominated by Eskom, the national wholly State-owned utility, which also owns and operates the national electricity grid. Eskom currently supplies about 95% of South Africa's electricity.

In global terms, the utility is among the top seven in generating capacity, among the top nine in terms of sales, and has one of the world's biggest dry-cooled power stations, Matimba Power Station.

Eskom was converted into a public company on 1 July 2002. It is financed by net financial market liabilities and assets as well as reserves.

While Eskom does not have exclusive generation rights, it has a practical monopoly on bulk electricity. It also operates the Integrated National High-Voltage Transmission System and supplies electricity directly to large consumers such as mines, mineral beneficiators and other large industries. In addition, it supplies directly to commercial farmers and, through the Integrated National Electrification Programme (INEP), to a large number of residential consumers. It sells in bulk to municipalities, which distribute to consumers within their boundaries.

INEP is one of South Africa's major achievements and unprecedented internationally. Some 3,5 million homes had been electrified by mid-2005, translating into over 435 000 homes per year.

Between January 2003 and January 2004, South Africa increased its electricity output by 7,1% with a peak demand of 34 195 MW on 13 July 2004, as opposed to the 31 928 MW peak in 2003. Of the new capacity to be built, Eskom will target about 70% (in MW), with the balance from IPPs.

In 2004, Eskom announced major plans to expand its generation and transmission capacity to

ensure supply for the future. The first step is the reintroduction of three of its previously mothballed power stations.

These are Camden in Ermelo, Grootvlei in Balfour, and Komati, between Middelburg and Bethal, with a combined nominal capacity of 3 800 MW. The first unit of Camden was expected to be returned to service in 2005, followed by Grootvlei in 2007 and Komati in 2008.

Restructuring of the electricity supply industry (ESI)

In December 1998, government released the *Energy White Paper*, which sets out its policy objectives for the entire energy sector. These objectives are to increase access to affordable energy services, improve energy governance, stimulate economic development, manage energy-related environmental impacts and secure energy supplies through diversity.

Restructuring aims to improve the quality of life of all South Africans and to increase economic growth and redeploy assets.

To ensure non-discriminatory and open access to transmission lines, and taking into consideration the financial stability of Eskom, government, in the medium term, is to establish a separate state-owned transmission company. It will be independent of generation and retail businesses, with a ring-fenced transmission-system and market-operation functions. Initially, this transmission company will be a subsidiary of Eskom Holdings and will be established as a separate state-owned company before any investments are made in current or new generation capacity.

Over time, a multimarket electricity-market framework will ensure that transactions between electricity generators, traders and power purchasers take place on a variety of platforms, including bilateral deals, and future and day-ahead markets.

A regulatory framework is in place that will ensure the participation of IPPs and that diversified primary energy sources be developed within the electricity sector without hindrance.

The planning and development of transmission systems will be undertaken by the trans-

mission company, subject to government's policy guidelines.

During 2003, Eskom implemented a revised business model to prepare for capacity requirements and the impending restructuring by splitting its business into regulated and non-regulated divisions.

Eskom's core business, its strategic support businesses, and target markets were reviewed and agreed upon.

The Generation Division will continue to be part of Eskom. In 2003, the power stations in the division were paired together to form clusters to prepare the generation sector for flexibility to accommodate different options in a changing ESI.

The Transmission Division takes responsibility for the electricity grid. Worldwide transmission is a natural monopoly. In South Africa, an efficient regulatory body must be established that will grant all players access to the grid. For example, customers could buy from sources other than Eskom, such as the SADC electricity pool or IPPs, but still use the same transmission infrastructure to have power delivered to them.

The Distribution Division will undergo the most radical change. Government's policy on the electri-



In 2005, the Department of Public Enterprises gave decisive impetus to the Pebble-Bed Modular Reactor (PBMR) Project. The project is now factored into the department's future energy planning and a major intention-to-purchase agreement between Eskom and the PBMR was negotiated. It was probably a world-first and forms the foundation for the further development and industrialisation of this technology.

Due to the urgency with which climate change has to be addressed and the hopes for future hydrogen energy sources, the PBMR assumes a key place in the department's long-term planning.

Cabinet approved the Human Capital Research and Innovation Frontier Programme to build the science base needed to ensure the long-term sustainability of the PBMR project, which is a uniquely South African nuclear technology innovation.

city distribution industry (EDI) requires the division to be separated from Eskom and merged with the electricity departments of municipalities to form a number of financially viable regional electricity distributors (REDs). An interim body, called EDI Holdings Company, is overseeing the transition period. The REDs will be subsidiaries of the company until they can become independent. They will be responsible for distributing electricity and collecting revenue.

Electricity distribution industry

The EDI is valued at R50 billion. The Minister of Minerals and Energy, Ms Lindiwe Hendricks, launched South Africa's first RED in July 2005 in Cape Town. RED 1 leads the way for the other five distributors.

REDs will provide competitive electricity tariffs and offer an efficient electricity service, thus ensuring that consumers get a reliable electricity supply. These entities will in the long term enable access to electricity for all.

REDs will consist of Eskom Distribution and the local authorities. They will buy electricity from power generators such as Eskom on wholesale prices determined by the National Electricity Regulator (NER).

The launch was highlighted by the signing of the Service Delivery Agreement and the Agreement on Operating and Transition Plan for Transfer between RED 1 and the City of Cape Town; and RED 1, City of Cape Town and Eskom respectively.

National Electricity Regulator

The NER was the regulatory authority which presided over the ESI in South Africa. In November 2005, the National Energy Regulator (NERSA) replaced the NER. NERSA also undertook the functions of the Gas Regulator and the Petroleum Pipelines Regulatory Authority.

The NER was funded through a levy imposed on electricity generators, which was passed on to all electricity customers. The role of the NER was to license generators, transmitters and REDs, to approve the prices at which electricity is sold and to set minimum standards for quality of supply and service.

National and regional co-operation

The NER was elected the first chairperson of the formalised African Forum for Utility Regulators. The NER was also the founding member of the Regional Electricity Regulators' Association (RERA) and the South African Utility Regulators' Association (SAURA), which were launched in September and October 2002 respectively. The NER is the chairperson of SAURA and a chairperson of one of RERA's portfolio committees.

The main purpose of RERA is to provide a platform for co-operation between independent electricity regulators within the SADC region.

Integrated National Electrification Programme

The INEP remains the flagship of the Department of Minerals and Energy. By May 2005, the INEP had delivered connections to 232 287 households at a cost of R582 million, 2 233 school connections at R100 million, and 50 clinic connections at R118 million.

Government announced in February 2004 that it would allocate R200 million towards providing free, basic electricity to poor people in an effort to improve their living conditions. The National Electricity Basic Services Support Tariff Policy was gazetted in July 2003. The policy aims to bring relief, through government intervention, to low-income households and to ensure optimal socio-economic benefits from the INEP. Qualifying customers are eligible for 50 kilowatt-hours (kWh) of free electricity per month. Eskom is a service-provider for free basic electricity in its areas of supply. By December 2003, 35% of the municipalities, which have about 425 000 customers, entered into agreements with Eskom. Formal procedures to roll out the implementation of free basic electricity to these customers have started.

By providing this basic service, government hopes to offer social relief to those who earn less than the national minimum wage levels.

Although users have access to a basic quantity of 50 kWh per household per month in terms of the policy, users will pay the normal tariff for any consumption exceeding 50 kWh per month.

By May 2005, the Department of Minerals and Energy was ready to hand over free basic electricity policy implementation to the Department of Provincial and Local Government. The department's intervention added 3,5 million qualifying recipients.

New jobs and small, medium and micro-enterprise opportunities in KwaZulu-Natal, the Eastern Cape and Limpopo have been created as a result of the Non-Grid Electrification of Schools Programme.

By May 2005, about 1 100 schools had been electrified through the programme. Achieved in one year, this represents more than 50% of the total number of schools electrified in the previous five years. School electrification is done parallel to the installation of e-learning facilities to ensure that learners become computer literate.

Rural households using solar energy will benefit from a limited operation and maintenance subsidy up to a maximum of R40 per household.

Rural solar-energy users will then be liable for paying any amount above the R40 monthly subsidy.

To make paraffin more affordable, the Department of Minerals and Energy removed the levying of value-added tax on it.

Southern African Power Pool (SAPP)

The SAPP is the first formal international power pool in Africa.

The objectives of the SAPP are, among others, to:

- co-ordinate and co-operate in the planning and operation of electricity power systems to minimise costs, while maintaining reliability, autonomy and self-sufficiency
- increase interconnectivity between SADC countries to increase the reliability of power supplies
- facilitate cross-border electricity trading
- fully recover costs of operations and equitably share benefits, including reductions in generating capacity and fuel costs, and improved use of hydroelectric energy.

Member countries are Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zambia, Zimbabwe and the DRC.

The SAPP faces the following challenges:

- lack of infrastructure to deliver electricity
- lack of maintenance of infrastructure
- funds to finance new investments
- insufficient generation – running out of excess capacity by 2007
- high losses.

To lay down the rules governing electricity exchange between utilities, the SAPP Agreement between operating members has been drafted. By mid-2005, it had been signed by the following nine national utilities: BPC (Botswana), EDM (Mozambique), Eskom (South Africa), SNEL (Zaire), ZESA (Zimbabwe), NAMPOWER (Namibia), ZESCO (Zambia), SEB (Swaziland) and LEC (Lesotho).

The success of the SAPP can be measured by the following changing volumes of energy traded by Eskom since its inception:

- 1996:	4 648 GWh
- 1997:	5 513 GWh
- 1998:	3 197 GWh
- 1999:	3 128 GWh
- 2000:	3 872 GWh
- 2001:	6 710 GWh
- 2002:	6 956 GWh
- 2003:	9 977 GWh.

It is now possible for SAPP members to delay capital expenditure on new plants due to the existence of interconnections and a power pool in the region. This is an important aspect in developing the economies of southern Africa.

Biomass

Fuel wood obtained mainly from natural woodlands, is the primary source of energy used by households in most rural areas for cooking and heating. In some areas, this resource is 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 increasingly being used as fuel.

To be effective, planning for a sustainable fuel-wood supply requires decentralisation, understanding of local conditions and flexibility.

Supply-side interventions focus on satisfying a range of local needs and the realisation that community forestry involves not only the planting of trees, but also community participation, which is central to all activities.

Planning must ensure their integration into broader rural development, land use, natural resource management, and agricultural and energy planning. Interventions should build on the best indigenous practices identified. (See chapter 23: *Water affairs and forestry*.)

By mid-2005, Eskom was looking at harnessing biomass as a grid-supply option, while also planning to pilot new technology aimed at providing rural power in a remote area in the Eastern Cape. This technology, called a gasifier system, will use waste from a rural sawmill to provide electricity to power the creation of business ventures in the area. The system was expected to be installed towards the end of 2005.

Renewables

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

The department strengthened international relationships in this area through the support offered to partnerships established during the WSSD in 2002. Such partnerships will overcome market barriers, promoting widespread use of sustainable energy solutions. These include the Global Village Energy Partnership and the Renewable Energy and Energy Efficiency Partnership.

The department's capacity-building programme for renewable energy and energy efficiency (CaBEERE) is funded by the Danish International Development Agency. It is yielding significant value in capacity-building in the department, as well as various strategies and studies to support the enabling environment created by government.

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
- 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.
- The local production and commercial dissemination of solar cookers, which is a collaborative project between the German Development Agency and the Department of Minerals and Energy.
- Solar thermal-power generation, which is a collaborative programme with Eskom. It also involves the SolarPACES Programme of the International Energy Agency.
- Small-scale hydropower.
- Landfill gas exploitation.
- Rural water supply and sanitation.

Following Cabinet approval of the *White Paper on Renewable Energy*, the department proceeded with the development of its Renewable Energy Strategy. This is essentially the implementation plan for widespread roll-out of the various technologies identified in a macro-economic study undertaken in the latter half of 2003.

The White Paper's target of 10 000-GWh renewable energy contribution to final energy consumption by 2013 was confirmed to be economically viable with subsidies and carbon financing. Achieving the target will add about 1 667 MW new renewable energy capacity, with a net impact on GDP as high as R1,071 billion per year; additional government revenue of R299 million; additional income that would flow to low-income households of as much as R128

million, creating just over 20 000 new jobs; and water savings of 16,5 million kilolitres, which translates into a R26,6-million saving.

The study also highlighted the technologies to be implemented first, based on the level of commercialisation of the technology and natural resource availability. These technologies include:

- sugar-cane bagasse for cogeneration
- landfill gas extraction
- mini-hydroelectric schemes
- commercial and domestic solar water heaters.

These technologies are to be deployed in the first phase of the target period, from 2005 to 2007. The department will introduce nominal, once-off capital subsidies to assist project developers in producing economically sound projects that are readily financed by financial institutions.

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/m² 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 W/m² for South Africa, compared with about 150 W/m² for parts of the USA, and about 100 W/m² 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.

The *White Paper on Energy Policy* identifies universal access to electricity as one of the primary goals of South Africa's energy policy.

To achieve this goal, it was decided to integrate non-grid technologies into the INEP as complementary supply-technologies to grid extension. A pilot programme has been launched to establish a limited number of public-private sector institutions in conjunction with the relevant municipalities to pro-

vide electricity services on an integrated basis. The service-provider will own and maintain the systems, allowing longer-term financing to ameliorate monthly payments. It will provide the service against a monthly fee.

Once the underlying managerial and funding issues have been resolved, the process will be expanded to cover all rural areas.

Solar power is increasingly being used for water-pumping through the rural water-provision and sanitation programme of the Department of Water Affairs and Forestry.

Solar water-heating is used to a certain extent. Current capacity installed includes domestic 330 000 m² and swimming pools 327 000 m² (middle to high income), commerce and industry 45 000 m² and agriculture 4 000 m².

Three co-operatives 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.

Solar-passive building design

Houses and buildings in South Africa are seldom designed from an energy consumption or energy-efficiency perspective. The energy characteristics of low-cost housing are particularly bad, resulting in high levels of energy consumption for space heating in winter. The net result is dangerously high levels of indoor and outdoor air pollution in townships, due mainly to coal burning.

Research has shown that low-cost housing could be rendered 'energy smart' through the utilisation of elementary 'solar-passive building design' practice. This can result in fuel savings of as much as 65%. Such savings on energy expenditure will have a major beneficial impact on the household cash-flow situation. Energy-efficient homes may be constructed at the same direct cost (and lower life-cycle cost) as energy-wasteful houses. The challenge is to develop awareness and to ensure implementation of basic energy-efficiency principles.

National solar water-heating programme

Water-heating accounts for a third to half of the

energy consumption in the average household. In South Africa, this derives mainly from electricity, being the most common energy-carrier employed. Removing this expenditure could lead to significant improvements in the disposable incomes of the lower-income sector.

Furthermore, the equivalent of a large coal-fired power station (2 000 MW+) is employed to provide hot water on tap to the domestic sector alone. Since the inception of the accelerated domestic electrification programme through grid extension, a major distortion of the national load curve has emerged, with the early evening load peak growing significantly.

Modelling indicates that the introduction of solar water-heating can ameliorate the situation substantially.

Switching from electrical to solar water-heating can, therefore, have significant economic and environmental benefits.

There are economic benefits for home owners in reducing their energy bills. Expensive generation capacity to address load peaks will be obviated, and the introduction of new base-load capacity will be postponed. Benefits for the country include reducing greenhouse gas (GHG) emissions, and the release of scarce capital for other pressing needs.

A roll-out programme of solar heaters has commenced, with the focus on middle- to high-income households in Gauteng, the Western Cape and KwaZulu-Natal. The initiative is spearheaded by the CEF.

Solar-thermal power generation

The minimum direct normal radiation (DNR) to justify a combined solar thermal power plant is 1 800 kWh/m² per year. According to the Renewable Energy Resource Database, the area exceeding the minimum required DNR in South Africa covers about 194 000 km². A 100-MW solar thermal plant requires roughly 3 km² (1800 kWh/m² per year). If 1% (1 940 km²) of the identified area is available for solar thermal power generation, South Africa has an installed potential of 64,6 GW, which is about 36 217 GWh/year.

Back-up and energy-storage constraints are limiting the wider economical utilisation of solar electricity generation (solar thermal and PV).

Stirling Dish Demonstration Project

The system consists of a mirror collector that follows the sun during the day and a Stirling engine mounted at the focal point of the mirror collector. As the collector follows the sun, the working gas inside the engine is heated, which is converted to mechanical energy and drives a generator to generate electricity. Eskom's Research, Development and Demonstration Division Project is aimed at assessing the technical and economic feasibility of this new technology. To achieve these objectives, a 25-kW unit was installed at the Development Bank of Southern Africa in Midrand, Johannesburg, in 2002.

Wind

Eskom's demonstration wind farm at Klipheuwel is exploring the use of wind energy for bulk electricity-generation. Of the turbines, the most basic unit is actually performing the best under high wind (summer) conditions, while the largest turbine is performing the best under weak wind (winter) conditions. Overall, the total production annually has been just more than 4 GWh. The Klipheuwel wind farm has a total capacity of 3,2 MW, and is expected to generate at a load factor of between 20% and 30%.

The wind farm consists of three units, i.e. two Vestas (Danish) turbines of 660 kW and 1 750 kW respectively, and a Jeumont (French) turbine of 750 kW. The blade spans are 47, 66, and 48 metres respectively. The first unit started generating on 16 August 2002 and the last on 20 February 2003. Each wind generator has its own small meteorological station on top of the turbine, as well as an aircraft warning light. The wind turbines at Klipheuwel generate at wind speeds between 11 and 50 km/hour. Full power is reached at 50 km/hour.

The proposed wind farm in the Darling district of the Western Cape was approved in March 2005.

This facility will consist of four Danish-designed wind turbines that will produce 1,3 MW of electricity each, bringing the total output of the wind farm to 5,2 MW.

This is the first renewable energy power-generating facility to be developed by a private company, which will feed into the national power network. It

will also be the first commercial wind farm in South Africa.

The project will be developed with financial assistance from the Danish Government through its funding agency, Danida. Referred to as the National Demonstration Project, it will be used as an example for future public-private partnerships in the establishment of electricity generation. Historically, this was largely the sole domain of Eskom.

The installation is to be erected below Moedmaag Hill about 12 km from Darling along the way to Yzerfontein on the West Coast. The structures will be 50 m high and the blades will have a span of 31 m.

Approval was granted after the Environmental Impact Assessment as prescribed by legislation. The Department of Environmental Affairs and Tourism established that the positive impacts will far outweigh any possible negative environmental impacts.

One of the activities of the Global Environment Facility-funded South African Wind Energy Programme, which is supported through CaBEERE, is to quantify South Africa's commercial exploitable wind resources.

Moderate wind regimes, for example the large sparsely populated areas of the Karoo and Northern Cape, can be economically exploited in stand-alone or hybrid electricity-generation configurations with PV and/or diesel-generator sets. A small local supply industry focusing on small stand-alone battery-charging systems already exists.

Hydro

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

The Eastern Cape and KwaZulu-Natal are endowed with the best potential for the development of small, i.e. less than 10-MW hydropower plants. The advantages and attractiveness of these plants are that they can either be stand-alone or 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, irri-

gation, flood control, etc.), which are critical to the future economic and socio-economic development of South Africa.

The SAPP allows the free trading of electricity between SADC member countries, 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 MoU signed between the utilities of the DRC, Angola, Namibia, Botswana and South Africa. A Westcor office has been set up in Gaborone, Botswana, and will comprise staff from the five national utilities. Westcor will tap into some of the potential in the DRC. 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 Highland Water Project can contribute some 72 MW of hydro-electric power to the system in the short term. Global pressures regarding the environmental impact and displacement of settlements by huge storage dams will likely 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 36 of 1998).

Ocean energy

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

The main reason why this energy resource is not currently 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 proven.

Eskom is monitoring the development of these technologies and will take a decision whether to investigate them further upon completion of their initial tests.

Energy and the environment

Energy and the global environment

On a global scale, South Africa's contribution to GHG emissions is small. On a per-capita basis, however, it is well above global averages and that of other middle-income developing countries.

Furthermore, the economy is carbon-intensive, producing only US\$259 per ton of carbon dioxide emitted, as compared with US\$1 131 for South Korea, US\$484 for Mexico and US\$418 for Brazil.

Sources of greenhouse gas emissions

The energy sector is a major source of GHG because of the heavy reliance on coal for electricity generation, the Sasol oil-from-coal process and a variety of other indigenous energy uses such as household coal burning.

In addition, 57% of the coal-mining methane emissions can be attributed to these two uses of coal.

Energy and the national environment

There is some contention regarding the polluting effects of the energy sector, particularly in the Mpumalanga highveld – the location of most of Eskom's coal-powered stations and the largest Sasol plants.

As is the case internationally, there is ongoing debate about the desirability of nuclear energy.

Energy and the household environment

Coal is used by about 950 000 households country-wide. This causes indoor air-pollution problems, which have a serious health impact.

It has been found that in some cases, especially regarding particulate matter, exposure can exceed World Health Organisation (WHO) standards (180 mg.m⁻³) by factors of six to seven during winter, and two to three in summer. A national programme has been established to introduce low-smoke alternatives into the townships.

Fuel wood is used by three million rural households as their primary energy source. Studies have shown that fuel-wood users are exposed to even higher levels of particulate emissions than coal users. In one study, exposure levels were found to exceed the WHO lowest-observed-effect level by 26 times.

The Department of Minerals and Energy participates in the National Housing Interdepartmental Task Team and has contributed towards the development of norms and standards for solar-passive and thermally efficient housing design.

The department is investigating the introduction of improved woodstoves and other alternatives, such as solar cookers and biogas, in an attempt to address these pollution problems.

More widespread is the use of paraffin by low-income households, rural as well as urban. Paraffin has, however, associated health and safety problems. The distribution of child-proof caps and the dissemination of information on the safe storage and use of paraffin are some of the measures being taken by the department and other role-players to address the problem.

Integrated Energy Planning (IEP)

The Department of Minerals and Energy published the first IEP for South Africa in March 2003. A full copy of the IEP is available on the department's website.

The department is embarking on a second phase of integrated energy planning, as required by the *1998 White Paper on Energy Policy*.

IEP2 will focus on addressing the gaps identified in the first IEP and through a proper consultative process will identify the scenarios and sensitivity studies that will be considered in the second IEP.

Integrated energy centres (leCs)

The Department of Minerals and Energy initiated the leC Programme in 2002/01 as part of its contribution to the Integrated Sustainable Rural Development Programme (ISRDP) in support of government's strategy on service delivery and poverty eradication. The programme targets the Presidential nodal areas

The department's main strategies for increasing the ability of rural communities to get improved energy supplies to assist ISRDP are:

- raising community awareness and empowering a cadre of rural energy activists, so that they can express their needs and provide an informed constituency to understand and respond to government policies
- establishing leCs in rural areas
- assisting local authorities to incorporate energy planning into their integrated development plan processes (especially in the context of electrification planning and non-grid electrification).

By mid-2005, there were three operational leCs, namely Kgalagadi leC in Kuruman (Northern Cape), Eshane leC in Greytown (KwaZulu-Natal) and Caba Mdeni leC in Matatiele (Eastern Cape). The department was preparing a strategy to roll out more centres. The centres are to be established as co-operatives of the local community and will provide sales outlets for energy products, such as petrol, diesel, paraffin, gas, and energy-efficient appliances. The communities around leCs are benefiting from the programme in that:

- energy sources such as paraffin, LPG, petrol, diesel, lubricants and other petroleum products are now more accessible
- energy products and gadgets, such as efficient bulbs, Eskom pre-paid cards, solar cookers, etc. are also available at these centres

- information on energy in general (including free basic electricity) is provided
- training on paraffin and LPG safety is provided by the Paraffin Safety Association of South Africa and the LPG Association, respectively.

The leC programme is supported by Total SA and Sasol. Other stakeholders include the National Development Agency and Eskom Rural Development.

Energy data

The Department of Minerals and Energy is responsible for collecting and publishing energy data. The department and Statistics South Africa are in the process of signing an MoU that will, among other things, enable energy data to be regarded as official statistics.

Detailed, complete, timely and reliable statistics are essential to monitor the energy situation at national and international level. As part of a process to ensure that energy data meets national and international standards, the department intends to make the provision of energy data mandatory.

The department produces annual energy balances of the energy economy in South Africa, which conforms to internationally accepted standards. It also regularly produces a price report of energy commodities in the country.

Geology

South Africa has a geological wonderland, which comprises 10 different and unique areas across the country.

Barberton mountain land

This beautiful and rugged tract of country with some of the oldest rocks on Earth is situated in Mpumalanga. The renowned Barberton Greenstone Belt, the largest of its kind in South Africa, represents remnants of original crust, dated around 3,5 billion years. The greenstone formations represent the earliest clearly decipherable geological events on the Earth's surface. Silica-rich layers within the greenstone have revealed traces of a very early life form – minute blue-green algae.

The formations are surrounded by granites and gneisses more than 3 000 million years old.

Gold, iron ore, magnesite, talc, barite, chrysotile asbestos and verdite are mined in the area.

Bushveld Complex and escarpment

The Bushveld Complex extends over an area of 65 000 km² and reaches up to 8 km in thickness. It is by far the largest layered igneous intrusion in the world and contains most of the world's resources of chromium, PGMs and vanadium. This mega-complex was emplaced in a molten state about 2,060 billion years ago into pre-existing sedimentary rocks, through several deep feeder zones.

The impressive igneous geology of the Bushveld Complex is best viewed in Mpumalanga, in the mountainous terrain around the Steelpoort Valley. In abundance here are the imposing Dwars River chromitite layers, the original platinum-bearing dunite pipes, the discovery site of the platinum-rich Merensky Reef, and extensive magnetite-ilmenite layers and pipes near Magnet Heights and Kennedy's Vale.

The great escarpment is one of South Africa's most scenic landscapes. This area features potholes (at Bourke's Luck), the Blyde River Canyon and the dolomite formation in which giant stromatolites bear witness to the 2,5 billion-year-old fossilised remains of vast oxygen-producing algae growth.

Drakensberg escarpment and Golden Gate Highlands National Park

The main ramparts of the Drakensberg range, reaching heights of more than 3 000 m, lie in KwaZulu-Natal and on the Lesotho border. These precipitous mountains are the highest in southern Africa and provide the most dramatic scenery.

They are formed from outpourings of basaltic lava more than 1 500 m thick, covering the Clarens sandstones. Only a small remnant of the once-vast continental basalt field that covered much of the continent now remains, mostly in the Lesotho highlands.

The northern area of the Drakensberg has been declared a World Heritage Site. More than 40% of all known San cave paintings in southern Africa are found here.

The Golden Gate Highlands National Park features spectacular sandstone bluffs and cliffs. The sandstone reflects a sandy desert environment that existed around 200 million years ago. Dinosaur fossils can still be found in the area.

Karoo

The Karoo Supergroup covers most of South Africa and reaches a thickness of several thousand metres. The sedimentary rock sequence reveals an almost continuous record of deposition and life, from the end of the Carboniferous into the mid-Jurassic periods, between 300 million and 180 million years ago.

Karoo rocks are internationally renowned for their wealth of continental fossils, and particularly for the fossils of mammal-like reptiles that show the transition from reptiles to early mammals, and for early dinosaur evolution.

During this long period of the history of the Earth, southern Africa was a lowland area in the centre of the Gondwana supercontinent.

Initially, the prehistoric Karoo was a place of vast glaciation, then a shallow inland sea, followed by huge rivers, lush flood plains and swampy deltas, ending in sandy desert and finally, vast outpourings of continental basaltic lava heralding the Gondwana break-up.

Diamond fields

Kimberlite is the primary host-rock of diamonds and was first mined as weathered 'yellow ground' from the Kimberley mines, starting in 1871 at Colesberg koppie, now the site of the Big Hole of Kimberley.

At increasing depths, less-weathered 'blue ground' continued to yield diamonds.

The discovery of kimberlite-hosted diamonds was a key event in South Africa's economic and social development, and paved the way for the later development of the Witwatersrand goldfields.

Kimberlite originates as magma from very deep below the surface, and typically occurs as small volcanic pipes and craters at the surface. Included within solidified kimberlites are fragments of deep-seated rocks and minerals, including rare diamonds of various sizes.

The Orange and Vaal rivers' alluvial diamond fields and the rich West Coast marine diamond deposits all originated by erosion from primary kimberlite pipes.

Meteorite impact sites

Impacts by large meteoritic projectiles played a major role in shaping the surface of the Earth.

One such site is the Vredefort Dome, the oldest and largest impact structure known on Earth.

Recently declared a World Heritage Site, it is located some 110 km south-west of Johannesburg, in the vicinity of Parys and Vredefort in the Free State and North West.

This spectacular and complex geological feature, measuring 70 km across, has been proved to be the remnant of the original catastrophic impact by a large meteorite or asteroid, some two billion years ago. The original impact crater has long since eroded.

The Vredefort structure consists of a 50-km wide core zone made up of granitic rocks, surrounded by the ring-like collar zone of younger bedded formations. Younger Karoo sediments cover the structure in the south-east.

Pilanesberg

The Pilanesberg complex and National Park, located some 120 km north-west of Johannesburg in North West, is a major scientific attraction which includes a number of unique geological sites.

The complex consists of an almost perfectly circular, dissected mountain massif some 25 km in diameter, making it the third-largest alkaline ring complex in the world.

The geology reflects the roots of an ancient volcano that erupted around 1,5 billion years ago.

The remains of ancient lava flows and volcanic breccias can be seen.

The dominant feature of the complex is the concentric cone sheets formed by resurgent magma that intruded ring fractures, created during the collapse of the volcano. There are old mining sites for fluorite and dimension stone, and a non-diamond-bearing kimberlite pipe in the region.

Cradle of Humankind

Located mainly in Gauteng, this World Heritage Site extends from the Witwatersrand in the south to the Magaliesberg in the north, and is considered to be of universal value because of the outstanding richness of the fossil hominid (family of man) cave sites.

The Sterkfontein area near Krugersdorp stands supreme as the most prolific and accessible fossil hominid site on Earth. It comprises several scientifically important cave locations, including Sterkfontein, Swartkrans, Drimolen, Kromdraai, Gladysvale and Plover's Lake, all of which have produced a wealth of material crucial to palaeoanthropological research.

Table Mountain and the Cape Peninsula

Table Mountain is arguably South Africa's best known and most spectacular geological site, being made up of five major rock formations.

The earliest of these are the deformed slates of the Malmesbury group which formed between 560 million and 700 million years ago.

Coarse-grained Cape granite intruded around 540 million years ago.

The Table Mountain Group, deposited from 450 million years ago, consists of basal, reddish mudstone and sandstone, very well exposed along Chapman's Peak. Overlying this is the light-coloured sandstone that makes up the higher mountains and major cliff faces of the Cape Peninsula, as far south as Cape Point.

Much younger sandy formations make up the Cape Flats and other low-lying areas.

The Table Mountain group continues further inland across False Bay in the strongly deformed Cape Fold Belt.

Witwatersrand

The geology and gold mines of the 'Ridge of White Waters' are world-famous. Nearly half of all the gold ever mined has come from the extensive Witwatersrand conglomerate reefs that were discovered in 1886, not far from the Johannesburg city centre.

The Witwatersrand is the greatest goldfield of all time. More than 48 000 t of gold have been produced from seven major goldfields distributed in a crescent-like shape across the 350-km long basin, from Welkom in the Free State in the southwest, to Evander in the east.

The geology of the region can be seen at many excellent outcrops in the suburbs of Johannesburg.

The sequence is divided into a lower shale-rich group and an upper sandstone-rich group. The latter contains the important gold-bearing quartz-pebble conglomerates. These 'gold reefs' were formed from gravels transported into the basin and reworked 2,75 billion years ago. The gold and uranium originated from a rich source in the hinterland.

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