Presidential Address: Coal—An industry in change

by M.H. Rogers*

Synopsis

Coal has been at the forefront of mankind's drive to improve his quality of life and also for sustainable development, from the Industrial Revolution onwards. The international coal industry today is large, with some 3,7 billion tons being produced and consumed in 1997.

South Africa is an important participant in the coal industry, selling some 220 million tons in 1997 of which 64 million tons were exported. It is the second-largest thermal coal exporting country in the world.

Despite the size of the world coal industry, it is not immune to change.

The address examines growth projections for the industry and the change drivers that will impact on it in the future.

Environmental pressures, the most important of which being the climate change debate, the Kyoto Protocol arising from this debate and the development of clean coal technologies, to reduce the impact of coal production and usage on the environment are considered.

Other major change drivers considered are competition from other sources of energy and that between coal producers, the deregulation of the electric power industry, corporate restructuring and for the South African producer, legislative reform. The declining (real term) coal price, the consequent squeeze on margins and the need for producers to actively contain costs is covered.

Technology has, in the past, been the driver behind the growth and change of the South African coal industry and its future role in ensuring that coal is the fuel of choice for continued improvement in standards of living and economic development is addressed.

Introduction

Coal 'the black rock that burns' has fuelled the world population's drive for improved standards of living and economic and industrial development. From the smoke and grime of the Industrial Revolution in England in the mid-18th Century, coal has been mankind's primary energy source. It was used to smelt iron ores, to drive the steam engines that powered the factories of the industrial revolution and launched the world into the era of electricity in the 20th Century.

Today the coal industry is a very different one. Gone are the sooty images of the past. The coal industry is a modern, environmentally conscious and efficient driving force behind mankind's continued development. It is also international and very big. The world's demand for, and supply of, hard coal in 1997 amounted to 3,7 billion tons.

The first stirrings of the South African coal industry were in the mid-1800s in the Eastern Cape and KwaZulu Natal. The first coal to be produced on a commercial basis was on the farm Cyfergat in the Molteno district in 1859. Going back one hundred years to the five year period ending in 1899, coal sold by South African mines amounted to a modest 1,8 million tons. Since then sales of thermal and coking coal and anthracite have risen to some 221 million tons arising from a run-of-mine production of 290 million tons in 1997.

Coal from South African mines is consumed locally and is exported via the harbours of Richards Bay and to a lesser extent Durban and Maputo. The two biggest local users of coal are Eskom and Sasol which consumed 91,2 million tons and 44,3 million tons respectively in 1997 and together accounted for 85,8% of the 157,1 million tons of all types of coal used locally. The value of all local coal sales in that year was some R7,6 billion and is estimated to be R8,7 billion in 1998.

South African coal exports of all types, totalling 63,9 million tons in 1997 were destined for two main markets, being those in Europe and in the Far East. Some 51,8 % of exports were sold to European countries while 30,6% were sold to Asian countries. Other countries importing South African coal are in the Middle East, South America and Africa. Export sales in 1997 were worth some R9,5 billion in foreign exchange to South Africa and are estimated to have grown in value to R9,8 billion in 1998. The South African coal industry is important both nationally and

* *Deputy Managing Director and Technical Director, Duiker Mining Limited.*

internationally. South Africa is the third-largest hard coal exporting country after Australia and the United States of America and the fourth-largest hard coal producer although its reserves of hard coal are only the fifth-largest in the world.

Apart from the valuable foreign exchange earnings from exports, the coal mines of South Africa fuel the economic development of the country by providing the feedstock for Eskom (one of the five largest electric power generators in the world) and for Sasol (the world's largest coal-based synfuel and petro-chemical industry). The coal mines are also a major employer, providing direct employment for 54 000 people.

Major changes and developments in South Africa's coal industry started in the 1970s when the first of Eskom's current ten coal-fired base load power stations was commissioned. This was followed by the development of Sasol's Secunda complex and the start of exports from Richards Bay.

The industry has enjoyed an unprecedented growth in sales from 53 million tons in 1970 to the 221 million tons in 1997, a compounded growth rate of 5,25% per annum over the twenty-seven year period. This period of growth has also been one of change which has been driven by innovative technologies.

The national and international coal industry is undergoing change, the drivers of which are external to and within the industry. They are economic, environmental and regulatory. Despite these change drivers, forecasts are that the international demand for coal will continue to grow. If the South African coal mining industry is to participate in the growth, it will have to adapt to changes while it continues to grow and to harness new technologies to support this growth and change.

This address considers some of the issues facing the industry which are more complex and more diverse than in the past. They include in the South African context, pricing mechanisms, the ever present currency exchange rate forecasts, the global warming debate, the growth rate of the other Southern African economies, competition from other energy sources and other coal exporting countries, the ability of our reserve base and infrastructure to service future growth, productivity and costs, new legislation and corporate activity. The role of developing new technologies is also considered.

The markets for South African coal

The markets for South African coals are obviously determined by the properties and qualities of the products. The majority of South African coals are of medium rank, bituminous and are mostly suitable for use as thermal or steam coals.

While there are reserves of coking coal and anthracite in South Africa, these are small and in many instances nearing depletion. As a consequence, production of coking coal and anthracite is small in relation to that of thermal coals.

This address will therefore consider only the thermal coal markets. The three predominant end uses of thermal coal both locally and abroad are:

- as an input into the power sector for the generation of electricity
- as a fuel in the final consumption sector producing steam or heat, or as feedstock in the petro-chemical industry
- small amounts in the metallurgical industry for pulverised coal injection (PCI) in blast furnaces or for blending with coking coal.

Export markets

The international market for thermal coal is enormous, with some 308 million tons being traded in 1997, of which 281 million tons were seaborne. This accounts for 60% of the world's seaborne hard coal trade of 465 million tons and 55% of the world's total hard coal trade of 505 million tons. It is in the seaborne thermal coal trade that South Africa enjoys a position of eminence, exporting some 57,7 million tons in 1997.

The seaborne thermal coal trade has enjoyed continuous growth over the past two decades of approximately 10% p.a. The two major export destinations being the European/Mediterranean and Asian/Pacific regions, which imported 124,4 million tons and 143,6 million tons in 1997 respectively.

The ten major steam coal importing countries in 1997 are shown in Table I.

Table I

Major steam coal importers (1997)

Country	Tonnage Mt
Japan	64,1
South Korea	32,4
Taiwan	30,0
Germany	17,4
Netherlands	14,8
Denmark	13,5
United Kingdom	11,7
Israel	9,7
Belgium	8,5
Italy	8,4

Not included in this Table are two countries with potential to become major importers, namely China and India, who only imported 2,9 million tons and 3,1 million tons respectively in 1997, although together they are estimated to have consumed some 1,45 billion tons of steam coal in that year.

The nine major steam coal exporting countries in 1997 are shown in Table II.

Table II

Major steam coal exporters (1997)

Country	Tonnage Mt
Australia	73,6
South Africa	57,7
Indonesia	38,2
United States	31,3
China	26,1
Colombia	24,0
Poland	20,3
Former Soviet Union	14,1
Canada	6,4

In general, coal imports to the European/Mediterranean markets are sourced from South Africa and Colombia, with the United States as a swing supplier depending on prevailing prices. Australia's ability to access these markets is very much dependent on freight and currency exchange rates and it does so at opportune times, thus reducing the geographical advantage enjoyed by South Africa and Colombia. Venezuelan exports of 3,7 million tons in 1997 are expected to increase considerably, making it an important future competitor in the Atlantic market.

In the Asian Pacific Rim region, the main coal suppliers are Australia, Indonesia and increasingly China with some imports coming from South Africa.

There are many projections of future growth in the seaborne thermal coal market. These are generally based on extrapolation of past trends, knowledge of planned major power plant expansions, government population growth projections and hence energy requirements and any structural changes prevailing in the current markets.

While past trends are known, it is the projections of the many other determinants that require careful consideration in the preparation of long-term forecasts.

Some of these are:

- Consuming countries national energy policies and energy supply mix
- Energy resources available to countries
- Availability of infrastructure for the transport of energy e.g. roads, railways, gas pipelines and power grids
- Growth rates in coal-consuming sections of the different economies
- Environmental policies and pressures, the Kyoto Protocol being the most topical at present
- Projected economic growth rates taking cognisance of short term aberrations
- Changes to political and economic systems
- Privatization and the role of the State
- New and developing technologies
- Supplier and consumer corporate activities.

One such forecast is that prepared by the International Energy Agency. Salient points raised in the latest forecast prepared in 1998 are:

- On a worldwide basis coal's share of primary energy consumption is projected to decline by 11% from 27% in 1996 to 24% in 2020, whilst its share of energy consumed for electricity generation is projected to remain constant at the current 36% in the period to 2020.
- China and India are projected to account for 34% of the increase in the world's energy demand between 1995 and 2020, and 85% of the growth in coal usage. China will require 340 gigawatts of additional coal fired generating capacity and India 70 gigawatts by 2020.
- The reduction in government subsidies for coal mines in Germany, Spain, France and Poland will lead to ever reducing production levels from these countries.
- Japan, Korea and Taiwan are expected to continue recent trends in electricity demand and hence demand for thermal coal.
- Steam coal including PCI for blast furnaces will account for all of the projected increase in world coal trade.

The U.S. Department of Energy's Energy Information Administration's 1998 forecast for worldwide hard coal consumption is a 73% growth from the 3,7 billion tons in 1997 to 7,8 billion tons by 2020. However, based on alternative assumptions this could be as high as 9,5 billion tons or as low as 5,9 billion tons. Seaborne thermal coal trade is projected to grow by some 209 million tons to 490 million tons or 74% by 2020. These forecasts may in the short term be tempered by the Asian economic crisis, and in the longer term by the outcomes of the Kyoto Protocol.

While projections in volume growth are positive, those for coal prices are not. Continued improvements in supply chain efficiencies and in productivity of both capital and labour have reduced production costs and created excess capacity that has led to reduced FOB costs and a long-term decline in real coal prices received by producers. There is no evidence to suggest that this long-term trend will reverse. The move to spot purchases in the Asian market and competition from other energy sources in Europe are likely to reinforce this declining trend.

Local markets

As is the case with export coal, the South African inland market is predominantly a thermal coal market, but with a quality difference. In general export thermal coal has been washed and has a higher heat content and lower ash than the coal consumed locally.

The Table below shows the principal consumers of steam coal and tonnages used in 1997.

Future demand growth in the local market will obviously depend on economic development within South Africa and in its southern African neighbours.

Increased economic activity, particularly in the manufacturing sector, will fuel increased demand for electricity in addition to the increased demand for electricity that will arise from Eskom's RDP electrification programme which aims to bring electricity to 1,75 million additional homes and to all schools and clinics by 2000.

Eskom currently has spare capacity within its existing operations, being the still to be completed Majuba power station, the three mothballed power stations, Camden, Grootvlei and Komati and further potential at the yet to be announced Lekwe power station. However, Eskom's drive for improved operational efficiencies, increased availability of existing stations, its demand side management programme and power from Cahora Bassa should delay the commissioning of any further coal-fired capacity to 2007 and beyond. Large-scale electrical efficiency programmes by

Table III

Principal consumers of steam coal (1997)

Consumer	Mt
Eskom	91,3
Sasol	44,3
Merchants	5,4
Muncipal power stations	1,7
Mining	1,2
Chemical	1,2
Other	6,3
Total	**151,4**

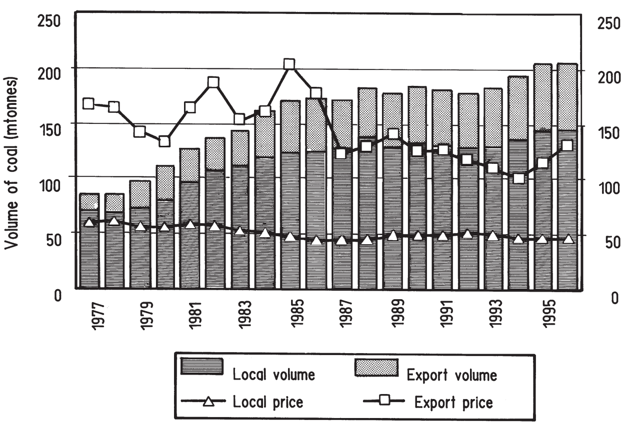
consumers could further delay the commissioning of new coal fired stations.

South Africa's membership of the South African Power Pool (SAPP), provides Eskom with the potential to access alternative sources of electricity such as that which could be generated from the Kudu gas field in Namibia and additional hydroelectric power from Cahora Bassa in Mocambique, Ruacana in Namibia and Inga in the Democratic Republic of the Congo. Alternatively current exports to the SADC countries could grow, especially to Angola, Mocambique and Malawi. Eskom's own supply side strategies are not limited to coal-fired plants, and consideration is currently being given to a number of other generating options including conventional nuclear plant, the so-called pebble bed reactor, hydro, pumped storage, gas turbine and integrated gasification combined cycle plants. These developments will clearly impact on the coal industry in South Africa, as will the restructuring of Eskom's generating, transmission and distribution sectors.

Sasol's consumption of coal into the future will depend on the successes of its process optimization programmes. Potentially, Sasol could in addition to its current production require a further 15 million tons in order to support increased process demand and to replace worked out mines. This coal could be sourced from its own reserves or be bought in from other South African producers. Input cost and the suitability of the coal for use in the gasification process are likely to be the determining factors. Coal requirements could be reduced should the Sasol/Arco Joint Venture decide to proceed with the development of the Temane gas field in Mocambique.

Increased economic activity will stimulate increased off-take in the cement, brick, water and agricultural industries which in 1997 consumed some 1,6 million tons. This market is small and is likely to remain so in relation to Eskom, Sasol and other industrial coal users. The off-take by municipal power stations is unlikely to increase while Eskom is able to supply power to municipalities at rates lower than their generation costs.

Prices received by coal producers have declined in real terms since 1977. This is shown in Figure 1 for both export and domestic coal.



Prices are in constant terms, adjusted using the producers' price index

Source: Chamber of Mines, 1998

Figure 1—South African coal volumes and prices 1977–1996

While the FOB price of export coal is much higher than that of coal sold locally it should be noted that railage to the port adds significantly to the production costs. Sales by Sasol Coal to Sasol Synthetic Fuels are at market related prices, although these may or may not be fully subjected to market forces. The long-term Eskom supply contracts account for the price stability of local coal sales.

Assuming that the positive growth projections for the demand for coal both locally and internationally are reasonably accurate, it is then incumbent on South African producers to ensure that reserves and infrastructure are available to service the growth and to retain market share. This will require new and growing technological support.

Change drivers in the coal industry

The environment

Concerns over the quality of the environment at global, national and regional levels and tighter environmental constraints are increasingly pressurizing the producers and users of fossil fuels to clean up and reduce pollution. While pressure has been applied to the extraction, preparation, transport and use of all fossil fuels, it is coal production and the combustion thereof that has attracted most attention.

When coal and other fossil fuels are burnt, a wide range of potential pollutants are formed. These are:

- carbon dioxide (CO_2)
- carbon monoxide (CO), resulting from incomplete combustion of carbon-containing fuels
- particulates resulting from finely divided mineral debris in the fuel
- nitrogen oxides (NO_X), produced from the combustion of nitrogen compounds in the fuel
- oxides of sulphur (SO_X), produced from sulphur compounds in the fuel.

Carbon monoxide has the least effect on the environment of these pollutants, although local concentrations in urban areas have been linked to ill-health on occasions.

Particulates are more of a problem, affecting the human respiratory system if inhaled over long periods. Excessive quantities deposited on plants can harm them. Particulates may also contain toxic metals. Emissions from power stations are relatively easily controlled through long-established technologies but are the subject of continual refinement and improvement.

The acid rain or acid precipitation phenomenon has been attributed to the SO_X and NO_X gases arising from the combustion of fossil fuels. These gases react chemically with water vapour and other substances in the atmosphere to form acids which are then deposited in rainfall. Apart from sourcing low sulphur coals, coal users have developed modern technologies to reduce these emissions during combustion or gasification.

Carbon dioxide is not poisonous and is a natural component of the Earth's atmosphere. However, the combustion of fossil fuels in ever-increasing amounts since the Industrial Revolution have caused the levels of CO_2 in the Earth's atmosphere to rise and these levels are predicted to continue rising. Combustion of fossil fuels is not the only cause of increased levels of CO_2. Natural phenomena such as volcanoes and forest fires and the removal of sinks by deforestation all contribute to increasing CO_2 levels.

The process of removal of carbon dioxide from the Earth's atmosphere, is by its dissolution in vast bodies of water such as the Earth's oceans and by photosynthesis in plants. These processes represent the well-known 'carbon cycle' whereby the concentration of CO_2 in the Earth's atmosphere is determined by the balance between the rate at which sources add the gas and sinks remove it.

The increasing levels of CO_2 and other greenhouse gases in the Earth's atmosphere are cause for concern since it is considered that this could cause long-term climate changes.

Climate change

The temperature at the Earth's surface is determined principally by the balance between the heat received from the sun and the heat radiated out into space. If more heat is received, or less is radiated out, the temperature will increase and vice versa. Some of the heat radiated from the Earth's surface is trapped by gases in the atmosphere and re-radiated back. Heat is thus recycled within the atmosphere, raising the temperature. This phenomenon, the greenhouse effect (shown in Figure 2), keeps the surface of the planet some 33°C warmer than it would be in the absence of the atmosphere.

The greenhouse gases (GHG) include water vapour, carbon dioxide, methane and nitrous oxide. These gases and others are natural components of the atmosphere and form part of physical, chemical and biological cycles such as the carbon cycle referred to earlier. These cycles include natural sources, which release the gases, and sinks which remove them from circulation. A sink is not necessarily a physical entity such as an ocean and can, as in the case of methane, be the reaction with chemicals in the atmosphere.

There is growing evidence to suggest that the atmospheric levels of key greenhouse gases, such as carbon dioxide, nitrous oxide and methane, are on the increase. Although natural variations in gas concentrations over space and time are normal, these increases appear to be much larger than would be expected naturally. Human activities are held to be responsible.

There are two conflicting schools of thought on the science of global climate change; one promoting the global warming effect and the other global cooling. After years of intense study, there are still important scientific gaps and uncertainties which limit the ability to predict the potential impacts of climate change. Notwithstanding these gaps, the international politics of climate change has gathered such momentum that it can no longer be ignored on the basis of inconclusive scientific evidence.

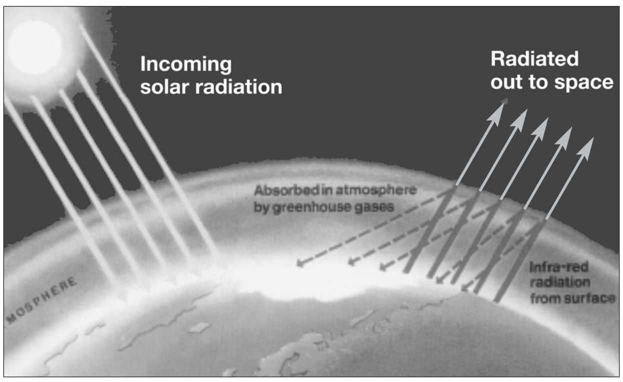


Figure 2—The greenhouse effect

As a consequence, climatic change figured prominently at the Earth Summit in Rio de Janeiro in 1992, and it was there that the UN Framework Convention on Climate Change (UNFCCC) was formulated and signed by participating parties. The signatories were required, *inter alia,* to:

'adopt national policies on the mitigation of climate change by limiting anthropogenic emissions of greenhouse gases with the aim of returning to their 1990 levels these anthropogenic emissions of carbon dioxide and other greenhouse gases by the end of the present decade'.

The UNFCCC came into force in 1994 and was later followed by the 'Berlin Mandate' which required the signatories to negotiate a protocol or similar legal instrument in time for the third Conference of Parties in December 1997 at Kyoto. This measure was to include 'quantified emissions limitation and reduction objectives as well as measures and policies to achieve these objectives'.

The Kyoto Protocol

The Kyoto Protocol established a legally binding obligation on the 24 so-called Annex 1 or developed countries to reduce emissions of greenhouse gases. In recognising that the G77 or developing countries are relatively low emitters of greenhouse gases and the need for sustainable development in these countries, no mandatory or voluntary obligations were placed on them. South Africa is classified as a non-Annex 1 or developing country.

The key elements of the Protocol are:

- The six so-called greenhouse gases identified and covered are:
  CO_2 - carbon dioxide
  CH_4 - methane
  N_2O - nitrous oxides
  HFCs - hydrofluorocarbons
  PFCs - perfluorocarbons
  SF_6 - sulphur hexafluoride
- Annex 1 countries have to reduce greenhouse gas emissions from 1990 levels by 5,2% in the first 5-year period from 2008 to 2012
- Differentiated emissions targets were established for the Annex 1 countries
- Joint implementation projects between Annex 1 countries that result in emission reductions or sequestration by means of sinks are permitted
- Non-mandatory policies and measures are to be implemented by Annex 1 countries which include the promotion of renewable energy, enhancing of sinks for greenhouse gases and the promotion of energy efficiency
- The establishment of Clean Development Mechanisms (CDMs) which allow Annex 1 countries to benefit in terms of compliance from certified emission-reducing projects in non-Annex 1 countries and which help them to achieve sustainable development
- Emissions trading between countries will be permitted.

These will be subject to rules to be developed and agreed.

The Protocol is scheduled to come into force only 90 days after it is ratified by 55 parties which together accounted for at least 55% of the 1990 level of greenhouse gas emissions caused by Annex I countries.

In South Africa, the responsibility for climate change issues rests with the Department of Environment Affairs and Tourism, which has established the National Committee on Climate Change (NCCC). This committee has been tasked with advising the Government on climate change policy and its implementation. The NCCC is a multi-sectoral body representing business, government, labour and NGOs.

To date South Africa has both signed and ratified the UNFCCC but not the Kyoto Protocol. This is not likely to happen until the Government has formulated its policy on climate change. However, in the interim, the NCCC is actively participating in developing the principles, rules, guidelines and modalties for the mechanisms, as there are potential opportunities to be gained and threats to be averted. Regional co-operation is being fostered in order to influence these discussions. South Africa, working firstly through SADC, the African countries and finally the G77 countries, has the opportunity to influence the outcome of the deliberations.

Although the climate change debate is controversial, and the global warming phenomena remains scientifically unsubstantiated the debate poses significant challenges for the South African coal industry. The potential implications are a reduction in exports and pressures to reduce emissions in South Africa which could lead to higher energy costs and a negative effect on the economy.

Clean Coal Technologies (CCTs)

The environmental pressures on the producers and users of fossil fuels and coal in particular, have necessitated the development of CCTs in which coal is produced, processed, transported and used in an environmentally friendly manner.

In the past coal mining activities were responsible for many forms of environmental pollution. Among these were atmospheric pollution arising from generation of dust in the mining process, in the coal preparation process, in transport and fumes from burning coal discard dumps. Contamination of water resources and ecosystems resulted from run-off waters which included acid mine drainage (AMD) arising from old mines, opencast mines and from spoil piles. Unrehabilitated or incomplete rehabilitation of opencast or strip mines affected topography, soils, water and also vegetation and fauna.

The impacts of coal mining activities on the environment are increasingly being diminished by legislative requirements, by informed management and the application of new technologies. Advanced dust suppression in operations, the cladding of burning discard dumps, the development of co-disposal of fine and coarse rejects and compacted discard dumps have substantially reduced atmospheric and water pollution. Mining operations, today are carefully monitored in terms of the Environmental Management Programme Report (EMPR) required by the DME (Department of Minerals and Energy). This report is continuously updated as mining plans change. EMPR auditing in many cases is supplemented by the ISO 14000 Environmental Management System.

The separation of process waters from fresh water, zero run-off from operations, controlled release of water into rivers and streams and the application of water resource management technologies are having increasingly positive effects on the country's water resources. The application of new water purification technologies to the large volumes of water stored in old workings could change the coal mines from being the polluters of the past to a water resource of the future.

Opencast mines' rehabilitation programmes are subject to close scrutiny by the authorities and are closely managed by operators. Computer based planning techniques and responsible management has resulted in many strip mines being returned to original use within five years of mining and in many cases with improved agricultural potential.

In the use of coal, CCTs are those technologies which successfully reduce particulates, acidic and carbon dioxide emissions and increase the efficiency of conversion of coal into electrical energy. The benefits to be gained in CO_2 reductions by increasing conversion efficiencies from typical levels of 35% to possibly 55 to 60% are demonstrated in Figure 3.

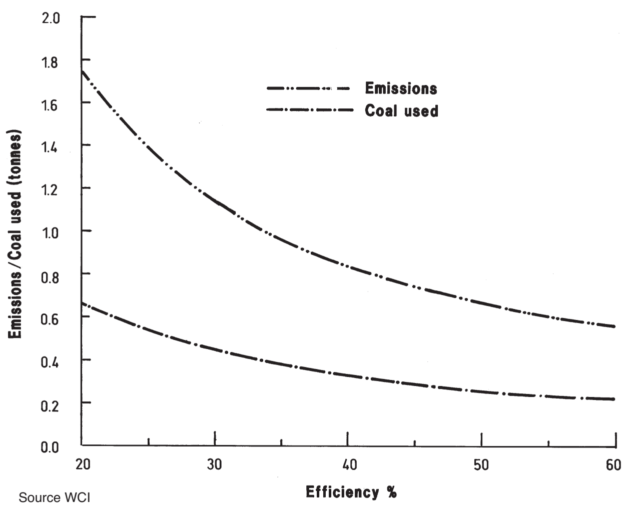


Figure 3—CO_2 emissions per MWh of electricity produced from coal at various efficiency levels

The waste products arising from coal combustion fall into three categories: particulates, those that cause acid rain, and those that are implicated in global climate change.

The control of particulate emissions is relatively straight-forward using baghouses, cyclones and electrostatic precipitators all of which are well tried and understood technologies.

Technologies exist for successfully abating sulphur and nitrogen oxides by bolt-on equipment or by making relatively small modifications to the combustion process. Newer processes, the so-called advanced clean coal technologies, offer even better control of these emissions.

Pulverized fuel combustion is the most widespread method of burning coal for power generation. In this process finely milled coal and air are blown into a furnace, producing heat which in turn produces superheated steam to drive the turbines which generate the electricity. In this case postcombustion CCTs are applied to remove pollutants. Flue gas desulphurization (FGD) techniques applied to emissions after the removal of particulates by means of baghouses or electrostatic precipitators successfully remove up to 95% of the contained SO_X.

However, one of the simplest methods of reducing SO_X is by using low sulphur coal. This does have supply and cost connotations, but through coal preparation and the blending of coals from various sources, SO_X emissions can successfully be reduced.

The removal of NO_X is accomplished by technologies which modify combustion conditions in the boiler. The aim being to restrict the quantity of oxygen available to react with the nitrogen, but at the same time to achieve complete combustion of the coal. Staged air systems in which combustion initially takes place in an oxygen deficient atmosphere and is then completed when secondary air is added, are often used.

These are known as low NO_X burners and are being widely adopted as they can be installed on existing plants at relatively low cost.

Advanced clean coal technologies cover methods of using coal other than in conventional boilers and furnaces. Developments in the use of ultra super-critical conditions in pulverized coal boilers are also included in this category. The two major advanced CCTs however are fluidized bed combustion (FBC) and coal gasification and liquifaction. These technologies offer two major benefits for protection of the environment namely,

- greater energy conversion efficiencies resulting in reduced carbon dioxide emissions per unit of energy produced as shown earlier, and
- more efficient removal of pollutants such as sulphur dioxide.

Fluidized bed combustion is an established technology in power stations, although it remains the subject of much research. In the FBC process coal is burnt in a bed of particles suspended by jets of air. The bed and contents are in turbulent motion so that there is even combustion and an efficient transfer of heat to the boiler tubes passing through the bed. Heat transfer is by means of conduction on impact as opposed to less efficient convection flow of hot gases in conventional boilers. This process is flexible as to the fuel burnt and can use very low grade coal as in China or indeed industrial waste and sewage sludge.

Powdered limestone or dolomite is added to the bed as a sorbent to trap sulphur dioxide by forming calcium sulphate which is then removed with the ash. Due to lower process temperatures and less excess air, less NO_X emissions occur. Two problems with the process are the production of nitrous oxide and other GHG by non-pressurized FBCs and significant quantities of solid waste particularly if high-ash, high-sulphur coals are burnt. Work on the development of the newer pressurized FBC process to overcome these problems continues.

Gasification is a process that converts heat energy in any hydrocarbon into a clean gas stream containing carbon monoxide and hydrogen and some methane, all of which are fuel gases. It is an efficient process converting between 80 and 95% of the input energy into energy contained in the product gas. Pollutants are safely removed and the produced gas is relatively free of all compounds that could cause pollution during its use.

Modern gasification technology was developed in Germany some 60 years ago and is widely used in the chemicals industry today. A more recent application is the generation of electricity using gas turbines, a technology which has evolved over the past 15 years, resulting in the Combined Cycle Gas Turbine (CCGT). CCGT technology has many advantages offering high energy conversion efficiency, low capital cost, short erection times and low emissions.

A much newer technology flowing from this but still very much in the demonstration phase is Integrated Gasification Combined Cycle (IGCC). In this process the heat arising from the combustion of gases in the gas turbine is used to drive the electrical generator while the hot exhaust gases are passed through a heat recovery steam generator to raise steam to drive a steam turbine, which in turn drives an electrical generator.

These processes offer the potential to improve conversion efficiencies from current levels of approximately 35% in a range up to 60%.

In South Africa, the use of advanced clean coal technologies is in its infancy, with research work having only just commenced. However, social priorities and political pressures do provide an opportunity to significantly reduce indoor and atmospheric pollution and this is regarded as another form of CCT. Since coal is readily available and is cheap, a significant proportion of the population living in the disadvantaged urban communities use raw coal as the primary energy source for cooking and heating, resulting in high levels of atmospheric pollution, particularly in winter.

Eskom's electrification programme of supplying electricity to 1,75 million homes between 1994 and 2000, although resulting in some increased power station emissions, will result in a significant reduction in the burning of raw coal and thus a net overall reduction in emissions and will improve the health and quality of life of these communities.

The DME is driving in parallel with Eskom's electrification programme, a project to develop a smokeless fuel to replace the use of raw coal for space heating and cooking in these communities. It is required to develop a technology which produces a fuel, costing the same as coal that can be used in the same combustion appliance and will not result in the generation of greater quantities of carbon dioxide either in its production or in its use. Since the coal-fired power stations in South Africa are relatively new and use pulverized fuel technology, upgrading to advanced CCTs is not warranted unless there is a significant gain in efficiency. However, once the current generation of power stations are replaced at the end of their economic lives, it will be necessary to do so using advanced CCTs. Current research is directed at the use of established FBC technologies for combusting our low grade and even discard coals as well as keeping abreast of other technologies such as pressurized FBC and IGCC as these develop elsewhere in the world.

Research in South Africa into clean coal technologies such as understanding the formation mechanisms of gaseous pollutants during the PF process and the primary abatement methods such as low NO_X burners continues. Research work by Sasol, is aimed at improving carbon utilization by improving gasifier efficiency and lowering the hydrogen to carbon monoxide ratios in the Syngas. Both these initiatives will reduce CO_2 emissions.

Competition

Competition in the coal industry is both external and internal. External competition arises from other sources of energy while internal competition is between producers and between consumers and is based on the ability to supply energy at the lowest unit cost.

Coal, the source of the world's energy for hundreds of years, is second only to oil as a source of primary energy, as shown in Figure 4.

Over time, the role of coal as a source of primary energy has shifted from one of extensive use in all sectors of industry to one where it is primarily used for the generation of electricity.

Figure 5 depicts coal's share in the generation of the world's electricity.

Coal has lost market share and is projected to continue to lose to oil and petroleum products, gas, nuclear and renewable energy such as that from wind, solar, hydro, biomass and geothermal sources. It has not only been economic considerations that have caused this shift, but also environmental pressures to reduce coal consumption. The introduction of carbon taxes in Europe is an example of these pressures that will have the greatest impact on coal due to it having the highest carbon content of all fossil fuels.

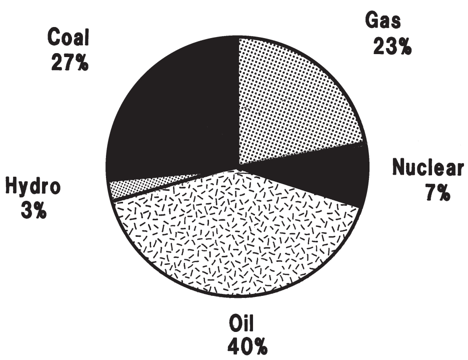
Increased demand for petroleum arising from increasing activity in the transport field and the use of natural gas for power generation and space heating are further reasons for this decline.

The major projected decrease in coal's share in total energy consumption is forecast to be in the European and former Soviet Union countries where usage is expected to drop from 25% to 16% by 2020 although volumes of imported thermal coal are expected to grow by some 30 million tons as a result of pit closures in those countries. Natural gas is expected to capture an increasing share of the energy market during this period.

With the exception of China where coal will continue to provide the primary source of energy, growth in worldwide coal consumption will be virtually all accounted for in electricity generation. In the area of non-electricity generation natural gas is expected to gain market share. Technological developments in steel-making could lead to a decline in coking coal usage in favour of electricity, using electric arc and direct reduction furnaces for example; a positive development for thermal coals.

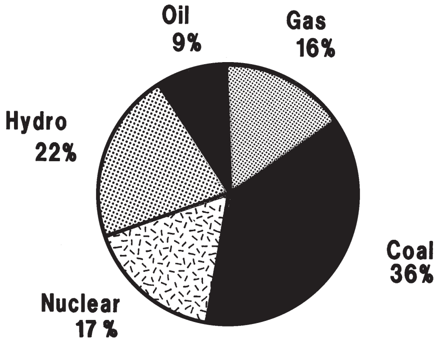
While it is projected that the use of coal as a source of primary energy will decrease, its use in power generation will increase despite competition from other energy sources.

Details of projected growth in international seaborne thermal coal trade are shown Table IV.



Source: BP Statistical review 1998

Figure 4—Total World Primary Energy Consumption (percentage by fuel 1997)



Source: EIA International Energy Outlook 1998

Figure 5—World electricity generation (percentage by fuel 1997)

Table IV

Projected growth in seaborne thermal coal trade

Major exporting countries	1997 mtpa	2010 mtpa	2020 mtpa
Australia	73,6	111,5	136,8
South Africa	57,7	69,0	84,7
Indonesia	38,2	51,0	60,4
United States	31,3	55,1	71,6
China	26,1	32,5	38,6
Colombia	24,0	52,5	67,8
Poland	20,3	9,5	9,5
Former Soviet Union	14,1	12,0	12,4
Canada	6,4	7,1	8,2
Total	**291,7**	**400,2**	**490,0**

The second form of competition in the industry is that amongst the coal producers.

Australia is projected to remain the world's largest steam coal exporter. New thermal coal export projects will benefit from the current restructuring, relaxation in work place practices with concomitant productivity increases, reduction in rail freight, harbour reorganization and expansions and a reduction in state taxes and royalties. Coal quality and proximity to the major growth markets will ensure this country's predominant position.

South Africa is projected to remain the second-largest exporter growing by 47% or some 27 million tons, from 1997 to 2020, despite being constrained by cost pressures arising from the need to wash all export coal.

Indonesia, a low-cost producer, also enjoys freight advantage in the Asian market. Here export growth is expected to continue, but not as rapidly as in the past as local production is increasingly diverted to its own Independent Power Producers (IPP).

China is the world's largest producer and consumer of coal and is well placed in terms of ocean freight with respect to the growing Asian markets. Export volumes however are small in relation to production, 26 million tons in 1997 compared to the 1,16 billion tons produced. Increased exports from China are dependent on its own requirements in the first instance and secondly, on a quality improvement and streamlining of railway and port constraints.

Colombia and Venezuela remain South Africa's main competitors in the Atlantic basin. Corporate activity in Colombia and the growing use of common port and rail facilities by producers will reduce FOB costs of these generally low sulphur, low ash coals.

While projections are positive for increasing volumes of seaborne thermal coal, competition from other energy sources and amongst producers will almost certainly lead to the continued fall in real term prices of coal. Essentially being price takers producers will have to continue to improve efficiencies along the coal continuum in order to achieve real term reductions in costs and to retain acceptable margins.

Deregulation of electricity supply

Worldwide-electrical utilities are by far the greatest consumers of coal using some 36% of production in 1997 in the generation of electricity. Developments in this industry will therefore have the greatest impact on coal producers.

Historically governments have regarded the electricity industry as strategic and have thus developed it as a public asset. Government controls have underwritten security of supply and ensured that prices have reflected the social importance of electrical power. Monopoly in the provision of power has been seen to be essential in order to take advantage of economies of scale.

This model is now being rejected by more and more countries around the world as being the best way to service customers needs and to meet projected growth targets. The new model is privatization and the introduction of competition in order to deregulate the power industry.

The liberalization of power markets is at different stages in a number of countries such as the UK, the USA, Argentina, Germany, the Scandinavian countries, New Zealand, Chile, Spain, Peru and Colombia.

Privatization is seen as a means of providing the ability to expand utilities to meet projected demand growth, through the use of private funding. Competition will ensure that customer care becomes central to the operator ensuring improved efficiency and standards of service. Liberalization has opened the market to competition, not experienced by the monopolies, with price, service and flexibility spin-offs for the customers. Deregulation has not been limited to the generation of power but also to power distribution networks.

Information technology developments now enable customers to switch networks and suppliers in a deregulated industry and allow the generators to schedule plant as a consequence of price setting on a half-hourly basis. An example of the benefits of deregulation is the decline in real terms of power costs by 20% over the past 7 years in the UK.

Input costs are all-important in this new competitive regime and the coal supplier faces increased competition not only from other sources of energy but also from other coal producers.

In the past, until 1997, Japan has traditionally set prices for seaborne steam coal into Asia. Contract negotiations between Japan's steel mills and suppliers from Australia and Canada established at benchmark price for coal that was used later in the year as the basis for setting contract prices for thermal coal that was used in the Japanese utilities. This became the bench-mark price for all imports not only into Japan, but South Korea, Taiwan and other Asian countries.

The high cost of power in relation to other OECD countries has forced the Japanese Government to compel the power industry to reduce the cost of power in order to reduce industrial and other costs. Although input costs only represent 15% of the overall generation costs, pressures are being applied to steam coal prices. The benchmark price system has fallen away. Buyer's options on long- term tonnage contracts with annual price setting are not being exercised and more tonnage is being bought on a spot basis with producers being awarded spot cargoes in exchange for price reductions. In addition, a bidding system for the supply of power into the grid by IPPs is being introduced in order to liberalize the market.

South Korea, Taiwan and other Asian countries have likewise increased spot purchases resulting in further downward pressures on coal prices.

The deregulation of the power industry has been accompanied by the growing use of financial instruments such as options and futures in electricity in order to hedge against price volatility. Risk to the generator is thus reduced and shared with those outside the industry.

The increasing liberalization and deregulation of the power industry continues to put pressure on coal prices. Producers can, in addition to reducing costs in order to maintain margins, follow the power industry and many other commodities into managing price risk by the use of derivatives in coal. This is a financial tool very much in its infancy in the coal trade, but one which can be expected to grow in the future.

Legislative reform

The coal industry in South Africa has not escaped the legislative reform programme since the coming to office of the new government in 1994. Indeed legislative reform in the industry started in 1991 with the promulgation of the Minerals Act 50 of 1991.

The new legislation has affected and will continue to affect all aspects of coal mining operations. Fourteen new Acts with bearing on the industry have been enacted since 1994. The most important of these being the new Mines Health & Safety Act which has redefined the approach to safety in the industry. The other two major areas of legislative reform have been in the spheres of labour legislation and the environment. The process is not complete yet, as regulations pertaining to mine health and safety are currently being reviewed and have then to be promulgated. The Minerals Act, currently under review, when promulgated will have far-reaching effects on the industry, particularly in respect of ownership of mineral rights.

While legislative review is part of the reform process in

South Africa, it is not without its consequences on the mining industry. Additional costs, levies and an increasing labour market rigidity are impacting on the industry's competitive edge. This is of concern in view of the relaxation in employment practices, reduction in rail and harbour costs and state royalty payments in Australia—one of our main competitors in the coal export market.

Corporate restructuring

The long-term decline of coal prices in real terms, consequent squeeze on profit margins, the low return on capital and increasing change in market fundamentals, has resulted in coal companies formulating new strategies to secure their business for the future.

The first major strategic change was the slow but deliberate disposal of coal assets by the multinational oil companies starting in the late eighties as they reverted to core business. At the height of involvement of the oil multinationals in the coal business there were some sixteen companies who were multinational in coal.

The disinvestment by oil companies presented the opportunities for metal mining companies to acquire coal interests. This was driven by the availability of relatively cheap coal assets, potential synergies with their existing coal operations and the ability to 'cherry pick' low cost, high productivity mines. The new coal companies have tended to limit transnational activities and as a result there are now some eight multinational coal companies and only two have interests in more than two countries.

The need to develop critical mass has resulted in consolidation of coal companies on both a national and international scale. Locally this is evidenced in the decrease in the number of shareholders in Richards Bay Coal Terminal (RBCT) from the ten of 1993 to six of today and the number of coal companies on the Coal Board of the JSE to only three (only one of which is operational in South Africa). Similarly, consolidation has taken place in the USA, Canada, Australia and Colombia.

State-owned or subsidized coal mining operations have also been subjected to market forces. The restructuring of these industries and the withdrawal of state subsidies as experienced in the United Kingdom and now in progress in Germany, China, Spain, Poland and possibly in India, could lead either to their demise or their re-emergence as more profitable players in the coal business.

These strategies, aimed at retaining competitive advantage, have reduced country risk through geographical diversification, increased critical mass and economies of scale, improved capital and resource productivity and have presented the opportunity to downstream into electricity generation as the deregulation of that industry progresses. Internationally, consolidation of ownership should result in a more disciplined approach to the establishment of new production capacity as existing capacity is maximized and utilized to the full. Producers will also have greater market muscle and excess capacity should diminish, bringing supply in line with demand.

In South Africa, the need to establish critical mass will lead to the coal companies increasingly consolidating reserves into larger, more productive blocks, either around existing operations or around undeveloped nodes. Smaller operators will benefit as smaller reserves, which would be uneconomical in the hands of the bigger companies, are released to them. Given the potential for increased port

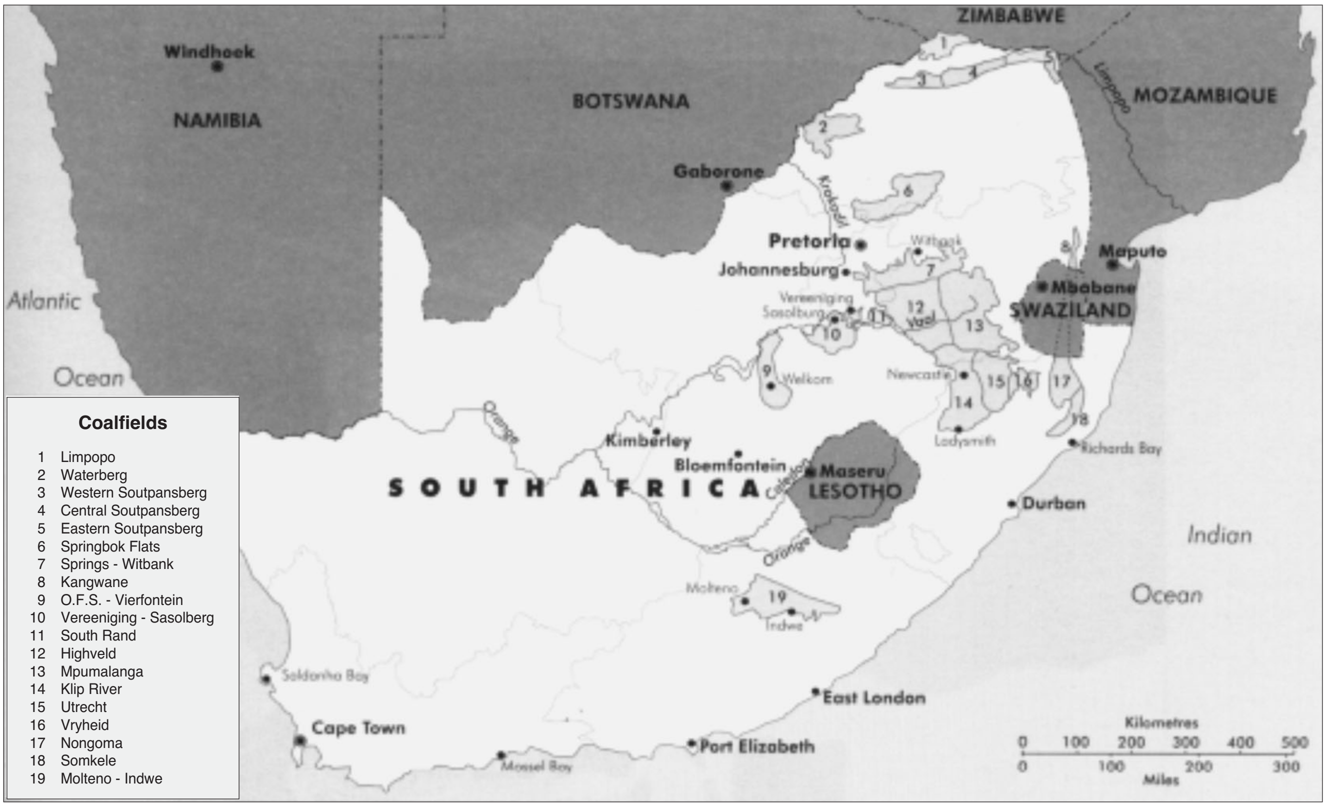


Figure 6—Coalfields of South Africa

capacity, the smaller operators would be in a position to participate in the growth of the seaborne thermal coal trade.

The freeing up of reserves resulting from consolidation and as a consequence of the new Minerals Act, coupled with the move to Black Empowerment, will impact on the general domestic market (GDM) in South Africa. The most likely outcome will be a move away from the GDM by the larger producers in favour of smaller, and Black Empowerment companies.

Change and the South African producer

Reserves

The South African coal deposits are hosted in the Karoo Supergroup of late Carboniferous to middle Jurassic Age (320–180 million years). The deposits were formed in the Gondwana Basin which covered parts of southern Africa, Australia, Antarctica, South America and India prior to continental drift. The distribution of the coalfields in South Africa are shown in Figure 6.

Table V

Distribution of resources and reserves

Coalfield	Resources (billion tons)	Reserves (billion tons)
Witbank	16,2	12,4
Highveld	16,9	10,9
Ermelo (Mpumalanga)	7,5	4,7
Utrecht	1,1	0,7
Klip River	1,2	0,7
Vryheid	0,4	0,2
South Rand	3,0	0,7
Vereeniging - Sasolburg	4,7	2,2
Free State	8,8	4,9
Nongoma/Somkele	0,2	0,1
Kangwane	0,5	0,2
Springbok Flats	3,2	1,7
Waterberg	55,4	15,5
Soutpansberg	0,5	0,3
Limpopo	0,2	0,1
Total	**121,0**	**55,3**

The last official estimate of coal reserves/resources in South Africa was published by De Jager in 1983. His recoverable reserve of 58,4 billion tons was later revised downwards in 1987 by Bredell to 55,3 billion tons on the basis of depletion by mining operations and a re-assessment of the Waterberg reserves. The distribution of these reserves and resources are shown in Table V.

Taking into account the subsequent depletion of reserves through mining, the consequences of changing market circumstances and more exploration results, the above mineable reserve estimates have been unofficially downgraded to 39,5 billion tons by Prevost of the DME.

The country's reserve and resource estimates as they are known at present are not adequate for informed projections on the future of the coal industry.

The DME has therefore commissioned a reappraisal of the country's coal resources and reserves. The assessment will take cognisance of new technologies, the new reserve and resource definitions now being developed by SAMREC and will consider quantity, quality, location, sterilization and for the first time 'above ground reserves' or coal discards. The assessment will be led by the Council for Geoscience and will involve producers and other interested parties and is expected to be published in 2002.

The bulk of the country's mineable reserves lie in the Witbank, Highveld, Ermelo and Free State coalfields. The coalfields are close to the major industrial centres of the country and are favourably located with respect to the Richards Bay coal line and harbour. The remaining large, virtually unmined, resource is the Waterberg coalfield. The 15,5 billion ton reserve was re-assessed subsequent to Bredell and is now considered to be some 6,3 billion tons. This reserve is remote from port access and most of the country's industries. Mining of the Waterberg reserves has been made possible by the establishment of a multi-product mine i.e. production of a prime coking coal for Iscor and middlings product for Eskom.

The Witbank, Highveld, Eastern Transvaal, Vereeniging/Sasolberg and Natal coalfields have been the source of the majority of the country's coal production in the past. This was for reasons of quality, physical conditions and accessibility. What remains of these coalfields now are the thinner seams, non-sterilized pillar reserves, those of lower quality and smaller in size, reserves with more difficult mining conditions and those dedicated to the two major inland consumers, Eskom and Sasol.

The re-assessment of resources and reserves, now long overdue, will certainly result in a better understanding of South Africa's ability to service the projected growth in the market referred to earlier. The challenge for the producers will be to provide the consumers with increased tonnage, consistent in quality and at a price that enables them to burn lower quality coals using new technologies. In order to achieve this, the producer will require consumer support.

New technologies will have to be applied in exploration, mining and coal preparation if the economic viability of a potentially larger, but lower grade and more difficult reserve base is to be ensured. In particular, the application of new technologies is required to upgrade coal resources to reserves and ensure the continued future of the coal industry.

Table VI

Capacity of coal exporting terminals

Terminal		Current Capacity mtpa	Potential Capacity mtpa
Richards Bay Coal Terminal (RBCT)	Richards Bay	66,5	69,0
South Dunes Coal Terminal (SDCT)		—	12,0
Matola	Maputo	2,2	16,0
McMyler		0,5	0,5
Bluff Mechanical Appliance Crane Berths	Durban	1,8	2,1
Total		**71,0**	**99,6**

Coal terminal capacity

As discussed earlier, the EIA forecasts that exports of coal of all types from the RSA will rise from the current 63,9 million tons to 75,1 million tons in 2010 and then to 90,8 million tons in 2020. The country's ability to service this projected demand is dependent on

- an adequate reserve base
- mine capacity
- rail capacity between the mines and ports
- coal terminal capacity, and other factors.

There exists potential to increase the capacity of the coal exporting terminals currently servicing the South African coal industry, as is demonstrated in Table VI.

The establishment of the SDCT has still to be announced although viability studies have progressed over a number of years. The terminal is currently planned as a new stand-alone facility at Richards Bay, but could also be incorporated into the RBCT with synergistic benefits for both parties.

A US$ 50 million upgrade of the Maputo harbour is currently being undertaken by an international consortium. The Matola Terminal infrastructure improvements and upgrades and deepening of sea channels in the harbour will ultimately facilitate the loading of panamax size vessels in Maputo.

In terms of harbour capacity South Africa has more than enough potential to meet projected exports.

The rail link between the coal mines of Mpumalanga and Richards Bay operated by Spoornet's COALlink, will with some minor upgrading and additional rolling stock, handle the increased volumes generated by SDCT. The potential increased throughput at the Maputo harbour is much dependent on the creation of a joint venture between Spoornet, CFM, the Mocambiquean rail authority, and an overseas operator in order to raise funds to upgrade the rail line between the mines and the Maputo harbour.

The coal continuum

The South African coal producer faced with growing market opportunities, increasing price competition from other coal producing countries and other sources of energy, a declining reserve base—necessitating a move to lower quality reserves with more difficult mining conditions and growing local and external environmental performance pressures must develop new cost-effective mining methods for the future. The coal consumer in South Africa and elsewhere, on the other hand, faced with input cost pressures will continue to seek coal of an acceptable quality at the lowest cost, and still be able to increase combustion efficiency in order to reduce output cost and emissions.

The coal business of the future requires a holistic approach, one commencing at the exploration and planning phases, progressing through mining, preparation, blending, transport, utilization of coal, the treatment of emissions and finally to the use or disposal of fly and bottom ash arising from the combustion process.

This is an integrated process in which value is added at each step, a continuum with feedback loops which will contribute to coal's continued prosperity.

The start of the continuum is the exploration phase in which a thorough understanding of the physical and chemical properties of the coal deposit as well as the depositional structure of the reserve must be acquired. Commercial valuation of coals has traditionally been based on its volatile matter content and calorific value. However, these do not give the user nearly enough information about the complex product being purchased.

Many different properties of coal are now evaluated for specific markets. Users of coal while requiring better quality coals in terms of absolute levels of these various qualities also require consistency of quality.

The properties of coal are expressed in chemical and physical terms. The most important chemical properties of coal are:

- total moisture
- the proximate analysis on an 'air dried' basis detailing the percentage volatile matter, inherent moisture, ash, and then fixed carbon by difference
- the calorific value or specific energy normally quoted on a 'net as received' basis in Mj/kg, kcal/kg or Btu/lb
- the ultimate analysis which provides the elemental composition of the organic part of coal providing the carbon, hydrogen, nitrogen, oxygen and sulphur content on a 'dry ash-free' basis. The higher the carbon content, the higher the rank of the coal
- phosphorus content
- chlorine content
- sulphur content and also its various forms
- ash analysis, i.e. an elemental analysis in which, typically, the content of the oxides of Si, Al, Fe, Ti, Ca, Mg, Na, Vi, Mn, S and P is determined
- heavy metals such as Hg, As, Cd, V, Pb.

The most important physical properties of coal are the

- bulk density
- size distribution
- ash fusion temperatures normally determined at three different stages of deformation
- Hardgrove grindability index (HGI)
- crucible or free swelling index (CSI)
- abrasive index
- slag viscosity at 200° F
- ash precipitation characteristics.

Coal being a complex rock consisting of organic and inorganic components, growing use is being made of petrography, an optical technique, to determine the organic constituents of coal and its rank. These are those properties which determine its combustion properties and behaviour in furnaces. The organic components are made up of macerals, such as vitrinite, exinite, fusinite, semi-fusinite and intertinites, and originate from the different forms of vegetable matter in the coal. The reflectance of the vitrinite is a measure of the rank of the coal. The higher the reflectance the higher the rank of the coal.

Obviously the better understood these properties are the more informed the decisions with regard to the mining, preparation and use of the coal will be.

An example of this is in the blending of coals. Some of the properties such as size, ash, moisture, volatiles, sulphur, macerals, ultimate and ash analysis are additive, others on the other hand, such as ash fusion temperature, HGI, abrasion index, CSI, bulk density and coking and caking parameters may or may not be. Coal petrography can be successfully used to predict the non-additive properties of blends.

The second output of the coal exploration programme is the geological model of the reserve detailing the geometry of the coal seams in the reserve, the geotechnical environment, the geohydrology, the reserve characteristics, quantities and qualities of coal which then form the basis of mine layouts and scheduling. These within the constraints of safety, local environmental requirements, human and capital productivity, operating costs and market requirements have to be taken into account when designing a suitable mining method for the reserve.

Upfront consumer participation in the mine planning process in order to provide an understanding of the diverse market requirements and opportunities that exist will enable the planning and development of multi-product mines employing—if required—selective in-seam mining methods, geographical sourcing and judicious blending of plant feed and products.

Changing circumstances in South Africa in the late 1960s and the early 1970s resulted in the move from hand-got mining to the use of continuous miners underground and the introduction of opencast strip mines utilizing draglines. Changing circumstances will again dictate a change in these mining technologies and methods in order to economically extract thin seam coal, to recover pillars in previously mined areas, to mine deeper reserves and to increase productivity.

Imported technologies, those developed locally and new technologies such as the use of the continuous haulages for coal clearance, highwall mining and pillar recovery using opencast methods and others can only be applied if the physical attributes of the coal seams are fully known and understood.

Until now the South African coal industry has been able to compete internationally despite poor labour productivity and while not making maximum use of the capital invested. The combined effect of declining prices and cost pressures and a changing reserve base now require a fundamental change in approach to productivity. New mining technologies and reorganisation of production cycles offer the potential of much needed improvements in productivity of both labour and capital resources.

While it may be argued that the South African coal industry can afford much lower labour productivity levels in relation to other exporting countries, cost pressures dictate otherwise.

Table VII compares labour productivity trends in South Africa, Australia and the U.S.A.

Table VII

Labour productivity comparison
Saleable output per employee per year (tons)

Year	South Africa	Australia	USA
1992	2500	6300	6200
1997	3600	8400	11500
Per cent improvement	44	33	85

While it is recognized that there may be a different basis in compiling a comparison such as this, there are three points to be noted:

- The very low productivity levels in South Africa, particularly since all export coal is washed and this is not the case for all Australian and U.S.A. coals.
- Although there has been 44% improvement in productivity in the past five years, South Africa's productivity is still approximately 43% of that of Australia and 31% of the U.S.A. five years ago and comes off a low base.
- Labour costs in South Africa comprise 40% of the cost per saleable ton. These have risen by 8,2% in the last year to R15,57 per ton of all saleable tonnage. This figure is negatively skewed by raw coal sales to Eskom and Sasol. Labour costs for export coal is in the region of R25 to R30 per ton because of the yield effect. By comparison labour costs in New South Wales have decreased in the last year by 14,6% to R29,31 per saleable ton. The decreasing labour cost differential is a development that the South African producer can ill afford.

Considering that in general South African reserves are not amenable to the application of the highly productive long wall mining methods used in Australia and the U.S.A., there is a need for new and more highly productive mining technologies. These cannot be developed in isolation without a knowledge of the reserve, coal potential and markets.

South African coals are of medium rank and generally have high ash contents and therefore require upgrading or washing before export or use in the GDM. This step is value adding but it also adds to cost.

In order to maximize coal recovery, plant efficiency and revenue in the coal preparation process, a thorough understanding of the inherent and run of mine properties of the coal to be processed and the customers requirements and developing opportunities is needed. It is of benefit to the supplier and consumer that 'appropriate' quality coal is produced, appropriate for both the reserve and for the combustion appliance.

South African coal preparation processes are largely based on the use of dense medium baths and cyclones, and more recently the addition of spirals for fine coal recovery. The use of froth flotation for the recovery of the ultra fine fraction, whilst not new, is a technique gaining in application in South Africa. Refinements such as the application of plc controls to jig washing could see a resurgence of this technique in future. Generally the industry is reaching the limits of conventional coal preparation technology and the emphasis is now moving to maximizing recovery and cost reduction, whilst ensuring consistency of quality and reducing environmental impacts.

The potential for efficiency improvements in coal preparation is in areas such as the recovery of fine tailings, the dewatering of fines, particularly in view of the growing use of froth flotation and the ever-present need to reduce transport costs, optimizing of process efficiencies through process simulation, on-line analysis, real time process control and where applicable, the use of larger single units in order to effect economies of scale.

Discards, totalling almost 70 million tons in 1997 arising from coal preparation, offer potential benefits both as a source of revenue, and as an opportunity to reduce costs and environmental impact. There is potential for coal washery rejects in the agglomeration and briquetting of fine coal and for use in the FBC process for heat generation. Ash from the combustion process is a potential construction material for use in fill applications, as an aggregate, cement plant feed and soil and road base stabilizer. Ash suitably treated has potential for use in mining operations such as a pillar stabilizer or in AMD amelioration .

An upfront knowledge of the properties of coal discards and ash and their cost reduction and revenue potential will impact favourably on new project viabilities.

Research

Coal research in South Africa is undertaken individually by producers, consumers, government structures and research agencies such as the universities. Research programmes and projects are generally needs driven as these are identified by the various industry participants. There is no single nationally co-ordinated research programme or agency.

South Africa is a member of the International Committee for Coal Research (ICCR). Its contributions to the ICCR are co-ordinated by the Coal Research Forum, a loose coalition of producers, consumers, the government and research agencies.

Some of the major organizations and structures currently involved in coal related research are:

- ➤ ESKOM, where research is mainly directed at improving combustion efficiencies and the reduction of environmental impacts
- ➤ The State through a number of its structures, such as:
  - The DME with respect to policy development
  - The Water Research Commission who, together with industry representatives, define water research needs
  - The Science Councils such as CSIR, Mintek and the Council of Geoscience who undertake some coal related fundamental and exploratory research
- ➤ SIMRAC, a levy-funded, tripartite safety research programme involving the employers, the employees and the State. This programme is needs driven with respect to safety and health issues on mines.
- ➤ Private enterprise such as Sasol in the sphere of coal conversion
- ➤ The mining companies and mines, where efforts are directed at solving site specific issues and problems
- ➤ Collaborative Research. The recently formed Coaltech 2020, a voluntary association of coal producers, labour, Eskom, the Chamber of Mines, Miningtek, the government's FRD and the universities of Pretoria and the Witwatersand is a major initiative to promote coal research in South Africa.

Research initiatives and programmes have, prior to the advent of the Coaltech 2020 programme, understandably concentrated mainly on safety and health, the environment and resource utilization. The Coaltech 2020 initiatives are, however, directed more towards retaining the South African competitive edge; developing new technologies and mining methods which will also extend the useful life of existing infrastructure particularly, in the Witbank and Highveld coal fields; improve reserve utilization and increase the reserve base. The programme is wide ranging and includes geology, geophysics, surface and underground mining, coal processing, distribution of product, surface environment and social and human aspects.

In a recent development a research collaboration agreement has been reached between the South African and Australian delegations to the ICCR. There are currently three areas in which there is to be collaboration in research, viz:

- ➤ The design and stability of coal pillars
- ➤ The reduction of fires and explosions
- ➤ Improved effectiveness of escape and rescue operations.

Other coal producing members of the ICCR have indicated interest in collaborative research and as a consequence, the range of research topics has now broadened considerably.

The collaborative research outcomes and those from the Coal 2020 programmes, are going to be vitally necessary for application by the South African coal producer in order to retain the competitive edge and market share in the future.

Conclusions

The production and use of coal for the development of mankind has grown into a major international industry since the start of the Industrial Revolution. It is an industry based on large reserves and an industry projected to continue to grow. This growth is forecast to be driven by the Asian countries particularly China and India.

Climate change concerns have focused attention on the combustion of fossil fuels and on coal in particular. The industry has responded by applying technology and has developed the so-called clean coal technologies, which when applied to the production, processing, transport and combustion of coal, reduce its environmental impact. These technologies in many instances are still very much in the development phase, but as research and development continue, will lead to ever-reducing impacts on the environment.

Environmental pressures for change are not the only ones impacting the industry. Coal prices are subject to continuous decline by deregulation of the power industry, by competition amongst producers, by other sources of energy and by corporate restructuring. As a consequence, margins are being squeezed and the cost of production has to be contained or reduced in real terms.

In South Africa, producers will also have to contend with a declining and lower quality reserve base, which will become increasingly more costly to mine. Positive projections on growth in the seaborne thermal coal trade and the potential to increase export terminal capacity, present exciting challenges for the South African coal producer of the future.

Growth and change in the industry in the past was technology driven, technologies which were either developed locally or imported. Technology will of necessity continue to fuel the growth and change in the future. The extent of future successes will depend very much on the resources committed now and in the future to technology development and transfer. Producers should consider whether the initiatives such as Coaltech 2020 are sufficient or whether additional resources should be committed to maintaining the country's dominant position as a coal producer and exporter.

Co-operation between producers and consumers is necessary to convert the country's large coal resource into a coal reserve and to maximise the potential of the existing remaining and potential new reserves.

Coal has many positive attributes such as:

- the extensive worldwide reserve base
- being safe to transport, store and use
- being a secure and cost effective form of energy
- the potential for minimizing environmental impact by applying CCTs
- being a high technology fuel.

Coal, however, suffers from negative perceptions and a poor image. The use of appropriate technologies and aggressive marketing will change this, so that the issue for coal becomes one of *how* it should be utilized not *whether* it should be utilized. Technology has the potential to make coal the fuel of choice and the fuel for the third millennium.

References

Chamber of Mines—1997/98 Annual Report.

DME—Operating and Developing Coal Mines in the RSA—1998.

Energy Information Administration / International Energy Outlook 1998.

Energy 2020—A report on future World Energy Demand. Oxford Economic Research Association.

Eskom Statistical Year Book 1996.

FT Energy World. December 1998.

ICCR 1998 Country Reports.

International Energy Agency—Coal Information 1997.

South African Coal Report—South African Coal Statistics 1998.

World Coal Institute—Coal Power for Progress and other publications. ◆

Top-class black graduates not yet readily available-HSRC*

Employers trying to comply with the Employment Equity Act face a daunting task to change employee profiles, as blacks and women make up only 32% and 45% respectively of the total graduate population in South Africa, a Human Sciences Research Council (HSRC) report on graduate statistics states.

The HSRC's Register of Graduates—the primary source of information concerning graduate availability within South Africa—has just published a comprehensive report on graduate statistics (South African Graduate Statistics 1999: Profiles and Trends). This publication provides figures on the availability of potential employees, as well as the demographic information required by employers for the setting of employment equity targets.

'The situation is not rosy for employers who are hoping to find graduates in the 'designated groups' that can fill the positions that they offer,' says Yvonne Shapiro, project leader of the Register of Graduates.

Qualification trends since 1991 show that black people are now claiming 45% of the total qualifications awarded annually, and women 50%. Closer examination however, reveals that these two groups are obtaining the qualifications at lower levels than their white or male counterparts. In addition, the categories within which they fall are mostly those where an oversupply of qualified people already prevails, such as education.

'Certain study fields still attract particularly few black candidates. This makes it especially difficult to change employee profiles unless more black people can be encouraged to undertake study in these fields. The challenge to South Africa over the next few years is therefore to produce top-class black graduates in the fields where today they are simply not available,' Shapiro says.

According to HSRC research the most prominent lack of black graduates is found in the qualification categories of Natural Sciences, Engineering, Built Environment (Architecture, etc.), Health (except Nursing), Law, and all Economic and Management Sciences (except Administration). ◆

* *Issued by: Corporate Communications, HSRC, Pretoria: Contact: Yvonne Shapiro Tel: (012) 302-2450, e-mail: YTShapiro@silwane.hsrc.ac.za*

Jigging technology takes award*

Mintek and Bateman Titaco were the joint recipients of the Associated Scientific and Technical Societies (AS&TS) 1999 award for 'outstanding contributions to science or the application of science' at the Association's annual award ceremony.

The award was made for the development and industrial implementation of a process for the recovery of ferro-alloys from slag dumps, which has led to the recovery of low-cost saleable material from dumps, which were previously uneconomic to process, providing an additional source of metal, and at the same time reducing the potential environmental threat inherent in the dumps. There are now seven commercial plants using this technology in southern Africa, and 500 new jobs have been created. ◆

* Issued by: The Communications Division, Mintek, Private Bag X3015, Randburg, 2125