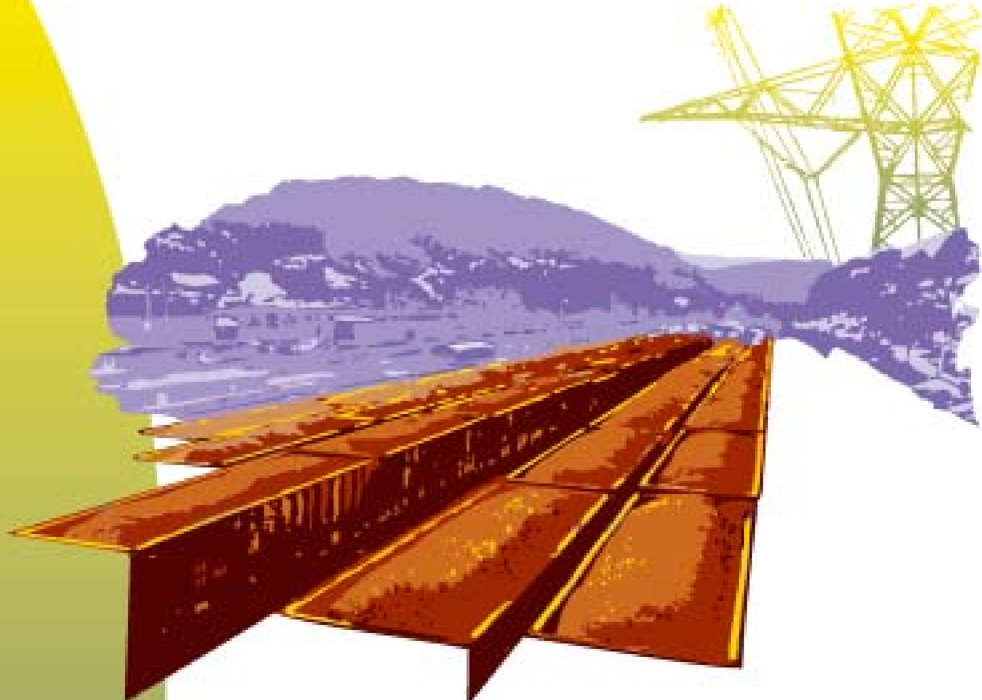
COAL INDUSTRY ADVISORY BOARD

INTERNATIONAL ENERGY AGENCY



Coal in the Energy Supply of India

OECD

COAL INDUSTRY ADVISORY BOARD

INTERNATIONAL ENERGY AGENCY

Coal in the Energy Supply of India

OECD

INTERNATIONAL ENERGY AGENCY

9, rue de la Fédération,
75739 Paris, Cedex 15, France

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-six* of the OECD's thirty Member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions.
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
- To operate a permanent information system on the international oil market.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To assist in the integration of environmental and energy policies.

** IEA Member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. The European Commission also takes part in the work of the IEA.*

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- To achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy.
- To contribute to sound economic expansion in Member as well as non-member countries in the process of economic development.
- To contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), the Republic of Korea (12th December 1996) and Slovakia (28th September 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

FOREWORD

India urgently needs modern energy to support its large, expanding population and growing economy. The country has vast coal resources which for many years have supplied a major share of its primary energy supply. The ever-increasing use of domestic coal has brought great benefits, but also poses serious challenges. By supplanting traditional biomass energy to a very large degree, coal has improved both the quantity and quality of the energy available to the Indian people. Coal also contributes decisively to India's energy security, since the country has limited oil and natural gas production. Strong economies are indispensable in reaching the widely recognised goal of sustainable development. For India, a strong economy will depend on a strong and efficient coal industry.

This report, undertaken by a study group of my colleagues in the CIAB, outlines the current situation of coal in India. It also identifies some of the major issues that must now be addressed. Key areas of concern include low coal quality, transportation gaps, low mining productivity, and possible environmental requirements. None of these challenges is new, and these same issues have been resolved in other countries. Deregulation, privatisation, market-based pricing and competition are important, if not essential elements in the modernisation of India's coal industry.

The Indian government and coal companies have already begun a far-reaching process of change. This report provides suggestions and encouragement for accelerating the pace of change. It is our sincere hope that these ideas, based on long and varied experiences in the global coal industry, will prove helpful to India.

I would like to thank my colleagues from RWE Rheinbraun, especially Dr Hans-Wilhelm Schiffer, who did most of the research and writing of the report. I would also like to thank our colleagues in the IEA Secretariat, who encouraged us to undertake the study and bring it to publication.

Jim Gardiner
Chairman of the Coal
Industry Advisory Board

The International Energy Agency is grateful to the Coal Industry Advisory Board for preparing this study and to the Government of India for its co-operation and support.

Robert Priddle
Executive Director
International Energy Agency

The Government of India welcomes the interest of the IEA Coal Industry Advisory Board in the coal industry of India. Considerable progress has been made in improving the commercial performance of the industry, while ensuring that it continues to play a role in the broader social fabric of Indian society.

Investment in the coal industry is recognised as being of critical importance for its future. Effort has been directed to attracting capital and know-how into the industry from abroad. By lifting production from domestic coalfields, Indian enterprises can help match growing coal demand and offset rising imports. At the same time, imported coal will play an important role, particularly to supply coal qualities that cannot be supplied from our own mines and to meet gaps in supply and demand. Investment in ports and inland transport will therefore also be important. I hope that this report will encourage investors to look closely at the potential of the coal industry in India, and contribute to its continuing progress.

We are conscious of the related need to bring about change in the way our electricity industry functions, and to ensure environmentally responsible use of coal in power generation and other uses. The IEA's work in these areas is of considerable interest to us.

N.K. Sinha
Secretary
Ministry of Coal and Mines
Department of Coal
New Delhi

TABLE OF CONTENTS

FIGURES

TABLES

Note

The unit *tonnes of coal* measures physical quantities of coal produced, transported or traded. It does not reflect the wide variations in calorific values and qualities that also affect the value of coal. Indian coal is classified into seven quality grades, with ash contents varying from less than 13.5% to 50% and calorific values ranging from 6 200 to 1 300 kcal/kg.

Figure 1
India

1. SUMMARY AND RECOMMENDATIONS

Summary

This study reviews Indian coal supply and makes suggestions to help overcome some of the continuing difficulties facing the industry. The main points of the study are summarised below.

The government's policy goal is to ensure a secure energy supply based on the country's huge domestic reserves. Domestic coal production cannot meet the demand for electricity generation or industry. Imported coal will be needed to meet quality standards and any growth in demand.

The long-term goal of the Government of India is to ensure energy supplies for more than one billion people – 17% of the world's population. About 80% of energy supply is produced domestically. With about one-third of energy supply, coal is second as an energy source only to renewables (very largely traditional biomass from plant and animal sources, but also including over 1 000 MW of wind power and some solar energy plants). Over 90% of the coal supply is indigenous production. Coal consumption has been growing at about 4.8% per year, and this rate is expected to increase in the future. To achieve its goal of energy security, Indian government policy focuses on expanding coal production. But imports also play an increasingly important role, primarily for coking coal. The Indian iron and steel sector is the second largest coal market after power generation, but only 20% of domestic coal meets coking coal quality standards.

India has the world's third-largest hard coal reserves, after the United States and China. Indian coal is generally low in sulphur but high in ash and low in calorific value. Domestic coking coal requires intensive washing to make it suitable for coke-making. Even then, it is only marginally acceptable because of its inert material content. For this reason India imports much of its coking coal. Domestic

1. Beneficiation includes a number of processes to reduce the inert content of coal to meet quality requirements for particular uses. By reducing the volume of material to be handled, beneficiation also reduces transport costs. Beneficiation processes can include separation of the coal from rock particles, crushing and screening of the coal into uniform particle sizes, and washing to yield commercial-quality steam and coking coal.

steam coal is generally more suitable, but without beneficiation[1] its high ash content can reduce boiler efficiency and reliability and hamper efforts to reduce emissions. The high inert content of untreated coal also imposes an extra load on the transport system.

Indian hard coal production in 2000-2001 totalled 310 Mt and consumption 317 Mt. About 225 Mt per year is produced from opencast mines and the remainder from underground mines.

Coal production is insufficient to cope with growing demand for electricity and industrial energy. Investment in electricity and coal supply is impeded by subsidised electricity prices and the poor financial state of the utilities which cannot afford to pay adequate prices for coal. Investment in coal supply is impeded further by regulation of distribution and controls on foreign investment.

Transport costs and low productivity reduce the competitiveness of domestic coal.

Main consumers are located far from production sites in the east of India. Long transportation distances add to costs, especially where coal is not washed. Indian coal is often uncompetitive with imported steam coal.

State-owned companies mine most of the coal in India. Coal India Ltd – the world's second-largest coal supplier – produces about 86% of total production, and Singareni Collieries Company Ltd produces 8%. Productivity in Coal India mines ranges from 152 tonnes to 2 621 tonnes per miner per year, compared with about 12 000 tonnes in Australia and the United States. This low productivity is attributable to the low level of mechanisation in underground operations, obsolete techniques and inadequate investment in replacement equipment. Several of Coal India's subsidiary companies are chronically loss-making. Low productivity operations, mostly engaged in underground mining, make substantial losses whereas other companies, with mainly opencast operations, achieve positive returns.

India's state-owned railways transport 51% of mined coal. A further 23% is transported on industry-owned rail networks. Coal is the largest single freight item handled by the railways, and rail freight can account for half the price to inland consumers. Multiple gauges reduce the efficiency of the rail network. Expansion of the network and new rolling stock will be necessary to meet any growth in coal transport, but expansion is unlikely because low profitability limits the scope for investment from internal resources.

Coastal shipping supplies the southern sections of the country, moving coal railed from mines in the centre and the east. Deliveries are uncertain during the monsoon months and delays of weeks can occur. Private investment in ports is unrestricted; steel companies and others operate their own facilities. New private ports are planned.

Power generation is the main consumer. Electricity demand growth is outstripping supply capacity.

The largest consumers are the electric power sector (67%), the iron and steel sector (13%) and the cement industry (4%). Other industrial consumers include the textile, fertilizer and brick industries. In 2000, some 15 Mt of coking coal and 9 Mt of steam coal were imported, primarily from Australia and South Africa.

About 75% of India's electricity is generated from coal, and 70% of indigenous coal is used to generate electricity. Despite growth in power output of 5% to 9% annually, electricity supply is inadequate to meet industrial and urban demand growth. Supply failures are increasingly common in peak periods. Because of widespread use of high-ash run-of-mine coal, many of India's power plants have low-load factors and efficiency.

Coking coal demand for steel-making is growing slowly but is expected to accelerate. Coal use in cement-making is growing faster than domestic supply capacity.

India's steel industry occupies tenth place in world crude steel output. The sector has not expanded as quickly as the government had planned, and coking coal demand has risen only slightly. The government expects demand to rise more rapidly in the future. Coal use in cement-making is growing faster than the supply capacity of the domestic coal industry. Lower-quality domestic lignite is replacing hard coal in some cases. Since 1990, imports have met growth in demand from coastal producers. Demand for other coal uses is growing more slowly.

Overall, coal demand is forecast by government authorities to increase by about 7% per year to 2007, largely because of the planned addition of 116 GW of coal-fired power generation by that year. If growth on this scale is achieved – and that is questionable – a supply gap of some 133 Mt per year is forecast by 2007.

Liberalisation of the coal industry has started, but customs duties and tax continue on imports, and the government controls distribution to major consumers. Some private investment is allowed, but state-owned companies dominate the industry.

The growing imbalance between demand and supply has prompted liberalisation of the coal market. Prices of coking and higher-quality steam coal were deregulated in 1996. Complete deregulation of prices for all coal qualities took place in 2000. Prices now vary according to quality, but mining companies are still unable to set prices that fully reflect production costs. Import quotas were lifted in 1993 and import duties have been steadily reduced from an initial 85% to 35% in 1994 and to 10% in 1997. Import tax was also lowered, from an initial 35% to 3% in 1997. Distribution of coal to core markets such as power stations and steel producers remains controlled by the Ministry of Coal and Mines, while distribution to other sectors is left to the coal companies.

Private investment is now permitted in "captive" mines supplying particular consumers. Foreign investment is also permitted on a case-by-case basis, up to 50% of the equity in an Indian firm. In 1997, the subsidiaries of Coal India were restructured as financially independent competing units. Several international collaborative agreements encourage technology transfer.

Local environmental regulations on mining and rehabilitation are having an impact on coal production, but power generation emissions are not regulated.

Resettlement of communities, rehabilitation of mined sites, dust, noise, and underground fires are important environmental issues. There are no limits on sulphur dioxide or nitrogen oxide emissions, but the government has prepared a catalogue of measures to mitigate these emissions as well as greenhouse gases and particulates. Cost is a major barrier to the use of advanced clean coal-fired technologies. All companies which use at least 25% ash in their end-products are exempt from excise duty.

Further reforms are needed. A policy framework is necessary that takes into account the need for progress in reform of the electricity sector.

The Indian coal industry requires large-scale investment, particularly to expand mine capacity and to improve beneficiation of local coal. Investment in transport is also necessary. The scale of investment required calls for continuing liberalisation of the domestic coal market and the reduction of restrictions on foreign investment. Investment is impeded by inadequate geological data and by the lengthy and bureaucratic approval procedures governing land acquisition and new mine development. Rationalisation of existing mines is necessary. Employment policies and labour relations need to be addressed to raise productivity and mining profitability. Only then can adequate investment be generated for new facilities, especially in coal beneficiation plants to improve coal quality and reduce the burden of transporting waste material. Reform of the coal industry should be part of wider economic reform. Progress will be influenced strongly by reform in the electricity sector.

Imported coal will continue to be necessary. Competition with imports should be a stimulus to improving performance in the domestic industry.

Recommendations

Raising the commercial performance of the industry to international standards should be the principal objective. The way to achieve this objective should be the creation of a freely competitive coal industry supplying a financially viable electricity industry.

Specific policy measures that are recommended include:

- Accelerating price reforms in the electricity sector.
- Allowing buyers and sellers freedom to choose with whom they do business.
- Fully liberalising coal pricing.
- Encouraging the industry to rationalise quality standards to better match coal products to consumer needs, especially in the power and steel industries.
- Encouraging the industry to close unprofitable mines.
- Addressing labour productivity and labour relations.
- Accelerating the opening of the coal sector to private investment, including foreign investment in mining, beneficiation and marketing.
- Removing impediments to full competition with imported coal, including the removal of remaining customs duties and taxes.
- Establishing a timetable for the privatisation of the existing coal companies.
- Establishing a framework of environmental standards for coal mining and consumption.
- Funding research and development on clean coal technologies through public-private partnerships.

2. POLITICAL AND ECONOMIC OVERVIEW

Political Overview

State and Political Organisation

In 1947, India became independent from the United Kingdom. The constitution of the Indian Republic came into force on 26 January 1950. The twenty-eight states and seven union territories have autonomous powers.

The President of India is the constitutional head of the Union's executive. The Prime Minister and the Council of Ministers advise the President. In practice, the President acts in accordance with the Council's advice. The Council of Ministers is responsible to the House of the People (*Lok Sabha*), consisting of an upper and a lower house. Most of the members of the upper house are nominated by the state parliaments. The members of the lower house are elected by proportional representation. To become law, bills require the approval of both houses.

At the state level, the Governor is the head of the executive, advised by a Council of Ministers responsible to a Legislative Assembly. Real executive power lies with the Council of Ministers. Some powers are shared between central and state governments. Decisions affecting trade and industry, for example, are subject to the jurisdiction of both the states and the central government. Delays in implementing statutory economic reforms are possible when differences of opinion arise between the central government and the state parliaments.

Demographic Developments and Education

India has the second-largest population in the world after China. With one billion inhabitants (May 2000), India has 17% of total world population, but only 2.42% of total world area. The population density averages 330 inhabitants per square kilometre.

High population growth of 1.9% per year is a result of higher life expectancy coupled with fertility rates. Fertility rates remain high compared to the OECD average, even though a slow-down is clearly emerging in some states, such as Tamil Nadu and Kerala.

About 219 million Indians live in cities, and more than 10 million people live in each of the cities of Mumbai (Bombay), Kolkata (Calcutta) and New Delhi. Much of the growth of urbanisation is due to job-related migration. The urbanisation trend has slowed down recently from that of previous decades.

In spite of the tremendous expansion of its urban population, India remains a “country of villages”. Higher population growth in absolute terms has taken place in rural regions. The rural population tends to be concentrated in regions with favourable agro-ecological conditions. Large cultivated areas are found in the low plains of India’s north. A huge area, which relies upon artificial irrigation, extends from the “five-river state” of Punjab in the north-west to the Ganges-Brahmaputra lowlands. Large continuous cultivated areas can also be found along the east coast, on the southern west coast up to the highlands of Karnataka, and from Mumbai (Bombay) in the centre-west to Gujarat. Among India’s prosperous states are Maharashtra and Gujarat on the west coast, while the poorer states include Bihar, Madhya Pradesh, Uttar Pradesh and Rajasthan in central India.

A large middle class supplies most of the qualified workforce for the commercial economy. It has high living standards, not much below those of some OECD countries. However, a uniform education system is hampered by linguistic, religious and social differences. It is difficult to obtain standard levels of education in both urban and rural areas, because of strong population growth and a shortage of teachers. The government has launched a special programme to lower the country’s high illiteracy rate. It is increasing the number of colleges of applied sciences to supplement existing universities and other institutes of higher education.

Economic Overview

Two-thirds of the Indian labour force is employed in agriculture. Per capita gross domestic product (GDP) averages US$ 450 a year (1999), making India one of the world’s poorer countries. Rice and wheat form the basis of the food supply.

Industrialisation has spread rapidly since independence. To stimulate industrialisation, India has relied upon nationalisation of such important sectors as banks, insurance, steel and energy. The iron and steel sector was developed in co-operation with Germany, Great Britain and Russia. The chemical base, in particular the petrochemical industry, was developed, as were the mechanical, automotive and electrical engineering sectors. Despite the emphasis on heavy industry, even more of the country’s industrial output is accounted for by light industry. Cotton, wool and jute processing, and the production of silk and artificial fibres, play a significant role in India’s economy.

In the three decades following independence, India achieved a low rate of GDP growth for a developing country of 3.9% per year. Poor performance resulted from the declared goal of self-sufficiency coupled with a ban on supplementary imports, the nationalisation of heavy industry and the high degree of regulation in the private sector. Because of the emphasis on promoting heavy industry, processing and finishing industries contributed a low share of GDP compared with construction, mining and utilities.

Balance of Payments

In the early 1980s, imports of machinery and equipment, electrical engineering products and energy, particularly coking coal and crude oil, outpaced exports. The requirement to obtain special licences obstructed exports. The negative trade balance resulted in two devaluations by 1991.

In the early 1990s, the Indian government adopted far-reaching economic reforms. An increase in exports was achieved by relaxing foreign-trade restrictions. Between 1993 and 1996, exports grew by 18% to 21% per year. Principal exports are now agricultural produce, textiles, diamonds and production plants. India's steel industry is also competitive internationally and ranks seventh in size worldwide.

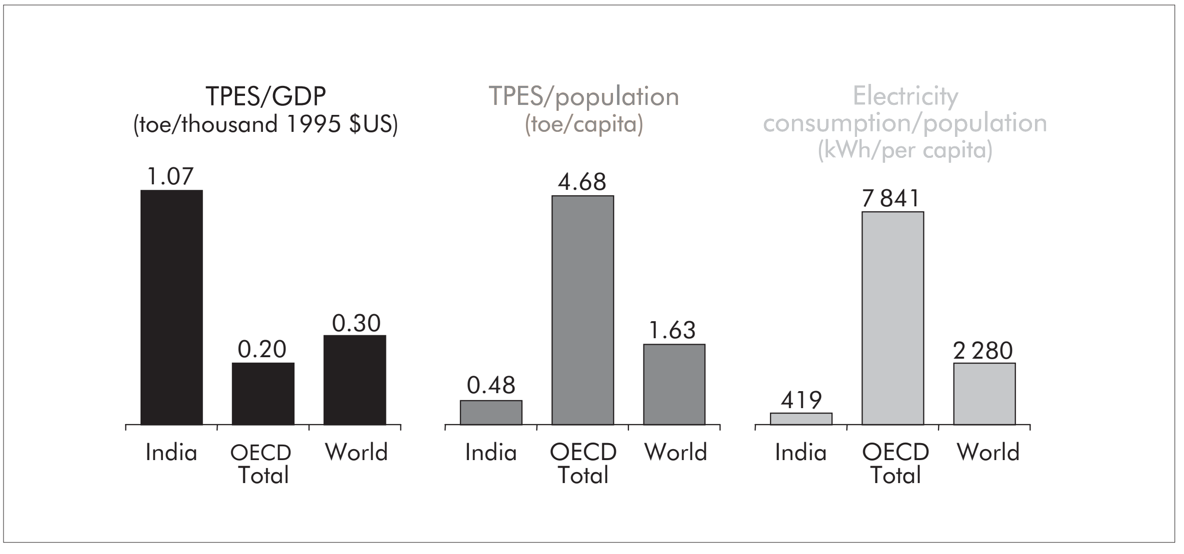
Import duties have been lowered significantly since 1991. Even so, the duties remain high, especially on technology products. Dependence on imported crude oil is a huge burden on the balance of payments. Because household incomes are low, the government has chosen to subsidise the price of several oil products, electricity and fertilizer.

The value of the currency is market-determined. It has moved from 40 to 49 rupees to the US dollar in the last five years.

Economic Reforms

India has a mixed economy, with growth driven equally by the public and private sectors. Deregulation measures since the early 1990s are intended to replace economic planning with a market-based system for the allocation of resources. In 1991 the International Monetary Fund provided financial support for structural adjustment.

Figure 2
Energy Indicators, 1999



Source: IEA, *Energy Balances of Non-IEA Countries*, IEA/OECD Paris, 2001.

State-owned enterprises have failed to achieve attractive investment returns for potential investors or to create sustainable infrastructure. Foreign investment has been limited by government policy. Deregulation is now encouraging increased investment in industry by domestic and foreign interests. Majority foreign share-holdings are now possible in some cases, and the government plans further relaxation of investment regulations. The states can authorise privatisation of power plants with capacity of up to 250 MW.

An autonomous Divestment Commission was established in 1996 to sell financial stakes in public corporations. The commission was later transformed into the Ministry of Divestment, with the goal of privatising 40 public-sector undertakings. Political opposition, especially from the labour unions, has impeded progress.

While progress has been made in deregulation, other policy reforms are also necessary. Labour laws are complicated and inflexible compared with the new company regulations. For example, bankrupt firms have to pay their former employees for several years, even after operations have ceased.

Prior to the economic reforms, the five-year plans by which the central government allocated budgets to the states were the country's central macro-economic policy instrument. Today, the plan sets non-binding economic targets and production options, defines priorities and decides grants of public funds. While a central aim of the plan is a radical reduction of poverty and unemployment, there is also special focus on development policy in the energy sector, since the frequent power supply shortages often paralyse other economic activities.

Tables B.1 and B.2 in Annex B show progress in selected economic and energy indicators in recent years. Despite uneven performance, macro-economic indicators confirm that the reforms have had a positive impact on the economy. The balance of payments deficit has been reduced, the rate of inflation has stabilised and industrial output has increased. In 1995-1996, real GDP growth reached 7.4%, but has gradually declined to 4.5% in 2001 as the pace of reform has slowed and infrastructure investment fallen behind demand. External factors have also played a role, such as the Asian economic crisis in 1997-1998 and the slow-down in international trade in 2001-2002.

3. THE ENERGY SECTOR

Primary Energy Resources

India is the world's sixth-largest energy market after the United States, China, Russia, Japan and Germany. Compared with the size of the economy and population, domestic energy production is small. India's share of global energy production is a mere 2.3% compared with the United States' 21% and Europe's 12%.

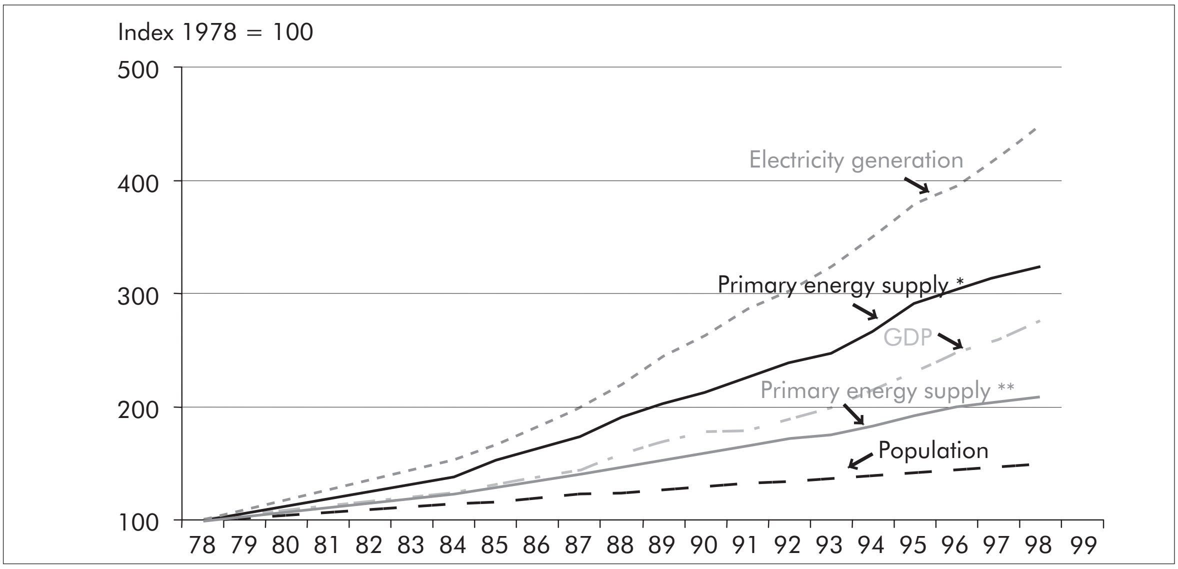
Under British colonial rule, energy infrastructure was poorly developed, and economic activity was largely dependent on non-commercial energy sources. Transportation and agriculture often used human and animal power.

Today, demand for commercial energy has soared with population and economic growth and with rapid urbanisation (see Figure 3). Power generation rose from 4.1 TWh in 1947 to 442 TWh in 1998. More than half a million townships, 90% of all Indian towns, are now connected to the power grid. But per capita electricity consumption is still one of the lowest worldwide – 416 kWh in 1998, compared with 15.6 kWh in 1950.

The long-term goal of the Indian government is to ensure energy supplies for more than one billion inhabitants, 36% of whom live in poverty. In 1999, India's total primary energy supply (TPES) was 480 Mtoe (million tonnes of oil equivalent), of which combustible renewables and waste (CRW) accounted for approximately 198 Mtoe or 41.2%.

Including combustible renewables and waste, coal is the most important energy source, with a share of 33%, followed by oil and petroleum products, with a share of 20%. As shown in Figure 5, over 90% of the coal supply is indigenous production, whereas more than half of the crude oil and petroleum products supply is imported. Indigenous energy sources account for 80% of India's energy supply, of which about half is combustible renewables and waste. If combustible renewables and waste are excluded, because of its non-commercial nature and questions related to reliability of data, coal is by far the most important energy source with a share of 56% of total primary "commercial" energy supply in 1999 (see Figure 4).

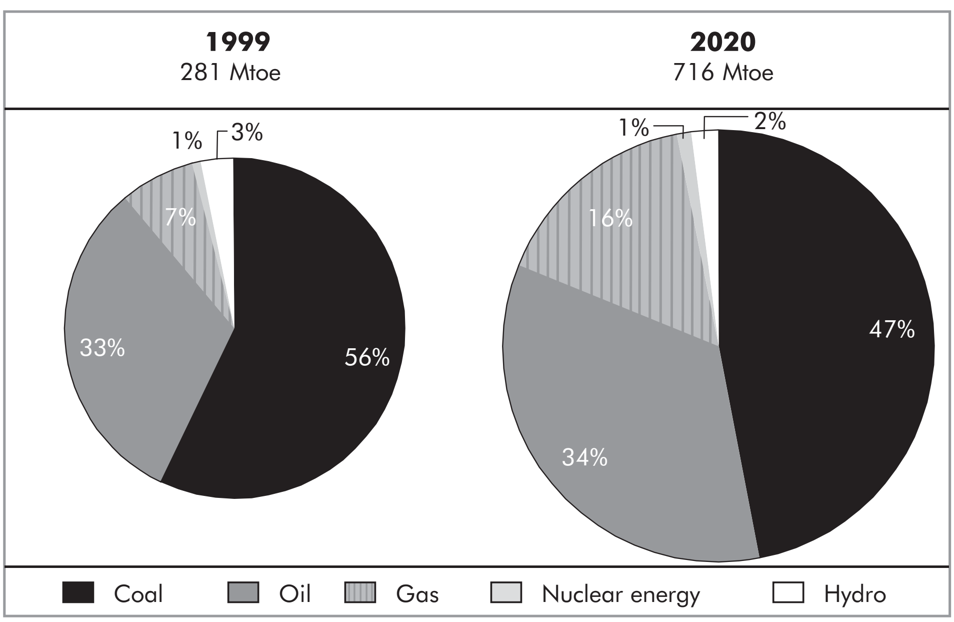
Figure 3
Growth in Energy Supply, Population and GDP



* Including combustible renewables and waste.
** Excluding combustible renewables and waste.

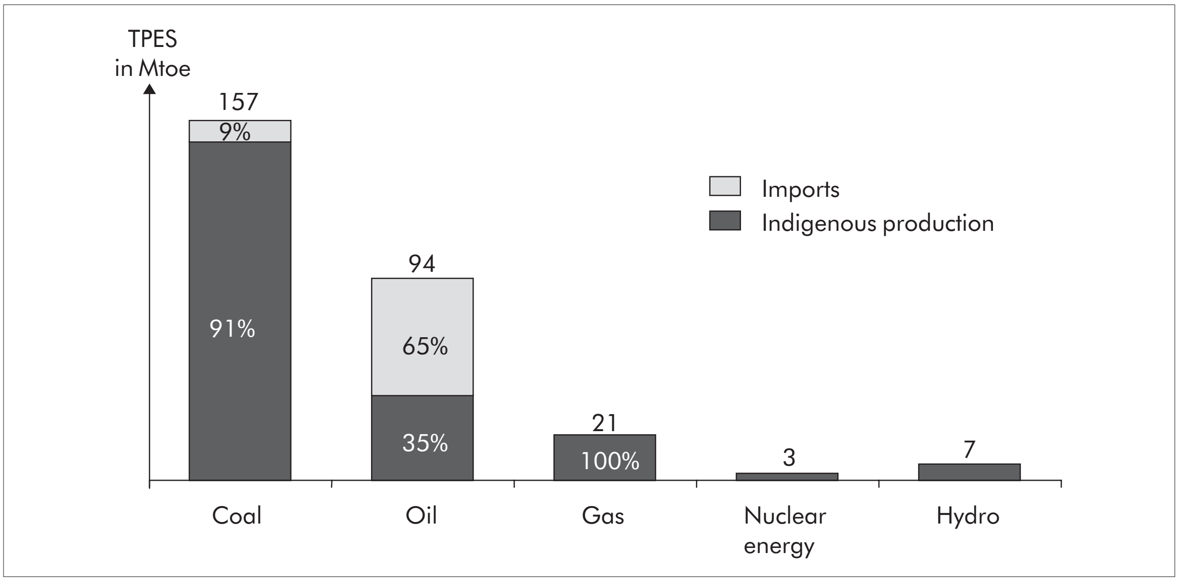
Source: IEA, *Energy Balances of Non-IEA Countries*, IEA/OECD Paris, 2001.

Figure 4
Supply of Coal, Oil, Gas, Nuclear Energy and Hydro



Source: International Energy Agency.

Figure 5
Energy Imports, 1999



Source: International Energy Agency.

Coal

India has the world's third-largest hard coal reserves, after the United States and China. The coal is mostly at relatively shallow depth and 75% of coal extraction is by opencast operations.

Since 1990, coal consumption has increased at a rate of 4.8% per year. In 1999-2000 it was more than 317 million tonnes.

Industrialisation has increased the demand for steam coal to generate electricity and to meet the energy needs of the cement, textile and brick industries. About 75% of electricity is generated from coal, compared with an average of 37% worldwide, and 70% of indigenous production is used for electricity generation. The Indian iron and steel sector is the second-largest coal market after power generation, although only one-fifth of domestic coal meets the quality standards for coking coal.

Indian coal is generally high in ash and low in calorific value, which makes it undesirable for many uses, but it is generally low in sulphur. Domestic coking coal requires intensive washing to make it suitable for coke-making, and then it remains only marginally acceptable because of its ash and inert material content. Excess ash and trace elements in coking coal and the coke-oven coke it produces, can reduce the efficiency of the blast-furnace and reduce the quality of the pig-iron it produces. For this reason, India has for many years imported higher-quality coking coal for its iron and steel sector. Domestic steam coal, while generally more suitable, also has a high ash content which can reduce boiler efficiency and severely hamper efforts to meet emissions standards.

Because the country's hard coal deposits are located principally in the east of India, many of the main consumers are far from the sites of coal production. Long transportation distances add considerably to the cost of domestic coal, especially where the coal is not washed and large quantities of inert material are transported. This can make Indian coal uncompetitive with imported steam coal, even at inland locations.

India's reserves of natural gas and oil are small.

Natural Gas

Gas reserves are estimated to be over 560 Mtoe, most of it located off the coast of Mumbai. The state-owned companies Oil and Natural Gas Corporation Limited (ONGC) and Oil India Limited (OIL) produced 20.7 Mtoe of gas in 1999. ONGC and OIL produce some gas along with crude oil, but inadequate pipeline and distribution systems result in about one-fifth of the gas output being flared.

About two-thirds of natural gas consumption is used in the fertilizer and other petrochemical industries. Most of the remaining third is used for electricity generation. Although natural gas consumption increased at a rate of nearly 11% per year in the early and mid-1990s, growth stalled between 1997 and 1999. Nevertheless, since 1991, gas consumption has increased at a higher rate than primary energy consumption.

The state-owned Gas Authority of India Ltd is responsible for distribution. Construction of gas-fired power plants is planned in coastal areas where they can be supplied by sea with liquefied natural gas.

Crude Oil and Petroleum Products

Current crude oil reserves total over 760 Mtoe. Production of crude and petroleum products reached 33.2 Mtoe in 1999. Another 46.4 Mtoe of crude and 15.7 Mtoe of petroleum products were imported. Around two-thirds of domestic crude is produced off the coast of Mumbai. Other oil fields are in the regions of Upper Assam, Cambay, Krisha-Godavari and Cauvery.

Consumption of crude oil and petroleum products has increased steadily since 1990, especially in the transportation sector, and reached 90.1 Mtoe in 1999. Diesel oil accounts for the largest share of fuel consumption, at 47%.

India is heavily dependent on oil imports, which place a growing burden on its trade balance. Recently the government has been compelled to adjust prices to international levels and to cut back price subsidies. Low drilling recovery rates are a major problem in India. They average around 30%, well below the world average.

Hydropower

In 1999, hydropower generated some 81.4 TWh of electricity or over 18% of the total. The northern and Himalayan regions offer the largest sites for hydropower development. There are other suitable sites in the north-eastern areas, although development there has been slow. In the south, large reservoirs with strong seasonal changes in rainfall are also used to generate electricity.

Nuclear Energy

Ten nuclear reactors, mainly pressurised water reactors, are operated with a capacity of 2 225 MW. Eight more are planned. The share of nuclear power in total generation has remained unchanged, at around 2.5%, for the last two decades. Reactor efficiency is not very high by European standards, because small reactors were chosen to suit the Indian grid. A capacity of 3 320 MW is planned by 2004, to be built with support from Russia.

Domestic uranium, mined in Bihar in the east, is about 2 090 tonnes a year (1998-99), and is able to support up to 8 000 MW of nuclear capacity. India has proven uranium reserves of 34 000 tonnes (U238), of which 15 000 tonnes are economically exploitable, enough to support the planned additional nuclear generating capacity. There are vast resources of thorium, estimated at 363 000 tonnes, on the coast and on a few neighbouring islands.

Renewable Energy

India has one of the world's largest programmes for renewable energy. It covers all major renewable energy sources: biogas, biomass, solar energy, wind energy, small hydropower and other emerging technologies. A Ministry of Non-Conventional Energy Sources was created in 1992 as a key agency for non-conventional/renewable energy.

Non-conventional renewable sources continue to be a large component of the energy mix for rural and poor households. These sources include firewood, agricultural residues and cow dung, and are mainly used for heating and cooking. In the primary energy supply, however, the share of biomass has fallen from 70% in the 1950s to 30% today, and is being increasingly replaced by commercial sources.

Wind energy and photovoltaics are gaining in importance. India ranks fourth in the utilisation of wind energy worldwide. The largest wind farm in Asia operates in Tamil Nadu. Installed wind capacity exceeds 1 000 MW, and solar energy a further 57 MW. The government promotes the expansion of both technologies. India is the world's third-largest producer of solar cells and photovoltaic modules.

The country also has potential in coal-bed methane, in oil shale and gas hydrates, which have not yet been developed.

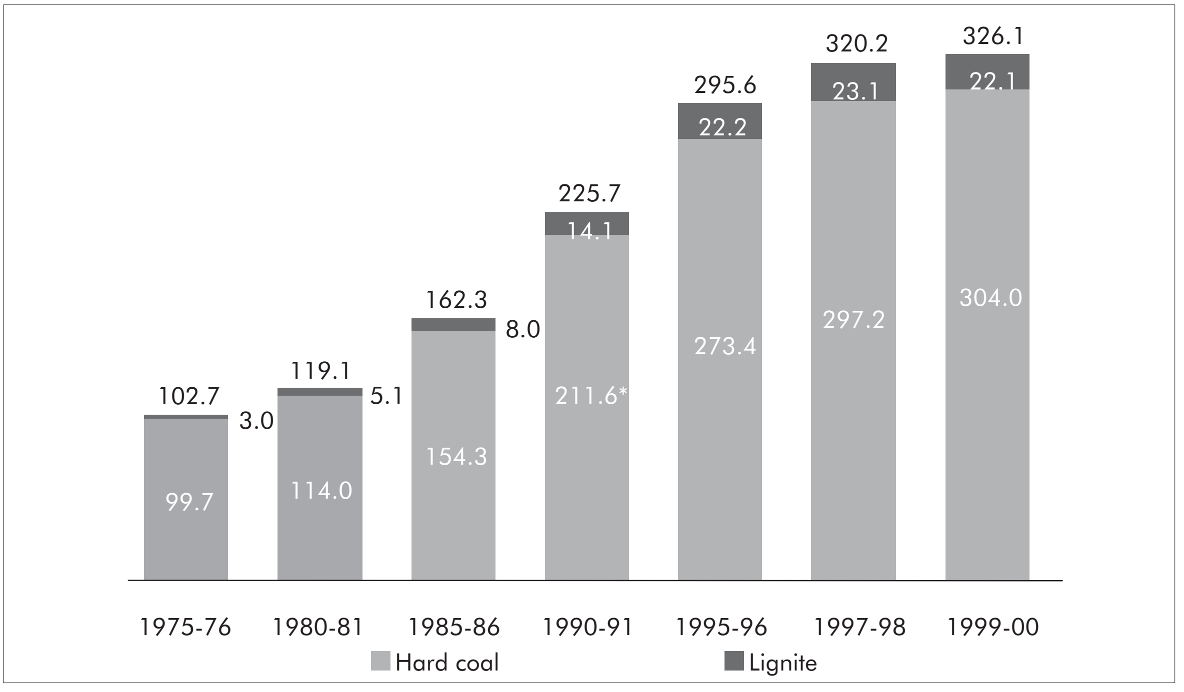
4. COAL SUPPLY

Resources, Reserves and Production

The Geological Survey of India estimates India's total hard coal resources as 214 Bt (billion tonnes). Table B.7 gives details. India's coal resources are at depths of 1 200 metres. Over 84 Bt are proven reserves, over 7% of world proven coal reserves. India's proven reserves represent nearly 275 years of supply at the current level of production. India also has lignite reserves of 28 Bt.

Figure 6

Production of Hard Coal and Lignite (Mt)



* Excluding Meghalaya figures for the unorganised sector.

Source: Coal Directory of India, Coal Controller's Organisation, Ministry of Coal and Mines, Kolkata (various editions).

There are 27 major deposits of hard coal located mainly in the east and centre of the country. Significant deposits, with their states and their share in nationwide proven coal reserves, are listed in Table B.8. Of the 84 Bt of proven reserves, some 85% are at depths of 100 metres or less, so that opencast mining is feasible.

India's proven reserves of lignite are located in Tamil Nadu and Pondicherry in the south, in Gujarat and Rajasthan in the west, and in Jammu and Kashmir in the north.

Figure 6 above shows the aggregate production figures for hard coal and lignite; details by state are given in Table B.12. Further details of production by mining company are given in Chapter 6.

Quality of Coal Reserves

Indian coal exhibits the typical qualities of Southern Hemisphere Gondwana coal. This coal is in interbanded seams with mineral sediments. Washing is difficult but necessary for efficient industrial use. Removing the deadrock in the beneficiation process significantly reduces the ash content of the raw coal.

Mostly lower-quality steam coal is produced. Of the total proven hard coal reserves, about 79% are steam coals. Only 20% of India's proven coal reserves are of coking coal quality, with just 6% in the prime coking category (see Table B.9). Most of the coking coal is mined in Bihar, from the Jharia deposits. The production of pig-iron requires low-ash coke to minimise the formation of energy-consuming slag in the blast furnace. Prime metallurgical coke can generally be produced only from low-ash coking coals.

Moisture content can affect calorific value and the concentration of other coal constituents. The moisture content of Indian steam coal ranges between 7% and 13% "as received", i.e. includes total moisture. The moisture content of Indian coking coal determined on an "air-dry" basis, i.e. includes inherent moisture only, ranges between 0.7% and 2%. In South-East Asia, the "air dry" moisture level is often used for steam coal as well.

Run-of-mine coal commonly used in Indian power plants (see Table B.10) generally has the following characteristics :

- Over 80% of coal has an ash content of 30% to 50%, with low iron content and negligible toxic trace elements.
- The moisture content is between 4% and 7%. During the monsoon months, the moisture content tends towards the higher value.
- Sulphur content is low, 0.2% to 0.7%.
- The gross calorific value is between 3 000 kcal/kg and 5 000 kcal/kg.
- The volatile matter content is between 18% and 25%.

Because Indian coal has good reactivity, combustion characteristics are favourable despite higher ash and moisture content. Other favourable characteristics include low concentration of sulphur (<0.6%), chlorine (<0.1%), and toxic trace elements, a high ash fusion temperature (>1 100 °C), and a favourable base/acid ratio (0.2-0.3). The low sulphur content is useful in blends.

Figure 7
Major Coalfields and Mining Centres

Despite these advantages, Indian hard coal is still of low quality. The high ash content of Indian steam coal leads to technical difficulties and higher costs at power plants. Problems include excessive ash disposal requirements, slagging of walls and fouling of the upper works and economisers in boilers. These problems cause thermal losses and can cause catastrophic failure of the entire system. High ash content also leads to higher particulate emissions and/or higher precipitator or baghouse operating costs. Other quality drawbacks in untreated coal are the presence of stone particles, shale and occasional metallic foreign objects from the mining process.

Coal producers do little to reduce these handicaps or to improve their product. Indeed, in the past, some domestic Indian coal suppliers have damaged the reputation of Indian hard coal by consistently under-performing in the area of quality management. Coal consumers have experienced several successive years of deteriorating coal quality. These failings have led to payment disputes and litigation. Because of the steady deterioration of coal quality – in particular low calorific value and increased ash content – the plant load factor of many coal-fired power plants in India is only 65%. In the past, several power plants could not be supplied with coal of the calorific value and ash range specified by the original design. Resulting load limitations interrupt electricity supply.

Coal Beneficiation

Inert material in coal can be separated by expensive beneficiation processes to reduce the ash content and to meet quality requirements. Reducing the inert and ash content reduces transport cost. Beneficiation involves several steps. Raw coal is pre-classified, separated from rock particles using various separation techniques and crushed to a uniform size. Coal prepared in this way, also referred to as raw feed coal, is "screened" into coarse, fine or very fine grains. Further processes involve crushing and washing to yield commercial-quality steam and coking coal.

Indian hard coal contains fine foreign mineral matter. As a result, conventional separation processes produce very fine grain sizes. The moisture content of the coal rises because large volumes of water are used, resulting in a loss of energy efficiency in use. Processing to avoid washing the fine material or subsequent "de-watering" can be the most costly stage in beneficiation.

Coal Trade

Hard coal exports are very small. Since 1990-1991, 100 000 tonnes has been exported annually to Bangladesh, Bhutan and Nepal.

Coking coal is increasingly imported to supply the iron and steel industry, and to improve average coal quality. Over 30% of total coking coal requirements are met by imports. Between 1990 and 2000, imports of coking coal rose from 5.1 Mt to 15.4 Mt. In 2000, major coking coal suppliers were Australia (10 Mt), China (360 000 tonnes), Canada (45 000 tonnes) and the US (22 000 tonnes). Indonesia also shipped 4 Mt of injection grade coal to Indian blast-furnaces, which was classified as coking coal. Imports from Indonesia doubled between 1999 and 2000. The main coking coal importers are the state-owned steel companies Steel Authority of India Ltd. (SAIL) and Vizag, as well as a private company, TISCO. Most coking coal is unloaded in ports located on the eastern coast of India, such as Vizag, Haldia and Paradip.

Figure 8
Coal Production and Consumption Centres by State and Sector, 1998

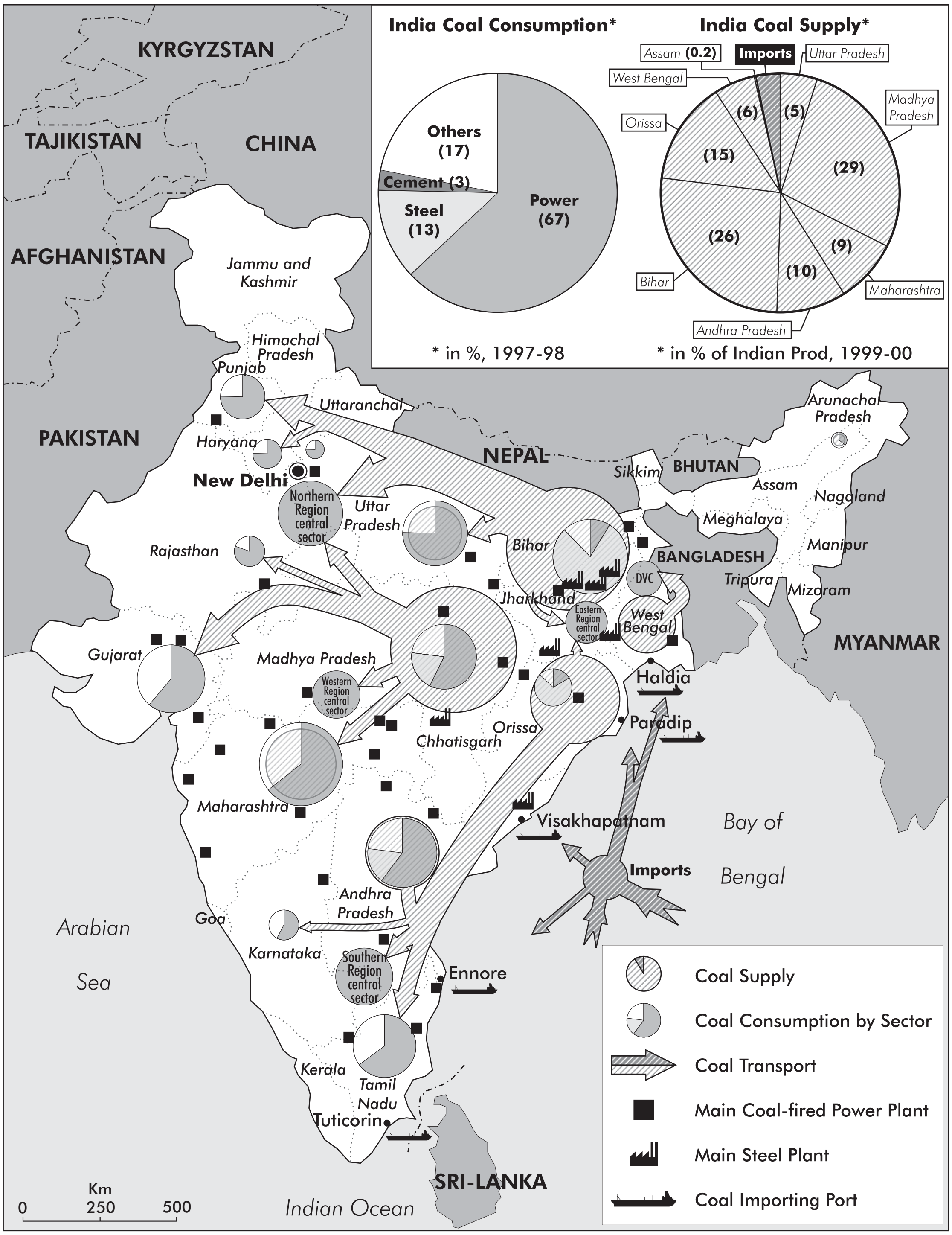
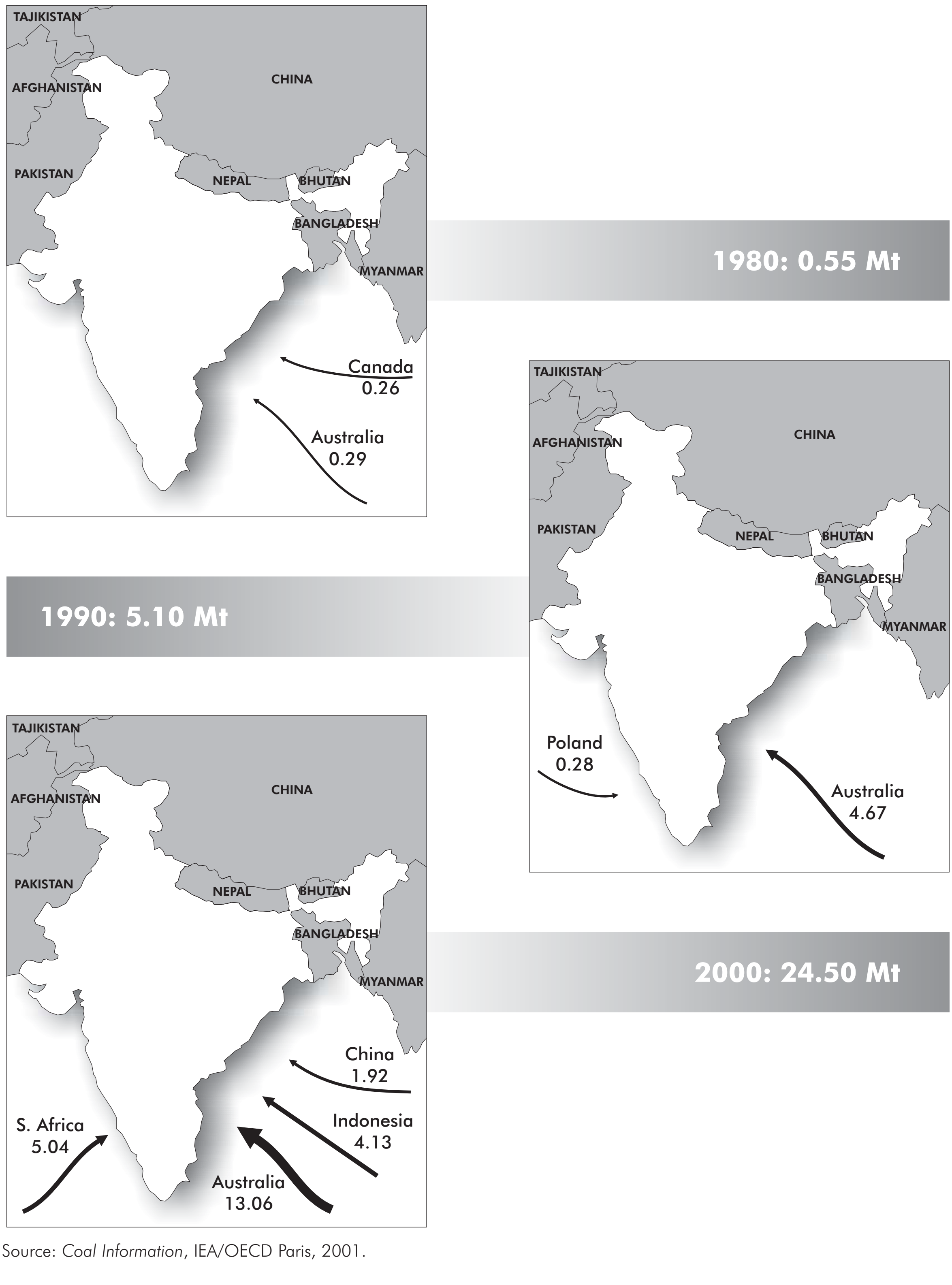


Figure 9
Coal Import Trends



Source: *Coal Information*, IEA/OECD Paris, 2001.

Some of the imported coking coal is mixed with domestic coking coal to reduce the average ash content. The pattern of imports is shown in Tables B.17 and B.18. Coking coal imports are likely to grow as demand for steel products increases.

Thermal coal imports, primarily for electric power generation and the cement industry, increased from 0.1 Mt in 1990 to 9 Mt in 2000. The main suppliers were South Africa (5 Mt), Australia (2.5 Mt) and China (1.6 Mt). Thermal coal imports are competitive with domestic coal in the coastal states of Tamil Nadu, Kerala, Maharashtra and Gujarat, which are all located some distance from domestic coal sources.

5. COAL DEMAND

Demand for coal totalled 317 Mt in 1999-2000. Consumption has been rising steadily in the last twenty years and is forecast by the Indian Planning Commission to increase to 513 Mt in 2002-2003, to 716 Mt in 2006-2007 and to 815 Mt in 2009-2010. Other sources estimate a slower rise with annual increases of 6% to 7% over the next ten years to about 690 Mt in 2009-2010.

The largest consumers are the electric power sector (67%), the iron and steel industry (13%), the coal producers themselves, and the cement industry (4%). Other industrial consumers include the textile, fertilizer and brick industries.

Electricity

Authorities Responsible for India's Electricity Sector

The Ministry of Power, created in July 1992, is responsible for the development of electricity. The Department of Atomic Energy is responsible for the energy use of nuclear technology and for operating nuclear power plants. The Ministry of Non-Conventional Energy Sources was created in 1992 to develop a programme for the use of renewable energies, including biomass, photovoltaics, wind and hydropower, with the aim of promoting development in rural areas.

The functions of the Ministry of Power are strategic planning, policy formulation, processing of projects for investment decisions, monitoring the implementation of power projects, and manpower development and training. The ministry also initiates and administers legislation on thermal and hydropower generation and electricity transmission and distribution. It provides research, development and technical assistance on matters relating to hydroelectric power other than the smallest hydro projects, and thermal power and transmission systems. Each of the state governments has its own power ministry, responsible for its involvement in the power sector.

Several authorities and agencies operate centrally under the Ministry of Power:

- The Central Electricity Authority (CEA) assists the Ministry of Power in all technical and economic matters. The CEA is a statutory body established in 1948. Its main function is to develop a sound, adequate and uniform national power policy, to formulate long-term and short-term plans for power development and to co-ordinate the development of national power resources. It plays a major role in the development of energy policy, in co-ordination between utilities and in setting power rates. Other tasks include the collection of data on electricity generation, distribution and consumption. It prepares cost-benefit studies, and studies on efficiency and transmission losses. The CEA also undertakes the design and engineering of power projects, and assists the development of technical expertise in the state electricity boards and generating companies.

- The Rural Electrification Corporation finances electrification programmes for rural areas.
- The National Office for Hydropower initiates new hydro projects.
- The Power Finance Corporation guarantees financing for new power plants or the electricity grid. Companies must prepare operating and financial action plans to receive guarantees for project financing.
- The Power Grid Corporation is responsible for extensions to the electricity network, and also, in part, for the administration of the existing high-voltage grid, transformer plants and substations.

The Power Grid Corporation is the main provider of extra high voltage and high voltage transmission networks. It is responsible for all existing and future transmission projects in the central sector and for the emerging national grid. Responsibility for administering the electricity network is shared between the corporation and the State Electricity Boards, which are responsible for most of the electricity generation and supply at state level. The state boards also manage electricity distribution to final consumers and collection of payments for electricity.

Power Generation

Between 1990 and 2000-2001, total electricity generated rose steadily from 290 TWh to over 500 TWh. In the same period, total power plant capacity was increased to around 102 GW. Thermal capacity accounts for 71% of the total, followed by hydropower with 25%, nuclear energy with 3% and wind energy with 1%. In the past forty years, the share of hydropower in power generation has fallen by half. Coal-fired power plants have around 60% of total capacity. The fuel shares used in power generation in 1999 are shown in Figure 10, together with the IEA's projected figures for 2020. As a fuel source, coal is even more dominant than is indicated by its share of plant capacity and is likely to remain so.

Electricity supply is inadequate to meet growing demand arising from urbanisation and industrialisation. Electricity output has risen by between 5% and 9% annually, but demand exceeds supply, and is projected to increase sharply (see Table B.6). Supply failures in peak periods are increasing. Moreover, some regions have an inadequate electricity infrastructure. At present, 90% of the inhabitants of urban areas are connected to the power grid, but only 30% of rural households.

The State Electricity Boards manage over 60% of national power plant capacity and are in charge of power distribution in twenty-five states. The State Electricity Boards also distribute electricity supplied by the central government from power plants owned by the National Thermal Power Corporation (NTPC) and the National HydroElectric Power Corporation (NHPC). NHPC operates its own plants, and promotes and integrates the development of hydroelectric, tidal and wind power throughout India. The state-owned companies NTPC and NHPC have 31% of national power plant capacity. Private operators account for 9%. NTPC produces one-fifth of India's total electricity from thermal plants. In

2000, it had a total installed capacity of 19 435 MW. The company is one of the world's largest suppliers, with 20% of the total capacity and 27% of thermal plant capacity.

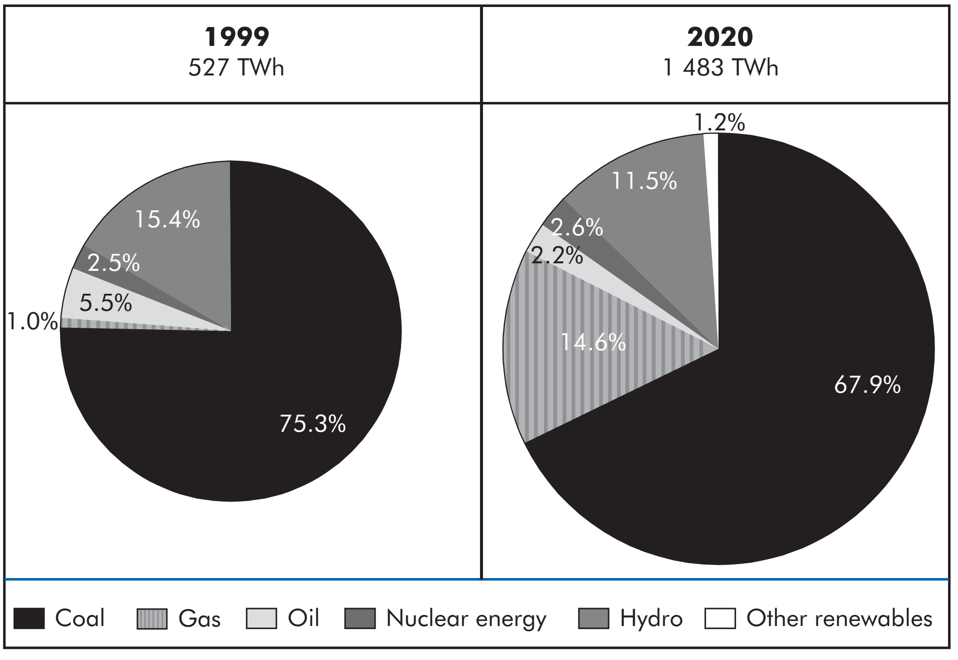
The five biggest private electricity companies are Tata Electric Company, Ahmedabad Electric Supply Company, Surat Electricity Supply Company, Bombay Suburban Electric Supply, and the Calcutta Electric Supply Corporation. All are both producers and distributors.

Growth in power plant capacity has not reached the targets set in the five-year plans. The original target for new capacity in the ninth five-year plan, ending 2001-2002, was some 40 000 MW, but the actual capacity built has been less than half that figure. Power failures, voltage fluctuations and network disruptions are regular occurrences in regions where capacity has not been extended.

NTPC and NHPC are expected to build 14 000 MW thermal capacity and up to 21 000 MW hydro capacity by the end of the eleventh five-year plan in 2012. But only 4 500 MW thermal capacity and around 2 000 MW hydro capacity are under construction.

NTPC excepted, the electricity sector has experienced low efficiency at thermal power plants and high transmission and distribution losses. These, together with an inadequate coverage of costs because of the power rate structure, have reduced returns to the producers. As a result, some consumers have built their own power plants to secure supplies. These plants accounted for 12 000 MW, and produced about 42 TWh of electrical energy in 1997.

Figure 10
Electricity Generation



Source: International Energy Agency.

The plant load factor is an indicator of operational efficiency in thermal systems. Because of the widespread use of run-of-mine coal, many of India's power plants achieve only a low plant load factor. India's average 66% is low compared with the international standard of between 85% and 90%. The main cause of the low plant load factor is the fluctuating quality of the steam coal and its high ash content, averaging about 40%. Very few power plants purchase their coal from a single mine, so that boilers must be able to cope with varying coal qualities.

Power plant trials have demonstrated that where ash content of coal can be reduced from 38% to 28%, it is possible to improve the efficiency of conversion to electricity by 2%. Fly ash and carbon dioxide emissions are also reduced. The average Indian plant load factor increased over the last decade from 53.9% to 66%. In contrast with poor performances elsewhere in India, NTPC has had remarkable success in increasing the load factor of its plants to international levels. The average for NTPC plants increased from around 70% in 1992-1993 to nearly 82% in 2000-2001. The improvement was due in part to newer plants, but particularly to good practices in coal washing, in plant management and in the control of firing conditions to suit coal quality.

Power plants have been kept in service beyond their expected life span to cope with rising electricity demand. Only in isolated cases have older plants been refurbished even though some are more than 30 to 40 years old and are judged inefficient. Because of their tight financial situation, the companies try to keep existing plants operating with the funds available. Some operators lack the expertise to maintain original plant efficiency by making replacements or modernising some process parts.

Private Investment in Power Generation

Private investors now have the right to build power plants and to acquire interests in domestic companies. But this reform, and the opening of the electricity market in 1991, have met with obstacles. Many planned facilities have not been built because of changes in permits. Up to 100% foreign equity is now permitted under the automatic approval scheme for projects relating to electricity generation, transmission and distribution. Projects qualifying for automatic approval of foreign investment are hydroelectric power plants and thermal power plants based on coal, lignite, oil or gas.

In 1998, the Central Electricity Regulatory Commission was established with jurisdiction over pricing for interstate transmission of electricity and regulation of the power rates of the National Power Corporation. It is also responsible for supporting investment by foreign companies, and the co-ordination of approvals for major projects, defined as thermal power plants of 1 000 MW capacity and hydropower plants of 500 MW capacity.

Individual states have introduced regulatory offices responsible for local power prices and for creating competitive conditions. The State Electricity Regulatory Commissions are responsible for streamlining the tariff structure and improving the financial health of the State Electricity Boards, using interest subsidies on loans and other incentives available from the Power Finance Corporation. The corporation was established in 1986 to mobilise non-budget capital for financing power generation projects.

Major projects are subject to the consent of the state governments. State approval for extensions to the energy infrastructure used to be viewed as a guarantee of assured financing. Now investors wishing to borrow funds from banks or sell equities are required to produce guarantees for financing and to provide details about the risks of the project.

A common problem is the distribution structure of the State Electricity Boards. Because of the financial difficulties of these boards, lenders for new investment projects demand state counter-guarantees and extra sureties from banks. Guidelines governing counter-guarantees were adopted in November 1994.

Since then, electricity producers proposing only to extend their power plant capacities have been exempt from simultaneously investing in the power grid.

The Power Trading Corporation of India was set up to supplement the distribution function of the State Electricity Boards and to protect the revenues of the independent private and public companies in the electricity sector. It offers services to major buyers, ranging from supplies to settlement, and assumes some of the distribution function for electricity generated by power plants belonging to the State Electricity Boards. The aim is to lower the financial risk for private investors which might otherwise arise from irregular income from power distribution and from the financial position of the State Electricity Boards.

Support from the World Bank has enabled the states of Orissa and Haryana to reform their electricity sectors. The states of Andhra Pradesh and Rajasthan also benefit from World Bank finance.

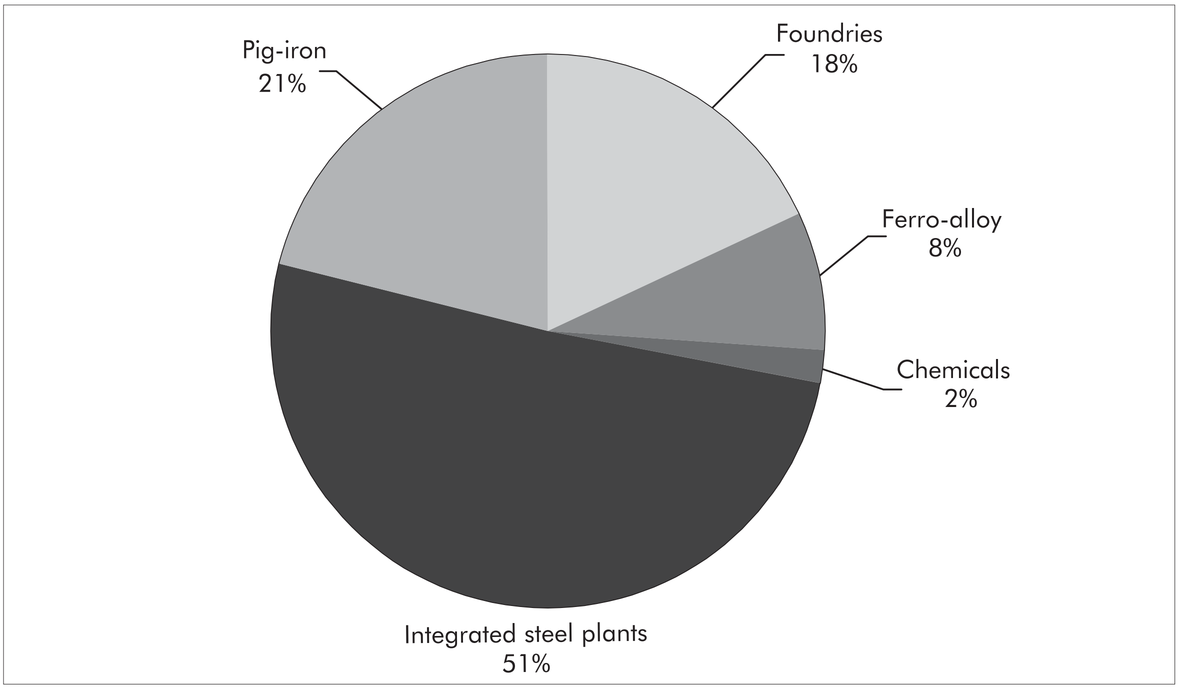
Coking Coal

Coke is consumed in three sectors in India (see Figure 11):

- Foundries, chemical units and ferro-alloy.
- Integrated steel plants.
- Secondary steel sector.

The total annual demand of these sectors is around 19.5 Mt. Coke demand is not shared evenly among these three main sectors nor among the different regions of India.

Figure 11
Demand for Coke – Principal Purchasing Sectors



Source: International Energy Agency.

Foundries, Chemical Units and Ferro-Alloy Operations

Foundries and chemical units are operated throughout the country by many small companies. The gross demand by foundries is estimated at 3.5 Mt per year. Consumption in individual foundries is not high enough to justify dedicated coking plants, so many foundries are dependent on merchant cokeries and imports. Some are located far from the coke source and pay a high price for their deliveries.

The total demand of the chemical/zinc sector is below 0.4 Mt per year. Very few chemical or zinc units are located on India's west coast, and their demand is fully met by local coke production. This sector is very sensitive to variations in price and quality and is very strict on quality control.

Ferro-alloy producers need a better quality coke, with very low phosphorus content, but their size requirements are less stringent than for the other consumers. Gross demand is estimated at 1.5 Mt per year.

Integrated Steel Plants

India has a few very large steel companies, among them TISCO, Bhilai Steel Plant and Vizag Steel Plant. These companies mine poor-quality coal to blend with imported high-quality coking coal. Coal blends are used by dedicated coke plants.

Gross coke consumption of the integrated steel plants is 10 Mt per year. The shares of the various companies are as follows (1998-99, Directorate-General of Commercial Intelligence and Statistics):

	Mt per year
• Bokaro	0.6
• Durgapur	1.2
• Bhilai	2.8
• Rourkela	1
• Iisco	0.6
• TISCO	1.9
• Vizag Steel	2 (estimated)

Secondary Steel Sector – Pig-Iron Plants

Most of the pig-iron plants were set up in the late 1990s, so their equipment is relatively new. They were generally planned to use indigenous coke produced by dedicated coke plants, but currently use imported coke.

Pig-iron plants are located in different parts of the country, but principally in southern India. Annual coke demand is 2.5 Mt in ten different plants.

The Coke Industry

Three different categories of coke plants exist in India:
- Small merchant coking plants in the Dhanbad area.
- Dedicated coking plants in Integrated Steel Plants.
- New merchant coke plants.

The city of Dhanbad is located in the state of Bihar, eastern India, in the middle of the Indian coking coal belt. A large number of small cokeries around this city produce high-ash coke (24% to 35%) using indigenous coal. The capacity of these units is low, between 6 000 and 48 000 tonnes per year, but together they produced about 3 Mt in 1999. Coke produced by the Dhanbad coke plants is mostly supplied to local foundries and pig-iron plants.

Dedicated coke plants in integrated steel plants produce 10 Mt per year, sufficient to cover this sector's demand. By blending indigenous and imported coal, these coke plants produce medium-ash coke, with an ash content of 17% to 22%.

Only two pig-iron units own dedicated plants. Sesa Kembla produces 280 000 tonnes per year and Usha Udyog 150 000 tonnes per year. Both are located in the state of Goa on India's west coast. Other pig-iron units have not built dedicated coke plants as originally proposed, because of the availability of cheaper foreign cokes or alternative domestic supplies.

Coastal merchant coke plants were built mainly during the 1990s. They are located on the west and east coasts in the states of Gujarat and Orissa, where they have the opportunity to use imported coking coal in order to produce a high-quality low-ash coke with an ash content of 11% to 12%. This product is sold to foundries, chemical and pig-iron units. These new companies, such as Gujarat NRE Coke, Wellman Incandescent or BLA Industries, are now facing competition from coke imports, particuarly from China.

Coke Imports

Coke has been imported for the past ten years because of a shortage of domestic production and high inland transportation costs. About two million tonnes per year are imported, almost 10% of global coke demand. Most is imported from China, Japan, Australia and Russia. Since mid-1998, an anti-dumping duty (currently US$ 25 per tonne) has been imposed on Chinese coke. Coke is imported mainly through ports on the south and east coasts. Visakhapatnam, Chennai, Paradip, and Kolkata and Haldia, are the major coke unloading ports.

India will continue importing coke because of the shortage of domestic products and regional imbalances in supply. Some states, such as Gujarat, have surplus coke supply capacity, while southern states face enormous deficits.

Steel Industry

India's steel industry occupies tenth place in worldwide crude steel production, with an output of 24 Mt in 1998. Demand for coking coal in the steel industry has risen only slightly, since this sector has not expanded as quickly as had been expected at the beginning of the 1990s. With India's continued economic growth, steel production is likely to expand. An Indian government forecast suggests steel production will reach 50 Mt by the year 2012.

Demand for steel is rising in the domestic market and in South-East Asia. In 1998, India's steel exports totalled 2.5 Mt and rose to more than 3 Mt by end 2000. Exports of iron ore to China have also risen. Indian steel producers have negotiated a technology transfer with China.

In 1996-1997, the production of iron and steel consumed 33.1 Mt of coking coal and 5 Mt of steam coal, with some of the demand for coking coal being met by imports. The expected rise in the output of iron and steel products should triple the demand for domestic steam coal by 2006-2007, while coking coal demand is expected to rise by 30% in this period.

Extensions to capacity in India's iron and steel sector will continue to be based on coke metallurgy. This process has two stages:

- Production of hot metal in the blast furnace.
- Conversion into steel by oxygen top-blowing.

Besides the end products, pig-iron and open-hearth pig-iron, iron production also yields slag that can be used in the cement industry. Thanks to new techniques in the blast-furnace process, coke consumption can be reduced and productivity increased. Use of the direct reduction process to produce steel is also gaining in importance. Five million tonnes is produced annually using this process, and production is expected to rise to 12 Mt per year by 2010. About 30% of India's steel is produced by the electric smelting process (the electric arc furnace), mainly using recycled scrap steel.

Indian steel producers specialise in high-quality steel that is competitively priced because of low raw material and wage costs. These advantages have been eroded by advances in production processes in other countries and by the use of low-quality domestic coal.

The introduction of pulverised coal injection (PCI) in blast-furnaces has made increasing headway in new plants, because it replaces more expensive coking coal. The Indian steel company TISCO operates two PCI-based blast-furnaces installed by the German firm Klöckner, and there are plans for more production facilities to be equipped with this technology. The capital cost of the PCI process is taking longer to amortise than expected. But the cost is expected to fall as greater use is made of coal with high ash content.

Cement Industry

Controls on cement prices and distribution were abolished in the early 1980s. At that time, cement production capacity was 27 Mt per year and demand only 18.7 Mt per year. The deregulation of the cement industry brought bigger and more efficient plants. Energy-efficient drying processes are now used in 88% of all plants. Most production facilities are located near the limestone deposits in the southern and western states. There are 122 large cement plants, with an installed capacity of 113 Mt per year, and more than 300 mini-plants with an estimated overall capacity of 9 Mt per year. Total production in 1999-2000 was 100.7 Mt, up 15% from a year earlier.

The rise in demand for cement has triggered a rise in demand for coal. Annual coal use in cement production rose from 5.2 Mt in 1980 to 12.1 Mt in 1990 and is currently nearing 16 Mt. Coal is the chief energy source for the cement industry. The coal quantities used vary enormously from plant to plant. Average consumption is about 220 kg of coal for one tonne of cement produced. Older wet-process plants require approximately 330 kg of coal per tonne of cement.

Because of inadequate electricity supplies, some cement producers have built their own power plants. The output of these plants amounts to some 800 MW, most of which is generated by coal. About 1.2 Mt of coal is burnt in these plants each year. Some plants use diesel as fuel and, increasingly, gas.

The tenth five-year plan projects annual growth in cement production of between 6% and 8%, which suggests that coal consumption in the sector will rise to 26 Mt per year by 2007. Of this total, the power plants operated by the cement industry will use 4 Mt per year by 2007. Indian coal producers have been unable to meet the growing demand of cement-makers. The industry frequently has had to use poor-quality coals. Hard coal is being replaced by lignite, but this comes at the expense of efficiency and economic operation. The supply gap in domestic coal, specifically for the cement industry, has widened. Imported coal has replaced domestic coal. The ash content of the domestic coal used by the cement industry is typically 35%. The norm only a few years ago was between 24% and 27%. High ash content reduces the efficiency of the kilns, so that the cement industry has been calling for increased use of coal beneficiation plants.

Owing to their proximity to lignite mines, the cement producers in the south and west are replacing the hard coal used in their operations. Some producers fear that the substitution of hard coal with lignite will eventually reduce the supplies of hard coal available for the cement industry even further. Since the liberalisation of the coal market, some cement companies have considered acquiring stakes in coal companies to secure their coal requirements.

Coal began to be imported for the cement industry only after 1990, and imports now amount to 1.5 Mt annually. Imported coal is economic where the cement production facilities are located on or near the coast and high transport costs can be avoided. Until the special duty on imported coal was repealed in 1996, imported coal was too expensive for many industries. Following the complete deregulation of domestic and imported coal prices, competition has reduced the price of higher-quality domestic coal. The increased use of imported coal, mainly in cement plants close to the coast, has helped reduce the pressure on the railways for coal transport.

Other Uses

Fertilizer production consumed 4.5 Mt of coal in 1995. Paper-makers, some with their own power plants for generating electricity and process steam, consume four to five million tonnes of coal annually. The textile industry consumes approximately five million tonnes of coal to generate power and steam. These industries account for 12% of coal consumption. Coal consumption in these industries has not increased strongly in the past two decades.

6. REGULATION, STRUCTURE AND REFORM

Regulation

Ministries and Agencies Responsible for Coal

The Ministry of Coal and Mines has overall responsibility for policy on developing and exploiting coal and lignite reserves. Its approval is required for projects of high value. The ministry's functions are set out in the Allocation of Business Rules, 1961. The ministry is responsible for:

- Exploration and development of coking and non-coking coal and lignite deposits in India.
- All matters relating to production, supply, distribution and pricing of coal.
- Development and operation of coal washeries other than those for which the Ministry of Steel is responsible.
- Administration of the Coalmines (Nationalisation) Act, 1973.

These key functions are exercised through public-sector enterprises such as Coal India Ltd and its subsidiaries and the Neyveli Lignite Corporation Ltd. The ministry acts in close association with the Singareni Collieries Company Ltd, a joint venture of the state of Andhra Pradesh (51%) and the Indian government (49%).

Coal Industry Structure

Commercial coal mining began in West Bengal in 1774. By the beginning of the twentieth century, coal output had reached six million tonnes annually. In 1947, coal production was nearly 30 Mt per year. The main consumers were the railways, which used mostly high-grade coal in steam locomotives. Most coalmines were privately-owned. The expansion of industrial power generation and of the steel industry was accompanied by reform of the coal sector, with priority given to coking coal.

During the 1960s, the coal mining industry stagnated because of low crude oil prices. In the early 1970s, the coal mining sector was nationalised in two phases. The coking coalmines in the Jharia region came under government control in May 1972, and the remaining mines one year later. The objectives of state management were to achieve more efficient coal utilisation and to ensure availability of coking coal for the steel industry. The state set out to meet the forecast increase in coal demand expected from industrialisation.

Following ratification of the 1973 Coalmines Nationalisation Act, only state-owned companies and iron and steel producers were granted coal-mining permits. Coal India Ltd was set up as a holding company in 1975 to expand coal production through government-financed investment projects. The second-largest coal company, Singareni Collieries Company Ltd, has been managed by the state since 1945.

The bulk of coal production in India is from government-owned mines managed by Coal India Ltd and Singareni Collieries Company Ltd. Collieries India Ltd produces about 86% of Indian coal and Singareni Collieries Company Ltd about 8% (see Table B.13).

The coking coalmines are owned by two iron and steel producers, Tata Iron and Steel Co. and Indian Iron and Steel Ltd.

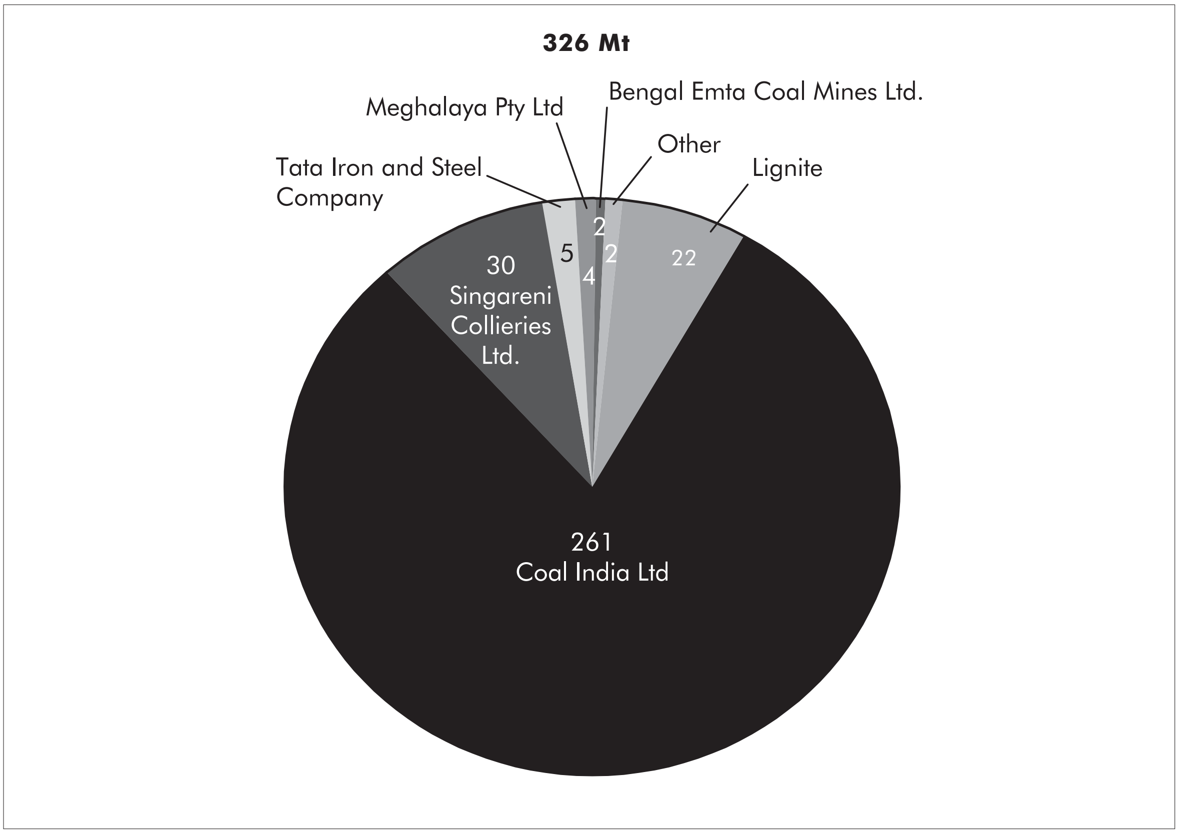
Coal India Ltd

In 1975, Coal India Ltd acquired the title to, and the right to manage, all mines owned by the national government. With an annual output of 268 Mt (2000-2001), Coal India is the world's second-largest coal supplier after the Russian mining company Rosugol. In April 2000, Coal India had a total workforce of some 562 000 employees, making it the world's second-largest employer after General Motors. Coal India Ltd is a holding company with seven coal-producing subsidiaries in several states:

- Bharat Coking Coal Ltd. (Bihar)
- Central Coalfields Ltd. (Bihar)
- Eastern Coalfields Ltd. (West Bengal)
- Mahanadi Coalfields Ltd. (Orissa)
- Northern Coalfields Ltd. (Madhya Pradesh)
- South-Eastern Coalfields Ltd. (Madhya Pradesh)
- Western Coalfields Ltd. (Maharashtra)

The North-Eastern Coalfields Limited, responsible for the development and production of coal in the north-eastern states, is directly controlled by Coal India Ltd. An additional subsidiary, the Central Mine Planning and Design Institute Limited, prepares plans, offers consultancy and undertakes exploration and drilling, but does not produce coal.

Figure 12
Coal Production of Various Companies, 1999-2000



Source: Coal Directory of India, Coal Controller's Organisation, Ministry of Coal and Mines, Kolkata (various editions).

Through these subsidiaries, Coal India Ltd controls 486 opencast and underground mines in nine states in the central and eastern regions, as well as some 19 coal-washing plants. The mines in Assam and Meghalaya, North-Eastern Coalfields, are also accountable to Coal India Ltd.

The Central Mine Planning and Design Institute Limited, the eighth subsidiary of Coal India, was established in 1970 in collaboration with similar institutions in Poland and Russia. It prepares mine-planning documents, geological studies and designs of opencast and underground mines. It also undertakes eco-audits, development of coal-processing plants, organisation of workgroup circles and the design of housing estates for miners and other social infrastructure.

Coal India Subsidiaries

Bharat Coking Coal Ltd

Bharat Coking Coal Ltd was managed by the steel producer SAIL until 1975. It is the largest coking coal supplier to the iron and steel industry, producing about 26 Mt per year of hard coal. Most of the coking coal is extracted in underground mines with little mechanisation. Some of these underground mines in the Jharia region are uneconomic and are threatened by the intrusion of water and by fires in the upper levels. Nevertheless, these pits produce the highest-grade coking coal in India. The company also operates 13 opencast pits, producing mainly low-quality steam coal.

The high ash content of the run-of-mine coal requires extensive processing to produce coking coal qualities. With a view to boosting competitiveness and ensuring supplies, much of the capital expenditure has gone into capacity extensions at coal-washing plants. Most coal-washing plants are more than 30 years old. With maintenance difficult because of their age and outdated design, the washing plants are in poor condition.

South-Eastern Coalfields Ltd

South-Eastern Coalfields Ltd produces some 59 Mt per year (1999-2000) of run-of-mine coal from 78 underground mines, 18 opencast mines and two combined underground/opencast mines. It is the largest Coal India subsidiary. It operates the largest opencast and underground mines and produces a total of one-fifth of Coal India Ltd's output. Favourable geological conditions in the region allow a high extraction ratio. The underground mine at Rajendra and the opencast pit at Gevra, with annual outputs of 0.5 Mt and 18 Mt (1998-1999) respectively, are India's most productive mines.

In its efforts to increase output from underground mines, the company has successfully introduced thick seam extraction with cable bolting, depillaring of contiguous seams with floor pinning, and powered support longwall technology. The company has collaborated with China at Balrampur and Rajendra underground mines. Plans are under way for extensions to existing mines, such as the Kusmunda and Dipka opencast mines, and for the development of new pits, with the aim of achieving a total output of 63 Mt per year by the year 2001-2002.

Other Subsidiaries

Central Coalfields Ltd, Mahanadi Coalfields Ltd and Northern Coalfields Ltd operate mostly opencast mines, producing low-quality coking coal and steam coal, totalling 118 Mt in 2000-2001, for power plants and the cement industry.

Central Coalfields Ltd is one of the leading suppliers of coal to the power and steel sector in India. Northern Coalfields Ltd is a major supplier to pit-head power plants, with an electrical capacity of 8 600 MW at the end of 2000. Coal is mostly despatched to these power plants by dedicated railways known as merry-go-round rail systems. Eastern Coalfields Ltd extracts coal from India's deepest and oldest underground mines. The coal is low-ash and of high calorific value. Including its opencast operations, total output was some 28 Mt in 2000-2001. Western Coalfields Ltd mines coal in underground and opencast operations under difficult geological conditions, owing to the groundwater-bearing layers located above the seams. It had an annual output of 35 Mt in 2000-2001.

Summary Performance of Coal India Subsidiaries

Annex A gives a detailed review of Indian coal companies' performance. Key statistics are set out in Table 1.

Table 1

Coal India Ltd – Summary Performance

Subsidiary	States in which company operates	Mines	Employees 1999	Production 2000-2001 (Mt)	Productivity tonnes/miner per year	Profit/(Loss) (million rupees)	Average production cost 1998-9 US$/t	Average sales price 1998-9 US$/t	Profit/(Loss) per employee 1999
Bharat	Bihar, West Bengal	109	86 300	26	315	(4 423)	20.6	16.1 (s) 18.1 (c)	(51 300)
Central	Bihar	71	60 800	31.8		527	(1 494)	10.7 (s) 15.6 (c)	(24 500)
Eastern	West Bengal, Bihar	119	119 400	28	224	(4 725)	25.4	15.3 (s) 18.9 (c)	(39 600)
Mahanadi 349 600	Orissa	9 ug 13 oc	17 200	44.8*		2 536	6 013	5.3	8.6 (s)
North-Eastern		6	4 200	0.7	152	na			na
Northern	Madhya Pradesh, Utta Pradesh	9	13 900	41.4*	2 621	8 021	9.6	15.3	576 500
South-Eastern	Madhya Pradesh	67 ug 11 oc	73 500	60.3	782	6 766	14.8	12.1 (s) 17.7 (c)	92 100
Western	Western	63 ug 34 oc	53 600	35.2	539	4 766	18.2	20.5	88 900
Coal India		**518**	**562 000**	**268.2**	**603**	**14 924**	**9.6**	**15.3**	**26 600**

ug = underground; oc = opencast; (s) = steam coal; (c) = coking coal.
* Production numbers for Mahanadi and Northern Coalfields are for 1999-2000.

Table 2
Coal India Ltd – Summary of Influences on Performance

Subsidiary	Comment
Bharat Coking Coal Ltd	High-grade coking coal in difficult mines, low-grade steam coal in opencast mines, 64% opencast.
Central Coalfields Ltd	Low-quality coking coal, steam coal – low prices, 90% opencast.
Eastern Coalfields Ltd	Deep and old mines using old technology. Low ash content and high calorific value coal; relatively high price, but much higher costs; 53% opencast.
Mahanadi Coalfields Ltd	Almost all mines opencast. Over 80% goes to power stations. Price is not high, costs are kept low by rising productivity, 96% opencast.
North-Eastern Coalfields	72% opencast.
Northern Coalfields Ltd	All opencast and lower cost; no coal washing; almost all coal goes to power stations.
South-Eastern Coalfields Ltd	Rising productivity has generally kept costs down, 72% opencast.
Western Coalfields Ltd	Small amount of coking coal, but mainly steam coal, 70% opencast.

While the precise effect on profitability is not clear, it is evident that productivity is heavily influenced by whether the subsidiary is able to employ opencast techniques. Productivity improves where the seams are shallow and have an economic ratio of coal to overburden. Productivity and sales price in relation to cost largely determine profitability. So, while Bharat Coking Coal's prices are high, the company nevertheless cannot offset its low productivity and high production costs, whereas Mahanadi Coalfields can make a profit despite the low price at which its coal is sold because of the high productivity and low costs of its opencast mines.

Singareni Collieries Company Ltd

Singareni Collieries Company Ltd is India's oldest state-owned mining company. The state of Hyderabad was the majority shareholder in the company, but in 1956 the regional reform assigned control to the government of the state of Andhra Pradesh. Since 1960, the company has been jointly managed by Andhra Pradesh and the central government. The company operates 60 underground and eight opencast mines. Output was about 30 Mt in 2000-2001, roughly 10% of total Indian coal supply. Coal mining in opencast operations began in 1980, and achieved a 57% share of the company's total output by 1999-2000. Unlike Coal India Ltd as a whole, over 40% of Singareni's coal is mined in underground operations, so that the company has much higher production costs. Financial difficulties could be reduced in the long term by making more use of lower-cost mechanised underground operations. The longwall mining method was first used in one of the company's mines in 1983 and this has subsequently helped cut costs. With the support of French and Australian specialists, Singareni is also using the mechanised room-and-pillar method.

The company's main buyers, taking three-quarters of total output, are power plant operators, The cement industry takes some 10%.

Neyveli Lignite Corporation Ltd

Neyveli Lignite Corporation is a state-owned operation, but 6% of the equity has been divested to private owners. The company has mined lignite at two pits in the north-east of the state of Tamil Nadu since 1957 and mainly supplies thermal power plants. Its mines produce about 18 Mt of lignite annually using bucket-wheel excavators, conveyors and spreaders. A new three million tonnes per year mine is being developed and other mines are being explored. A doubling of lignite production seems possible. The moisture content of the lignite is high because of the nearness of the coast and the monsoon rains, making mining difficult. Most of the lignite goes to pit-head power plants, producing 2 070 MW of electricity. Construction of two 210 MW units are planned on the existing power plant sites.

The Ministry of Coal and Mines is reported to be seeking to divest 26% of the company to a local power project in Tamil Nadu, partly owned by the CMS Company, United States.

Tata Iron Steel Company Ltd

Tata Iron Steel Company operates its own coking coalmines for use in its production processes. It has six underground mines in the Jharia coal basin and in the state of Bihar, as well as opencast pits in West Bokaro and Bihar.

On an area measuring 25 square kilometres in the Jharia coal basin, the mining companies Jamadoba and Sijua share three pits each. Over 60% of the seams have a thickness of 8.4 metres at a depth of between 100 metres and 600 metres. These opencast mines are highly mechanised, and they produced some 5.3 Mt in 2000-2001.

Development Plans for the Coal Industry

Ever since state economic planning began in India, the coal industry was the subject of strategies and targets in spite of its being in the private sector. It was only with the end of the fourth five-year economic plan (in 1973-74) that the nationalisation of Indian coal mining came into effect.

The first five-year plan called for an assessment of coal reserves and a breakdown by coal quality. Research was funded to develop a processing technique suitable for handling domestic coal qualities, and environmental data began to be collected.

The second five-year plan resolved to discontinue coal mining in some areas, in order to reduce transportation problems. The National Coal Development Corporation, a central government enterprise formed by State Railway Collieries, was directed to develop new coalfields in other states, resulting in the exploration and development of new coalfields, such as Singrauli, Korba, Talcher, Umer, Patherkhera, Korea, and Ib Valley. Development of these fields started during the second five-year plan and continued in subsequent plans.

Demand for thermal coal, already rising, was projected to grow further. An increase in coal output was sought in the third five-year plan which targeted the investment needed for technical progress in coal. The need for major investments in rail and sea transport was recognised in order to meet the rising demand for coal deliveries to buyers in the western and southern regions.

The fourth five-year-plan sought to increase coal supplies to meet power plant requirements, by upgrading mining methods and improving efficiency. Better co-ordination of mining and deliveries to power plants was sought.

By the start of the fifth plan, the State had assumed control of India's coal mining industry, and coal output began to rise faster than previously. The sixth five-year plan favoured opencast mining, in view of its shorter development period and higher coal recovery. Permission was given to meet demand for high-quality coking coal with imports, in particular for use in the steel industry. Some imported coking coal was also used for blending with domestic coals.

The seventh five-year plan renewed attempts to co-ordinate the planning of coal production, transport and demand. These efforts were motivated by delays in developing new coalmines because of obstacles met in the course of land acquisition, delays in capital spending on new and replacement equipment, the use of unsuitable mining technologies and inefficient project management. The sixth five-year plan had set environmental management objectives for the first time and the seventh plan included recultivation measures.

After liberalisation of the coal market in the early 1990s, the coal-mining sector was faced with new requirements. The eighth five-year plan set targets for productivity and for coking coal output. The plan encouraged mining companies to take on greater financial responsibility. It called for tighter time management, including the need to reduce the costs of projects already started in order to improve their competitiveness. The plan increased the importance of lignite because new lignite fields were discovered in the west at a distance from the previously known deposits.

The ninth five-year plan, ending in 2002, places domestic coal mining in the context of India's overall economic evolution. The government is aiming at complete deregulation of the economy and structural changes to stabilise economic growth.

Pricing and Distribution

The 1945 Colliery Control Order empowered the Ministry of Coal and Mines to control the prices and distribution channels of coal and to subsidise the companies. Energy prices for agricultural consumers and private households were cross-subsided by industry, trade and the railways for social welfare reasons. Agriculture is the second-largest electricity consumer in India, after industry. This subsidising policy has caused financial losses in energy generation and distribution.

Where no direct contractual relations existed between mining companies and buyers, the ministry required that coal producers distribute their products via the State Electricity Boards. Purchase prices for coal took no account of quality and extraction conditions. Differences of opinion on prices were a matter of constant contention between coal producers and buyers and led to losses in cases where production costs could no longer be covered.

The State Electricity Boards faced difficulties in collecting bills for electricity consumed. This affected the coal prices actually paid and weakened the viability of coal-mining operations.

In 1987, the Bureau of Industrial Costs and Prices was established and also empowered to fix coal prices, with a view to creating financial stability for the coal companies. The bureau fixed a unitary weighted average coal price for the domestic mining industry. The evaluation method considered the differing geological conditions in the various mining regions and estimated production costs assuming certain standards of efficiency. Not all mining companies met these across-the-board efficiency standards.

In March 1996, on the recommendation of the Bureau of Industrial Costs and Prices, prices of coking and higher-quality steam coal (quality grades A to C) were deregulated. Subsequently, prices for steam coal in quality grade D were also deregulated. Quality grades E, F and G remained controlled, but subject to adjustment every six months in line with the bureau's price index. Prices for low-quality steam coals have remained fixed.

Complete deregulation of prices for all coal qualities took place in 2000, after the 2000 Colliery Control Order superseded the 1945 Colliery Control Order. Prices of same-quality coal can now vary according to the cost of production (see Tables B.20 and B.21). Quotas on coal imports applied until 1993. Duties and taxes continue to be imposed on imports. The import duty was initially 85% of the price, but it was lowered for higher-quality steam coals to 35% in 1994 and to 10% in 1997. The tax on imported coking coal was lowered gradually from 35% to 3% from 1997.

Distribution of coal to power stations and steel producers is controlled by a Linkage Committee reporting to the ministry. Distribution to other sectors is left to the coal companies.

Liberalisation Policies

Since 1991, the government has cut back subsidies for state-owned mining companies. New policies have had to be developed to meet the forecast rise in coal consumption.

The 1997-1998 energy forecasts showed that the domestic coal industry could not cover the increase in future domestic demand, in particular the extra demand from new coal-fired power plants. The projected gap in coal supplies from domestic sources was projected to widen over the next ten years. The Committee on Integrated Coal Policy predicted that coal demand from power plants would be 288 Mt per year by 2001-2002, and would rise to 562 Mt per year by 2008-2009. Power plants alone account for 405 Mt in 2001-2002 and 835 Mt in 2011-2012, or 70% of total forecast coal demand. The growth in demand is projected to increase to over 5% per year during the tenth plan period, 2002-2007, largely because of the planned addition of 116 GW of coal-based power generation by 2007.

The consumption of coal for iron and steel production was forecast at 52 Mt in 2001-2002 or 13% of domestic coal output. Imports of 19 Mt per year of coking coal were projected to supplement the domestic coal supply. The Committee on Integrated Coal Policy projected an overall coal supply gap of some 133 Mt per year for the end of the tenth planning period in 2007.

The imbalance between supply and demand in the coal market was initially offset by running down stockpiles, by increased extraction from small private coalmines and by imports. Extra capital expenditure would be required if the domestic industry were to contribute more to closing the coal supply gap. With constraints on its budget, the government acted to liberalise the coal market. In June 1993, it resolved to modify the Coalmines Nationalisation Act, 1973.

"Captive" or dedicated coal-mining, which links major coal users to specific sources of supply, is now possible for both private and public-sector companies, including power generators, iron and steel producers, cement plants and coal washeries. This "coal linkage" is now governed by mandatory, legally-enforceable contracts. In an initial liberalisation phase, the government appointed a Screening

Committee under the Ministry of Coal and Mines to allocate coal blocks for captive mining. Fifty blocks, with gross coal reserves of 18 Bt, have been identified and several companies have been given permission to mine them. Where heavy capital investment is required to open new mines, the private companies can enter into joint ventures with existing coal companies. In most cases, private investors are able to extract coal near the point of use and thereby reduce transportation costs.

Foreign investment is allowed in captive coal-mining projects linked to power plants and other specific end uses. The extent of foreign equity participation that is permitted is decided on a case-by-case basis. With the approval of the Foreign Investment Promotion Board, foreign firms may buy up to 50% of domestic firms, subject to entry in the commercial company register. The Foreign Investment Promotion Board must approve the setting-up of coal-mining subsidiaries and the development of new pits by foreign investors.

Without government support, coal companies are finding it difficult to fund the purchase and replacement of equipment and new projects in existing mines. The private sector may have a role in purchasing equipment for leaseback to coal companies.

In 1997 the World Bank granted Coal India Ltd a loan of US$ 1.09 billion to encourage liberalisation, provided that overall coal output increased by 28 Mt per year in the subsequent five years. Further funds went to support 24 mining projects (replacements and extensions to existing production capacity) which, between them, are planned to have an output of 112 Mt per year in 2001-2002. The World Bank was also to grant loans for three new mines with a total capacity of 10 to 15 Mt per year, but the loan agreement was cancelled in July 2000 because Coal India Ltd could not sell the planned increased production. Domestic coal purchases stagnated in 1998-1999, because of slower industrial growth, delays in extensions to coal-fired capacity and competition from imported coal. Since October 1998, a new system of contracts with major buyers has ensured payment for coal supplies. It grants rebates for immediate payment and allows the option of paying against invoice and by credit. The purchase agreements stipulate coal quality in addition to price and quantity, and any quality infringements attract penalties.

Reform measures also include restructuring of mining companies to meet increased competition. Since April 1997, Coal India Ltd's subsidiaries have been regarded as financially independent units and have been expected to earn a profit. The executive board monitors the subsidiaries' longer-term financial transactions. In principle, debt-rescheduling options exist for transforming state loans into lower interest rate loans from private banks. Restructuring, closer co-operation with subsidiaries and a more stringent vetting of productivity levels through better performance measurement, may help to increase profitability in the long term.

International Collaboration

Collaboration with other coal-producing countries aims to:

- Bring in new technologies in both underground and opencast mining, to raise efficiency and develop skills.
- Pay for imported equipment not manufactured in the country.
- Attract foreign investment.

Joint working groups on coal were set up with Australia, Canada, China, France, Germany, Poland, Russia, and the United Kingdom. The priority areas include the acquisition of modern underground and opencast mining technology. Training of Indian personnel is an important consideration. With the liberalisation of the economy, greater efforts are being made to attract foreign investment to improve cost competitiveness.

Australia

Australia assisted Central Coalfield Ltd, on a turnkey basis, in the implementation of an opencast project with a beneficiation plant. The foreign exchange costs for this project were financed by a concessionary loan from the Export Finance and Insurance Corporation of Australia. The Australian side subsequently decided to withdraw from the Indo-Australian working group on coal.

Canada

Expansion of an opencast project of Eastern Coalfield Ltd from 5 Mt per year to 10.5 Mt per year has been completed by the Canadian Commercial Corporation on a turnkey basis, with financing of the Canadian goods and services by the Export Development Corporation of Canada.

China

A joint working group has been set up for bilateral co-operation between the Indian and Chinese coal industries. Three agreements have been signed on longwall projects with South-Eastern Coalfields Ltd. During the last meeting of the working group, the Indian side expressed interest in the development of opencast mines in China with Indian technology and expertise. The Chinese response is awaited.

France

France has helped develop Indian expertise in various ways:

- Advanced thick seam underground mining technologies, such as the blasting galleries caving method, have been introduced at the mines of Bharat Coking Coal Ltd and Eastern Coalfields Ltd. The blasting gallery technology was also applied in two Singareni Collieries Company drift-mine projects. After the completion of these two projects, Singareni signed a contract to implement the blasting gallery method in another mine project.
- High face longwall mining technology has been introduced at Eastern Coalfields Ltd and sub-level caving technology at Bharat Coking Coal Ltd.
- A training centre at Burradhemo (Eastern Coalfields Ltd), inaugurated in April 1994. Training is undertaken with French assistance.

A joint working group on coal was formed, with the intention of meeting annually. This working group has been merged with a proposed working group on energy.

Germany

Germany has assisted Coal India Ltd in studying underground voids in the eastern coalfields and on a project for subsidence and strata control in multi-seam working in underground mines. Further assistance is envisaged.

The focus of assistance from Germany is now on the lignite sector. The Central Mine Planning and Design Institute has signed memoranda of understanding with Rheinbraun Engineering und Wasser GmbH, Montan Consulting GmbH and Deutsche Montan Technologie, covering joint consultancy work. The institute carried out a technical assistance project on the implementation of clean coal technology through coal beneficiation in collaboration with Montan Consulting GmbH.

Poland

The Indo-Polish Joint Commission on Economic, Trade, Scientific and Technical Co-operation has four sub-committees on coal mining and power, trade, industry, and science and technology. The first meeting was held in Warsaw in 1998. Some projects have been completed. The Polish coal industry has offered its expertise in underground mining, washery construction, thermal power generation and mine safety and rescue.

Russia

The former Soviet Union assisted Coal India Ltd in the implementation of two opencast projects for Northern Coalfields Ltd and an underground project for Eastern Coalfields Ltd. The cost of the imported equipment for these projects was funded by a loan, and technical experts paid through the Bilateral Trade Plan.

Current projects with Russia are overall planning of the Talcher, Ib Valley and Korba coalfields; a study of slope stability of internal dumps in mines of Northern Coalfields Ltd; and development of the Raigarh and Bisrampur coalfields.

The United Kingdom

In January 1997, an Indo-British Coal Forum was established to foster co-operation. Activities include sharing state-of-the-art technology, exchange of information, identification of suitable projects and methods of funding, introduction of compatible technology for more efficient management in the Indian coal industry and skill development.

7. TECHNOLOGY, PERFORMANCE AND INFRASTRUCTURE

Mining Technology

Opencast Mining

In the period from 1970-1971 to 2000-2001, opencast coal production expanded more than tenfold in India. Annual output of hard coal from opencast operations is now 225 Mt per year, over 77% of total production. From the nationalisation of the mining sector, Coal India Ltd had invested some US$ 2.3 billion in developing opencast mining techniques up to 1995. Operations were switched to shovel-and-truck mining and to dragline operations for loose overlaying strata. To enhance the economic efficiency of mining operations, emphasis is increasingly being placed on higher capacity equipment. The choice of machines actually deployed depends on the stripping ratio. In mining areas with a low stripping ratio, shovels and trucks are used. Depending on the annual output of a given mine, operators use either excavators with a bucket content of 4.6 cubic metres to 10 cubic metres and heavy dumpers with a transport capacity of 35 tonnes to 120 tonnes, or excavators with a bucket content of 20 cubic metres and dumpers with 170 tonnes capacity.

Mines with a high stripping ratio use draglines with sizes between 20 cubic metres and 29 cubic metres or excavators between eight cubic metres and 10 cubic metres. Transportation is by dumpers with a loading capacity between 85 tonnes and 120 tonnes and by conveyor systems with upstream crushers. These machine capacities are low by international standards.

In the lignite mines operated by Neyveli Lignite Corporation, bucket-wheel excavators are used in combination with conveyor systems and stackers for dumping overburden.

Underground Mining

Coal India has invested some US$ 1.5 billion in mechanising underground mining. The share of hard coal mined underground by mechanical methods rose from 3.2% in the mid-1980s to over 45% in

1999-2000 in Coal India mines, and 40% in all mines. Despite increasing mechanisation, few advances have been made in underground operations, unlike opencast operations, because of difficult mining and geological conditions. The share of coal mined underground has fallen during the last two decades. Underground production has remained more or less stagnant while production from opencast operations has grown by nearly 10% per year.

The most common method used underground is bord-and-pillar[2] operations in thick seam deposits. The material is moved away partly by manual basket loading and partly by chain conveyor or rail wagons. The change-over from manual mining to automated loading systems is becoming feasible thanks to roof bolting which enhances safety in roadway support. Trackless mining systems are increasingly being preferred in underground operations. Mechanisation in bord-and-pillar working has involved the introduction of wheel loaders and dump trucks, load-haul-dump machines or side discharge loaders with designs adapted to suit mining conditions mainly in thick seams.

Underground mining using longwall operations was introduced in India 20 years ago, but support problems have continually arisen in roof control.

Some pits use coal plough or shearer operations in longwall mining. To support the immediate excavated area by the coalface, hydraulic struts are first installed by hand. Further extraction in the accessed area is then by longwalling along the lower part of the seam.

Future development in Indian coal mining will require extensive investment in equipment for both opencast and underground mining.

Performance

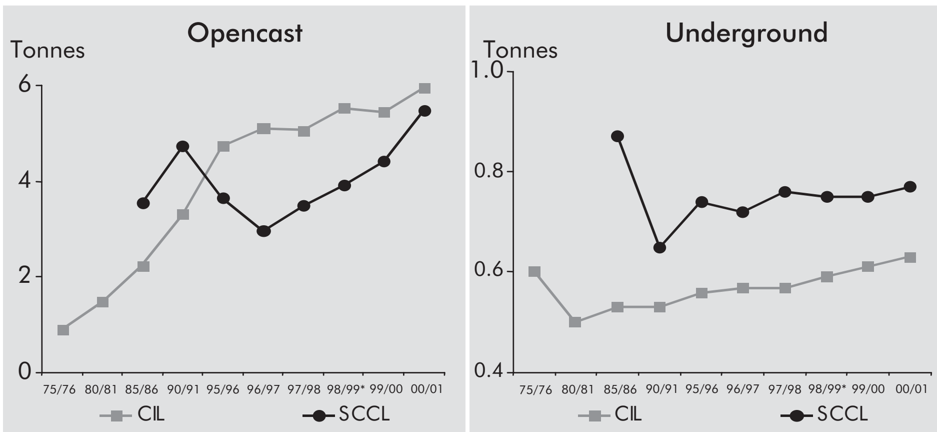
Productivity

Productivity in Indian coal mining has improved in recent years because of the growing share of opencast mining, as shown in Figure 13. Productivity in opencast mining at Coal India Ltd was only 0.9 tonne per manshift in the mid-1970s. It had increased to six tonnes per manshift by 2000-2001. Over the same period, the productivity ratio for underground mining remained at only 0.6 tonne per manshift. Total average productivity in hard coal mining was some 2.2 tonnes per manshift in 2000-2001. Further details are given in Table B.19, and in Annex A for individual companies. Productivity in opencast and underground mining is very low by international comparison. For example, the productivity of opencast coalmines in the US is 54.8 tonnes per manshift. The causes include the high labour component in underground operations, lack of technological know-how, the use of obsolete mining techniques and inadequate investment in replacement equipment.

Neither the government nor the industry is prepared to invest in equipment or training to raise productivity. Collaboration with international mining firms, and foreign investment, have been beneficial in this regard.

2. A mining technique in which chambers of coal are excavated, leaving pillars of material in place to support the roof.The pillars are left in position to minimise movement at the surface. If conditions permit, the pillars are later excavated. An advance on bord-and-pillar is longwall mining, where the machine shears the surface of the coalface and the roof collapses behind as the machine advances.

Figure 13
Productivity – Output per Manshift



CIL - Coal India Ltd.

SCCL - Singareni Collieries Company Ltd.

* April - December

Source: Ministry of Coal and Mines, *Annual Report 2000-2001*, New Delhi.

Transport

Inland Transport

With coal mining concentrated in the central, eastern and southern parts of the country, transportation links with the main customers are of great importance. India has a well-developed railway network with over 63 000 km of track. Of all coal mined, 51% is transported by the state-owned Indian Railways, and a further 23% by industry-owned networks. The latter are mainly "merry-go-round" systems operated between the mines and the pit-head power plants. Tables B.15 and B.16 give more details.

Coal is the largest single freight item handled by the railways, accounting for over 48% of total rail freight in 1998-1999. Coal's share of rail freight has risen 20% in the past 25 years. Indian Railways transported a total of 179 Mt in 1999-2000.

Rail freight accounts for over half the cost of steam coal (power grade F) at a distance of 750 km. In some major power stations in Gujurat and Maharashtra, the proportion of freight in overall coal costs is reported to be as high as 71%. Royalty on the basic price of indigenous steam coal varies between 12% and 19% depending on the grade.

A number of problems facing the railways reduce the efficiency and speed of coal transportation. Three different gauges – broad, standard and narrow – impair coal movement, since the gauge may change *en route* between the mine and a major customer. Different gauges lead to logistical problems such as different wagon loading volumes, and delays in shipment. The broad gauge handles 95% of total freight and 88% of passenger traffic. Some routes are single-track or not designed to cope with the high axle loads encountered in coal transports. Axle load can be reduced by screening and washing the coal prior to transportation. And only about 20% of the total network is electrified.

Coal uses three different transport corridors:

- The eastern coalfields supply the northern regions of the country via Mughalsarai. Some 30 trains are deployed every day on this route.
- Supplies to central India and the west are via Ajni and Katni, with some 20 trains a day.
- The route from the eastern coal-mining areas via Waltair in a southerly direction carries some seven trains a day, supplemented by a further 15 trains from the mines in central India.

Eighteen thousand wagons a day with a transport capacity of 30 tonnes each are sent by Coal India to its main buyers. Most of the coal is transported to power plants. The share of steam coal transported across distances of more than 500 km is approximately 40%. A large quantity (11 Mt in 1997) is also moved by rail across shorter distances from the mines in central and eastern India to the ports on the east coast – Paradip, Visakhapatnam (Vizag), and Haldia – to be shipped south.

Passenger and freight trains sharing the broad gauge track operate at varying speeds. With the expected expansion of rail freight, inadequate track development will give rise to bottlenecks in some regions. The ninth five-year plan calls for an average annual rise in coal extraction of some 5% per year, and it may be assumed that two-thirds of the output will be transported by rail. Further expansion of the track network and additional rolling stock are essential. Indian Railways have invested heavily in existing track systems, reducing the number of gauges and extending the track network, but the railway system still lacks necessary capacity.

A major expansion of the rail network is unlikely, because the railway company is unable to finance expansion from its internal resources. Moreover, subsidies for sections of track are determined politically, on the basis of passenger and freight ratios.

Other necessary measures include:

- Exact routing and scheduling of trains.
- Identification of critical rail links to coalmines and capacity expansions in these links.
- Extending the use of mine-operated routes between pits and power plants or steel producers, to relieve the railways.
- Transporting only treated steam coal on long routes.
- Construction of additional lignite-based power plants to reduce north-south coal movements.

Coal is also hauled by trucks, conveyor belt and aerial ropeways.

Maritime Transport

India has eleven seaports, managed by the Port Trust of India, which reports to the central government.

Coastal shipping services the south of the country, moving coal from the mines in the centre and east. The chief seaports on India’s east coast are Haldia, Paradip and Visakhapatnam. Besides deliveries of imported coking and steam coal, these ports handle 10-11 Mt per year of Indian coal, mainly for the southern ports of Chennai (Madras) and Tuticorin in the state of Tamil Nadu.

Coal is transported by sea in bulk freighters. The ship size used depends crucially on the distance to the port of discharge and on the locally allowed draught. Three ship sizes are available:

- Handysize 10 000 to 50 000 Dwt[3]
- Panamax 50 000 to 60 000 Dwt
- Capesize 80 000 to 150 000 Dwt

Handysize ships are used for short distances in coastal shipping and at ports with a low draught. Panamax and capesize freighters are used for coal imports.

During the monsoon months, deliveries are subject to uncertainty or may even be impossible because of rough seas. Delays of weeks may result.

Enlargement of some ports on the west coast would relieve the ports of call on the east coast and ensure more effective supplies to industry. So far, the ports on the west coast do not have the channels and berths needed for panamax and capesize freighters.

Ports on the east coast use special floating cranes to discharge cargoes offshore and transship freight on to smaller barges. This technique has worked well for ships transporting iron ore, but is only possible outside the monsoon months. It cannot be regarded as a long-term solution, since the costs are too high relative to those of freighters with self-discharging equipment.

Only the ports of Haldia, Paradip and Visakhapatnam are designed to cope with large cargo ships. Haldia has two berths with mechanised coal handling facilities and an annual capacity of 5 Mt. There are three berths discharging coking coal, two leased to the Steel Authority of India Limited (SAIL) and Tata Iron Steel Company Ltd. The terms of the lease give the two companies flexibility in volumes handled. The companies have been importing about two million tonnes annually.

Paradip is the outlet for coal from the Talcher coalfield. It has six mechanised multi-purpose berths for loading and discharging freighters. Since the decline in iron ore shipments, some berths have been used to discharge coal freighters. The port can take panamax vessels to a maximum load of 35 000 Dwt. To cope with the growing quantities of goods handled, the port is being extended with the financial assistance of the Asian Development Bank, which is lending US$ 170 million. Two berths with modern freight-handling systems are being built, and will expand coal-handling capacity to 20 Mt annually.

The outer port at Visakhapatnam (Vizag) can handle ships up to 48 000 Dwt. The inner port has five general cargo berths for ships with a capacity of 35 000 Dwt. The deliveries of coking coal are for the steel producers Vizag Steel and SAIL. A further port is planned in Gangavaran, 25 km south of Vizag. This would be very close to the Vizag Steel Company and would shorten the distance for transporting coking coal from port to user.

Coastal vessels transporting coal can discharge at five general cargo berths at Chennai. The Tamil Nadu Electricity Board uses one of these berths. Coal is stockpiled prior to transportation by rail to the power plants.

Located close to Chennai is Ennore, where a new port is being built. Financed by a US$ 180 million loan from the Asian Development Bank, berths are being built for freighters of up to 65 000 Dwt, along with mechanised discharging systems for coal. The annual handling capacity will be 12 Mt, with the

3. Deadweight tonne.

option of an increase to 16 Mt. The landing bridges at Ennore are expected to take over the discharging of coal freighters from Chennai because the new port can handle larger vessels and has been designed for direct supplies to the planned north Madras power plant.

Since the government now allows private investment in the ports, steel companies and energy suppliers have been operating landing bridges which they own or lease in the ports of Haldia, Visakhapatnam (Vizag), Chennai, Mumbai.

Some industrial companies and major consumers of coal are planning to build ports. Steel producers and the chemical industry, which purchase at least 1.5 Mt of imported coal a year, have shown particular interest.

Increasingly, the country's smaller ports are being fitted with discharging equipment for coal freighters in order to cope with the expected rise in coal shipments. Gopalpur is being extended as a port of call for capesize freighters to provide relief for the ports of Haldia and Visakhapatnam (Vizag). The ports of Gujarat, Pipevav, Alewadi, Dabhol, Jaigad and Redi are also being extended.

8. ENVIRONMENTAL REGULATION

Impact of Coal Mining on the Environment

Resettlement of Communities

In view of the country's high population density, the relocation of towns and villages is inevitable in areas where opencast mining is conducted, particularly in the eastern states. There are recurrent disputes between local residents and coal producers. In the period from 1982-1983 to 1992-1993, Coal India used 35 236 ha of land to develop coalfields and had to resettle 3 790 families. As the demand for coal increases, new land will be required to develop further coalfields. Disruption of village and rural communities has often been a problem.

Through its financing measures to develop new coalfields, the World Bank influences resettlement projects. The bank has laid down guidelines to keep relocations to a minimum and to set rules for compensation. These rules include offsets for lost assets, assistance and support during the transition period, and help to restore reasonable living standards. Coal India has been working on its own compensation and resettlement policy for the surrender of land.

Landscape Restoration

Both opencast and underground coal-mining have a sustained impact on the environment. The effects of opencast mining are widespread in view of the larger area required for extraction.

In the past, the Indian mine owners failed to restore the landscape after mining was completed. Most of the environmental degradation caused by underground operations occurred in the period prior to nationalisation. In the older mining areas like Jharia, Raniganj and East Bokaro, mining was not based on definite plans, so that more of the landscape than necessary was destroyed. Nationwide, some 18 000 ha has been judged unsuitable for human habitation because of mining damage, open excavations and overburden dumps.

Since nationalisation, coal output has increased dramatically. Most hard coal is now extracted in opencast operations. With growing environmental awareness in the public, there is greater demand for rehabilitation and restoration.

The loss of flora and fauna is particularly high in the case of opencast mining. In the late 1990s, opencast operations covered an area of 141 000 ha and it has been estimated that a further area of 57 000 ha has now been used for coal production, including 13 000 ha classified as forest. Of the area affected by opencast mines so far, 31% has been forest. Mining companies are being called on to compensate by afforestation in previous non-forest areas.

Pollution Control

Extensive work on pollution control has been carried out in new projects by Coal India Ltd, especially those funded by the World Bank under the Energy Sector Management Assistance Programme (ESMAP).

Fires in abandoned underground mines have been a problem in some areas. A project to recover burning mines saved 100 Mt of coal from uncontrolled burning in the Jharia mining area.

The Indian government has produced a catalogue of environmental measures to mitigate emissions of greenhouse gases as well as emissions of sulphur dioxide, nitrogen oxide, soot and suspended particulate matter.

Because coal is the chief fuel for India's power generation, large amounts of carbon dioxide are emitted in combustion. The average calorific value of coal used in Indian power plants has fallen steadily in recent years, so that more coal has been needed to produce a given amount of electricity.

Relative to worldwide standards, Indian emissions of sulphur dioxide are low because of the low sulphur content of the run-of-mine coal, usually less than 0.6%. Typical concentrations of sulphur dioxide amount to 1 250 mg/m^3 and of nitrogen oxide to 650 ppm at the exit of the burner chamber. The government has not set any limits on sulphur dioxide and nitrogen oxide emissions at power plants. Flue gas monitoring and cleaning systems have not generally been required. Installation of desulphurisation systems is required where several power plants with more than 500 MW total capacity are built at one location.

Since 1970, the average ash content of steam coal used in Indian power plants has risen by 10% to 15%. Emissions of suspended particulate matter in the exhaust air currently range between 7 500 and 9 000 mg/m^3. Electrostatic precipitators are the standard method for filtering out the fly ash from flue gas. Highly-effective precipitators are manufactured in India, although high particulate matter resistance, caused by the high ratio of ash content to sulphur content and alkaline components, reduces their efficiency. This means that the filters may not reach their planned efficiency of 99.7% under all circumstances. The limit value of 150 mg/m^3 for soot particles may be exceeded. The installation of electrostatic precipitators is now a legal requirement in new power plants. Together with water fogging systems, which produce a spray for separating the ash particles, they achieve effective dust filtering of the flue gas. It is unlikely that existing plants will be retrofitted with environment-protecting technology.

Since the 1980s, a project developed in co-operation with the US Agency for International Development and the National Energy Technology Laboratory has provided technical support for India's electricity sector. The project uses new technologies to increase the efficiency and enhance the environmental compatibility of power plants. The project was extended in 1995 to include a special programme to reduce carbon dioxide emissions. A central office is responsible for transferring technical information to the main Indian power plant operators. Plant operators are encouraged to co-operate with Indian manufacturers of power plant components to implement the improved technologies.

Clean coal technologies offer major improvements in efficiency and environmental performance compared with conventional sub-critical pulverised-fuel technologies, but at substantially higher cost.

The collaborative project is seeking to encourage the adaptation of clean coal technologies to Indian coal qualities. The primary goals include high thermal efficiency in power plants and lower emissions using coals of variable, usually poor, qualities together with the commercial exploitation of the ash residues produced from coal combustion. The entire project is based on the assumption that Indian companies are to be responsible for the manufacture and maintenance of the systems.

Fluidised-bed power plant technologies, such as circulating fluidised-bed combustion and pressurised fluidised-bed combustion, are likely to be preferred options from a technical standpoint, because they would permit more efficient use of coal with a low calorific value. However, they are not yet ready for commercial operations, and in view of the difficult financial conditions in the Indian electricity sector, their early use in normal power plant operations looks highly unlikely.

Retrofitting old plants is necessary, but boosting an old plant's efficiency usually requires major capital expenditure. In some cases, modernising a cooling system can increase the thermal efficiency of the plant as a whole. A review of cooling performance could be of value for many older power plants. Again, cost is an impediment in India and is unlikely to be overcome until electricity tariffs fully cover the costs of generation, transmission and distribution.

Reduction and Recycling of By-products of Coal Use

In 1996-1997, industrial coal use produced some 62 Mt of ash[4], some 80% being fly ash. A reduction in power plant ash can be achieved by using washed coal. The material washed out during treatment would still contain small amounts of coal particles, and these could be burned in specially designed mine mouth fluidised-bed plants.

In principle, residues from power plant combustion can be put to industrial use or disposed of in an environmentally sound fashion. Compared with other countries, however, the Indian economy has made little headway in the commercial exploitation of power plant ash. Of the 62 Mt combustion ash, mainly stemming from power plants, only 2% was used commercially in 1996-1997, unlike China, which commercially recycled a quarter of its 55 Mt of ash.

Fly ash is stored in large dumps, which are expensive to reclaim when the land is required for other purposes. Interim storage of the ash is usually in dedicated ponds or in stockpiles next to the power plants. Some of these ash ponds are built on permeable sand soils, so that pollution of the groundwater and nearby rivers can occur. Particularly in the dry season, volatile ash drifts. There is also no organised disposal system for power plant ash. Many plant operators do not co-operate with the authorities in charge of pollution control.

4. This quantity is essentially from power generation. Some industrial processes such as cement-making absorb ash directly.

In 1991, the National Thermal Power Corporation created a subsidiary to sell ash. Offices at its thirteen power plants provide information on using ash, and its ash sales have tripled in the last ten years. Firms recycling ash are supplied with dry ash free of charge for a period of five years. New companies recycling ash are also given low-interest loans for the acquisition of building land and, where joint ventures are formed with a view to using the ash, they may obtain additional capital funding support from the power plant operator. In spite of these incentives, ash dumping is still less expensive than setting up a recycling system, and only sluggish headway is being made in ash recycling The financially hard-pressed State Electricity Boards continue to dump their ash.

The government provides additional incentives for recycling. All companies using at least 25% ash in manufacturing their end products are exempt from excise duty. No customs duty is levied on imported ash-recycling equipment, unless it is obtainable on the home market.

Because of its high ash content, transporting untreated coal to remote power plants is expensive and an inefficient use of energy. It is estimated that over 60 Mt per year is being transported to remote power plants or to environmentally sensitive regions. The Ministry for the Environment and Forestry is planning a directive requiring power plants located more than 1 000 km from the mine to use coal with a maximum ash content of 34%.

Blending low calorific, high ash content domestic coal with higher-quality imported coal could be a profitable alternative to using imported hard coal only, where delivery distances are 1 000 km or greater. However, blending is not likely to be cost-effective if the domestic coal has a calorific value in excess of 4 000 kcal per kilogramme and an ash content of between 30% and 38%. Moreover, blending coals of different rank and petrographic make-up will lead to different combustion behaviour in the power plant. Blending of high-ash coal with low-ash coal (indigenous or imported) for supplying distant power plants can only be considered as a short-term fix. A more satisfactory approach would be to wash high-ash coal or import low-ash coal, whichever costs less.

9. OUTLOOK

General Conclusions

The Indian coal industry is complex. Analysis of its viability and prospects is made difficult by a long history of government intervention. Despite some progress towards reform, the industry still has to cope with a wide range of objectives set for it by the government. For these reasons, the focus of the discussion is on improving the commercial viability of the sector. It is likely that the Government of India will take into account other considerations of broad economic and social policy in reaching decisions concerning the coal industry. *Nevertheless, raising the commercial performance of the industry to meet international standards should be the principal objective. The way to achieve this objective should be the creation of a freely competitive electricity industry based on a freely competitive coal market.*

It is likely that transition costs will arise, notably the loss of employment from mine closures. These should be addressed without impeding necessary change in the industry. As industry performance improves, and if inwards investment is unrestricted, such costs would be expected to be offset, at least in part, by new coal-related investment.

Since the early 1990s, the Indian government has sought to achieve better use of resources, by reforming the planned economy and introducing some market-based policies, and by seeking joint-venture partnerships with foreign investors. Despite these efforts, there is still little in the Indian coal market to attract potential foreign investors. Such investors are discouraged by restrictive distribution channels, production allocation, administrative obstacles and continuing defects in the pricing structures for both power and coal. As a legacy of the planned economy, electricity prices are artificially low and the State Electricity Boards are burdened by debt.

The Indian government has been trying to increase the quantity and improve the quality of coal supply by gradually dismantling the quotas and duties on imported coking coal. Coal imports would step up competitive pressures in Indian coal supply, but regulations on exclusive supply linkages continue to tie customers to domestic coal producers and hinder competition. Moreover, inadequate geological data and a conservative approach to assessing the economic feasibility of new mining projects reduce the appeal of the Indian coal market to investors. The expansion of mining capacity has also been slowed by lengthy and complicated approval procedures for land acquisition and the development of new mines.

Despite coal price deregulation, mining companies are still unable to set prices reflecting their actual production costs. Among the Coal India subsidiary companies, low productivity operations, mostly in underground mining, make losses whereas other companies, with mainly opencast operations achieve a good return.

The study confirms the requirement to carry through liberalising reforms, and to rationalise mining operations, so as to generate adequate surpluses for the coal mining companies. Only then can adequate investment be made in new facilities, especially in coal beneficiation plants.

In the immediate term, restructuring and rationalisation of the industry and mobilisation of additional private investment are the keys to maximising the production of the domestic coal industry. These measures need to be supplemented by opening the market to imports.

Reforms in coal-consuming industries and coal transport must accompany reforms on the supply side. Electricity and transport prices must be based on full cost-recovery. The debt burden on the State Electricity Boards must be alleviated so that necessary investment in these sectors support and sustain changes in coal supply.

Specific Issues

Earning an Adequate Return on Power Plant Operations

The financial performance of the State Electricity Boards will play a crucial role in achieving an efficient energy sector and in obtaining new private investors, for both electricity and coal supply. The State Electricity Boards' financial troubles have various causes.

So long as the cost of power for private households and for small farm holdings remain subsidised below actual production costs, the state utilities cannot earn a profit and their plant cannot be properly amortised. They cannot pay adequate prices for coal. Losses from obsolete networks are due to a lack of investment capital. Subsidised electricity prices encourage uneconomic consumption of electricity. Irregular payments by consumers and a backlog of outstanding bills, illegal power tapping and faulty meter readings also need to be addressed.

Stabilisation and improvement of the utilities' financial situation can only be achieved by changing the level and structure of power rates and by removing subsidies. A scheme to address the debt of the State Electricity Boards is necessary, including administrative restructuring to improve bill collection. An adequate price will enable the State Electricity Boards and other utilities to invest and pay coal prices adequate to ensure reliability of quality and supply.

Considering New Types of Power Plant

Most Indian coal-fired power plants use run-of-mine coal from several mines that has a high ash content and differing grain sizes. New coal-fired power plants are built to accommodate these characteristics, but at a much higher cost than power plants using treated coal only. Less costly power plants could be built if supplies of high-quality prepared coal could be assured by contractual arrangements with beneficiation facilities, or by purchasing from producers of higher-quality coal.

Building plants close to the coast would allow the use of imported low-ash steam coal. This is an attractive option because of the highly-competitive nature of the international coal market. Import competition would encourage performance improvements in the domestic industry.

Improving the Quality of Domestic Coal

One-third of Indian power plants use coal with an ash content of more than 40%. Reducing the ash content would yield economic and environmental benefits.

Reducing the ash content of domestic coal would require more coal-washing plants to be built. Coal beneficiation plants built adjacent to mines would:

- Reduce the cost of transportation of inert materials from pit-heads.
- Increase grinding capacities and reduce wear in the grinding gear.
- Improve the efficiency of power plant operation by reducing the cost of boiler maintenance and cleaning by reducing slagging and fouling.
- Increase oil for the burner to increase flame stability.
- Slow wear of coal burners and the flue gas path.
- Increase plant load factor and energy efficiency of power plants.
- Reduce the capacity and area required for handling and dumping the combustion ash.
- Cut emissions from the power plant because of easier control of combustion and increased conversion efficiency.

But beneficiation plants are unlikely to be built because:

- Mining companies are unable to earn sufficient profit for investment.
- Coal buyers and producers recognise the need for investment in beneficiation, but hold each other responsible for undertaking the task.
- The impact of coal quality has not been seriously studied. Some coal producers doubt whether it is economic to treat and classify coal. The costs involved, even if reflected in the price paid by consumers, may not be offset by a sufficient rise in power plant efficiency.

Washing results in coal losses of 8% to 15%, depending on the coal's natural qualities. The high proportion of carbon in the rejects poses fire risks in overburden dumps at beneficiation plants unless properly treated. Use of mine-mouth fluidised-bed boilers could burn high-ash coal and washery rejects.

The Challenge to Indian Steel-Making

Indian steel producers specialise in high-quality steels. But their competitive advantages, low raw material costs and wages, are gradually being eroded by advances in production processes in other countries and by their persistent use of low-quality Indian domestic coals. Imported coking coal has so far offset this drawback.

The introduction of pulverised coal injection in blast-furnaces has made headway in new plants, because coking coal is becoming the most expensive raw material in production. Using pulverised coal injection allows a proportion of the coking coal input to be replaced, lowering production costs.

Coke will continue to be imported because of a shortage of domestic products and regional imbalances in supply. Some states, such as Gujarat, have surplus capacity while southern states face enormous deficits. Possibly, more merchant and captive coke plants supplying pig-iron producers could be built with foreign investment.

Opening up Adequate Coal Mine Capacity

Expanding domestic hard coal and lignite supply would require extensive investment. Until 1991, the Indian government financed 70% to 90% of Coal India's investment projects, but private finance will be necessary in the future.

The coal mining companies are not profitable and cannot invest. Financial backing from private investors is essential. Statutory conditions deter private-sector investors from acquiring interests in, or taking over mining companies. Private financing has been impeded by a generally unhelpful and bureaucratic approach by governments. The creation and enforcement of a regulatory framework for private-sector participation is essential. The recommendations of the Committee on Integrated Coal Policy provide a model for improving regulation.

Until completely free coal pricing and unimpeded distribution are introduced, neither domestic nor foreign private investors will show any interest in new mine investment. The lack of infrastructure and communications at some mines is still another bar to coal mine expansion.

In addition to these obvious constraints, there are indirect factors hampering private-sector captive coal projects. Suppliers may sell only to a single buyer, usually in the power sector. This rule is set aside only if the exclusive buyer fails to purchase the agreed quantity. Geological information is also limited.

Deadlines must be set for the evaluation of proposals for captive coal mining. In 1997, a Committee of the Confederation of Indian Industry proposed that projects should commence 30 to 36 months after initiation. This would speed up granting of mine lease grants, and approvals for environmental and forest clearances, rehabilitation and resettlement plans and mine plans. Improved co-ordination among the Ministry of Coal and Mines, the Ministry for the Environment and Forestry and the appropriate state government ministries would also be helpful.

Power-generating companies view captive projects as vital to the operation of a specific power plant. If the captive mine were not able to produce coal at the required rate, the whole power project would suffer. This problem could be resolved by abandoning the policy of allocating a mine's output to a specific buyer. Free competition among many producers and buyers would have significant economic benefits.

The geological reports offered in support of captive block bids need to be improved. Areas which require improvement include technical data such as quality parameters, hydrogeology, washability characteristics and geo-technical information. The present requirement that the total charge for a geological report must be paid in advance should be modified. Investors would be encouraged if the fee were split into an initial charge for viewing the geological report, and a balance to be paid at the time of financial closure of the project. The allocation of new pits should be worded to permit further prospecting in the pits after payment of the necessary dues so that potential mine operators could improve the geological information.

Attracting Foreign Investment

There are two ways in which private-sector investment could be encouraged:

- By making foreign investment more attractive.

- By allowing the nationalised companies to participate in joint ventures with private coal companies, with the latter being able to hold a controlling majority in the venture.

Private investment requires a private market. The Indian coal industry needs to be fully deregulated. Priority should be given to full deregulation of distribution and prices, creating real competitive conditions and making existing suppliers operationally efficient. International competition is essential to exert competitive pressure on the local coal market.

The guidelines announced for selecting blocks and pits for captive mining need to be amended so that some virgin blocks with a better grade of coal and having reasonable geo-mining conditions may also be offered to private-sector companies. Other necessary measures include investment in transport:

- Private investment in road construction in remote and underdeveloped areas could be made profitable through toll collection.
- The railways will remain the principal means for transporting coal. Some sections of the system are single-track or unsuitable for transporting coal because they cannot bear high axle loads. In the medium term, it will be necessary to extend the railway network to accommodate the rising traffic in coal freight. Measures to reduce the transport of ash and other material should be considered in this context as possibly more cost-effective alternatives to investment in railways.

Establishment of an independent regulatory body is also desirable. The legislative and institutional changes that would allow for independent regulation in the industry are being investigated.

Private industry is advising the government on measures to create a more favourable environment for larger private-sector participation in coal mining. Proposals include:

- Foreign equity should be allowed up to 74%.
- The government should promote joint ventures between public-sector coal companies and private-sector entities. Foreign companies should be allowed to hold a majority share and exercise overall control of mining operations.
- Competitive bidding should be used to evaluate private-sector offers. It is essential that the process for selecting private investors be transparent and objective. The government should streamline the decision-making process.
- Environmental regulation should be enforced by an independent regulatory body, with legislation providing a framework for its decisions.

Opening the market to foreign participation and investment would reduce the backlog of investment projects and facilitate the transfer of know-how. The government expects the liberalisation to bring a balanced coal market in the medium term, but this will only happen if reform is complete and if truly competitive conditions are allowed to develop. Recent reforms need to be accelerated and completed. Otherwise, the coal industry will remain a burden on public finances and a constraint on overall economic development.

In summary, coal in the energy supply of India now faces two distinct challenges.

There is an *internal challenge* to the Indian coal industry to meet additional demand, in particular from the power industry.

- There is the problem of coal quality. While Indian coal is low in sulphur, it is high in ash and of low calorific value. It cannot meet all domestic demand because of its quality and because it is not always economically competitive with imported products. Increasingly large amounts of coking coal are imported, and smaller but fast-growing quantities of steam coal as well. The place of Indian coal is challenged by imported coal of higher quality, reliable supply and often lower price. Investment in beneficiation and the development of simplified and uniform quality standards are necessary. Coal contracts need to be liberalised so that coal producers and buyers can freely compete.

- There is a problem of profitability in certain coal companies. Opencast mines are generally cheaper to operate than underground mines, essentially because of productivity. Labour relations are an issue. The industry needs to rationalise its operations, raise productivity and invest in capital and training.
- The Indian government therefore needs to implement a market-based policy framework to secure sustained investment in coal production, transport and use. Rationalising the existing coal industry and improving its governance are indispensable. India could benefit from the experience of other coal-producing countries undergoing rapid restructuring, notably China. It is essential that the government implement planned reforms in the power sector. Electricity generation is the largest consumer of coal and will remain so, but its present financial situation hampers its own development, as well as that of the coal industry. If coal is to maintain its large share of the energy supply in the longer term, the government must improve environmental standards, notably for sulphur and nitrogen emissions, and particulates.

There is also an *external challenge*, since India is a growing coal importer and is emerging as one of the main contributors to world coal demand. The domestic coal industry cannot satisfy the country's demand for coal. The government should ensure that coal consumers may secure stable relationships with producers in coal-exporting countries, such as Australia, Indonesia, China and South Africa.

The government may have an ongoing role in seeking international co-operation to improve technology exchange as a means of supporting the domestic industry.

Recommendations

Raising the commercial performance of the industry to international standards should be the principal objective. The way to achieve this objective should be the creation of a freely competitive coal industry supplying a financially viable electricity industry.

Specific policy measures that are recommended include:

- Accelerating price reforms in the electricity sector.
- Allowing buyers and sellers freedom to choose with whom they do business.
- Fully liberalising coal pricing.
- Encouraging the industry to rationalise quality standards to better match coal products to consumer needs, especially in the power and steel industries.
- Encouraging the industry to close unprofitable mines.
- Addressing labour productivity and labour relations.
- Accelerating the opening of the coal sector to private investment, including foreign investment in mining, beneficiation and marketing.
- Removing impediments to full competition with imported coal, including the removal of remaining customs duties and taxes.
- Establishing a timetable for the privatisation of the existing coal companies.
- Establishing a framework of environmental standards for coal mining and consumption.
- Funding research and development on clean coal technologies through public-private partnerships.

ANNEX A

PERFORMANCE OF THE INDIAN COAL COMPANIES

Bharat Coking Coal Ltd

Bharat Coking Coal Ltd is the main coking coal-producing subsidiary of Coal India Ltd. It operates 109 mines, with headquarters in Dhanbad in the south-eastern part of the state of Bihar. The company manages coal production in the Jharia coalfield, which is primarily in Bihar but extends into the state of West Bengal. Production in West Bengal accounted for only 2% of production in 1998-1999. Bharat Coking Coal Ltd produces about 50% of the coking coal requirement of the Indian steel industry. About 80% of its total production is coking coal. About 35% of its production is from underground mines and 65% from opencast operations.

Production and Productivity

Most of the underground mines are worked by conventional bord-and-pillar mining with manual loading. The company operates 124 side-discharge loaders and plans to increase mechanisation of the mines. The number of side-discharge loaders is planned to increase to 255 by 2004-2005. The company also operates one mechanised longwall system with power supports and shearers, using roadheaders for development. A second longwall system using conventional mining is also in operation.

Table A.1

Underground and Opencast Production by Method

Production Method	1998-1999 Production (Thousand tonnes)	Proportion of Undergound or Opencast Production (%)	Proportion of Total Production (%)
Conventional Bord and Pillar	6 708	68.9	24.7
Mechanised Bord and Pillar	2 288	23.5	8.4
Conventional Longwall	481	4.9	1.8
Mechanical Longwall	262	2.7	1.0
Mechanical Opencast	17 436	100.0	64.2
Manual Opencast	0	0.0	0.0
Total	**27 175**		**100.0**

In 1998-1999, nearly 70% of the company's underground operations were manual labour operations with very low productivity. Less than 8% of the underground production came from mines with mechanised longwall equipment.

Opencast mines are worked mainly by a shovel-loader combination. Two draglines are in operation for overburden removal. In 1998-1999, 266 thousand cubic metres of overburden were removed by manual labour, representing less than 0.5% of the total volume removed.

Heavy reliance on manual labour is reflected in productivity statistics. The company is third-lowest in average productivity for Coal India Ltd subsidiaries. Underground productivity has increased at an average annual rate of 2.8% since 1996, but opencast productivity has increased at an average annual rate of 7%. Expansion of opencast production is improving average productivity, but offset by the slow pace of investment in underground mechanisation.

Coal Quality and Preparation

Coal produced by Bharat has a high inherent ash content. Cokin-quality coal in particular often requires beneficiation to provide coke oven charges of a quality competitive with imported coal, and a coke which does not impugn blast-furnace performance and pig-iron quality. The company operates the largest number of washing plants in India. Following completion of the Madhuband facility in 1999, the company had 14.5 Mt per year washery capacity. Eight of the facilities are designed for coking coal production, while Dugda 1 and 2 are dedicated to steam coal production.

Table A.2
Coal Washery Capacity

Washery Name	Annual Capacity (Mt)	Year On-line	Equipment
Dugda 1	2.00	1998	Jig
Dugda 2	2.00	1968	Heavy media, cyclone, froth flotation
Bhojudih	1.70	1962	Heavy media, jig
Patherdih	1.60	1964	Heavy media, cyclone, jig
Sudamdih	1.60	1981	Heavy media, cyclone, froth flotation
Moonidih	1.60	1983	Heavy media, cyclone, HYD
Barora	0.42	1982	Heavy media, cyclone, jig, froth flotation
Mohuda	0.63	1990	Heavy media, cyclone, jig, froth flotation
Lodna Modular	0.48	1991	Barrel/cyclone
Madhuband	2.50	1999	Heavy media, cyclone, jig, froth flotation
Total Annual Capacity	**14.53**		

Despite apparently having an annual washery capacity of between 12 and 14.5 Mt, the company reported a raw coal feed of between 6.2 and 8.1 Mt annually between 1993 and 1999, with yields of clean washed coal of between 2.8 and 4.3 Mt annually. The yield of "middlings" is 2.1 to 2.4 Mt per year. Both the input of coal to the washery plants and the recovery rate of clean coal declined significantly between 1996 and 1999. However, raw coal input and washed coal production increased significantly in fiscal year 1999-2000. While middlings production has been more stable, it has also declined steadily since the mid-1990s.

Table A.3

Coal Preparation Summary

(Thousand tonnes)

	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
Raw Coal Production	29 422	29 070	28 595	27 300	31 023	27 176	27 901
Raw Coal Feed to Washeries	7 780	8 060	7 400	6 930	6 380	6 231	7 010
Washed Coal	4 066	4 310	4 220	3 547	2 999	2 811	3 597
Washed Coal Recovery Rate (%)	52	53	57	51	47	45	51
Middlings	2 364	2 174	2 119	2 067	2 139	2 113	1 933
Middlings Recovery Rate (%)	30	27	29	30	34	34	28
Total Recovery Rate (%)	**83**	**80**	**86**	**81**	**81**	**79**	**79**

There are several influences on the volume of raw coal washed and the plant performance rates. For example, a shift from underground to opencast mining generally provides more opportunity to control quality in the production process, and thus avoid washing. Conversely, a shift to mechanisation underground can result in more "dirt" for roof, floor and partings being produced with the raw coal, so increasing the need for washing, and lowering clean coal recovery rates.

Table A.4

Coking Coal Raw Production by Grade

(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
Steel-1	422	514	215	277	254	367
Steel-2	885	1 153	1 000	635	486	467
Steel-LV	363	289	251	285	265	329
Washery-1	2 237	2 320	2 557	2 019	1 601	1 332
Washery-2	2 297	1 770	1 496	1 566	1 873	1 663
Washery-3	4 768	3 796	3 394	3 888	4 450	3 364
Washery-3 LV	406	510	916	532	537	1 399
Washery-4	3 149	3 857	2 746	2 649	3 364	3 645
Washery-4 LV	9 160	8 879	10 095	9 994	12 118	9 459
Total Coking	**23 692**	**23 093**	**22 675**	**21 848**	**24 593**	**22 029**

LV: low volatile.

While it is not known how these factors are affecting Bharat's coal quality, the statistical data suggest that there are problems maintaining the utilisation rate of the washing capacity and with recovery of washed products. Commencement of washed coal production at Madhuband in 1999 should improve washed coal availability.

A review of the company's coal production classified by quality supports a conclusion that maintenance of coal quality has been an issue for at least the past six years. Although raw coking coal production has remained relatively stable, at between 22 Mt and 24 Mt annually, the production of higher ash Washery-4 coal has increased from 52% to 60% of total coking production. At the same time, production of premium steel-grade coals (Steel-1, Steel-2, and Steel-LV) has declined from 8% to 5% of total coking coal production.

About 20% of raw coal production is classified as steam coal. The data for 1993-1999 suggest that there has been a shift away from production of lower-quality D grade to higher-quality C grade coal. During the six-year period, lower-grade production declined from 73% to 47% of the total, while higher C grade production increased from 27% to 52% of the total.

Table A.5
Steam Coal Raw Production by Grade
(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
A	29	18	19	46	2	2
B	53	7	0	155	0	0
C	1 777	1 587	2 457	2 384	3 072	2 662
D	3 725	4 201	3 440	2 852	2 996	2 416
E	146	165	4	15	0	67
Total Steam	**5 730**	**5 978**	**5 920**	**5 452**	**6 070**	**5 147**

About two-thirds of coal sold is despatched by rail and one-third by road. The main coking coal consumers are steel plants located in the immediate vicinity of the producing mines with preparation plants at Bokaro Steel City, Burnpur and Durgapur. Steam coal is shipped to coal-fired power plants in the immediate vicinity including Bokaro, Chandrapura, Patratu and Santhaldih. Other coal-fired power plants within 500 km include Khalgaon, Farakaha and Kolaghat.

In fiscal year 1998-1999, Bharat Coking Coal Ltd also shipped coal to textile plants, brick kilns, fertilizer plants and cement plants. In addition, approximately 1.5 Mt was converted into hard and soft coke at company facilities.

Financial Performance

Despite being located close to major coal-burning facilities in the country, which should give it a transportation advantage, Bharat Coking Coal Ltd lost money in four of the last six years for which data are available. Losses approached US$ 117 million in fiscal year 1998-1999, when a depressed steel sector and low international coal prices affected revenues. Production costs increased steadily from 1993 to 1996 and then declined sharply for one year before resuming an upward track in 1999. A comparison of some standard competitive measures illustrates the stark realities that the company faces. Average raw coal production costs were 28% higher than the average pit-head value of all Indian coal production, suggesting that costs must be lowered significantly to compete with domestic Indian suppliers outside the immediate region. Comparing prices that Bharat charged for raw production in the steam and coking markets with its average raw coal production costs also illustrates the difficulties faced by the company. In 1997 and 1998, steam coal prices were respectively 1% and 22% below average production costs. In 1996 and 1998, coking coal prices were respectively 7% and 12% below average production costs. In 1997, a profit of US$ 1.93 per tonne may have been achieved on coking coal, but the company probably lost money on steam coal.

Although non-coking coal import costs increased by 5.4% to US$ 39.40 per tonne in fiscal year 1999-2000, coking coal prices declined by 5.5% to US$ 61.62 per tonne.

Table A.6
Financial and Competitive Performance

	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
Profit/(Loss) US$m	7 967	(50 346)	32 323	(97 295)	(39 523)	(116 762)
Profit/(Loss) US$/t	0.27	(1.73)	1.13	(3.56	(1.27)	(4.30)
Production Cost US$/t	19.46	18.38	20.86	21.96	18.16	20.60
Coking Coal Import Cost US$/t[1]				69.23	66.67	65.19
Non coking Coal Import Cost US$/t[1]				53.04	41.73	37.38
Average India Coal Pit-Head Value US$/t[2]	14.82	14.10	13.97	15.23	16.16	16.62
Average Price Paid to Company, US$/t Raw Steam Coal[3]					17.99	16.09
Average Price Paid to Company, US$/t Raw Coking Coal[3]				20.35	20.09	18.09

1. Landed cost, does not include import taxes.
2. Value for all India steam and coking coal production.
3. Estimated using posted prices for run-of-mine steam and coking coal and raw coal production.

Central Coalfields Ltd

Central Coalfields Ltd produces both coking and steam coal. Its headquarters are at Ranchi in south-central Bihar state. The company operates 71 mines in the Bokaro, Ramgarh, Giridih, and Karapura coalfields. It also operates seven washeries and produces coke. About 69% of raw coal production is steam coal. Raw coking coal production has declined from 44% of the total in 1993 to 31% in 1998. About 90% of raw coal production is from opencast mines, and 10% from underground mines.

Production and Productivity

Production has been fairly stable, fluctuating between 30 and 34 Mt per year in the past seven years, accounting for about 12.5% of government-controlled production. Production in the 1999 fiscal year declined 2.9% from the previous year. In the 2000 fiscal year, incomplete data suggest that production declined again, by about 1%, because of a lower output of coking coal. Steam coal production has increased steadily from 19 Mt in 1993 to 22 Mt in 1998.

Table A.7

Underground and Opencast Production by Method

Production Method	1998-1999 Production (Thousand tonnes)	Proportion of Undergound or Opencast Production (%)	Proportion of Total Production (%)
Conventional Bord and Pillar	2 565	82.9	8.0
Mechanised Bord and Pillar	531	17.1	1.7
Conventional Longwall	0	0.0	0.0
Mechanical Longwall	0	0.0	0.0
Mechanical Opencast	27 750	95.4	86.2
Manual Opencast	1 330	4.6	4.1
Total	**32 176**		**100.0**

Almost all production is from mechanised opencast mines. Although overburden removal at the opencast mines is mechanised, about 5% of the coal production was achieved with manual labour in 1998. The company operates 32 opencast mines, and 12 mines where both opencast and underground mining techniques are used. Opencast mining is conducted primarily with scrapers, bulldozers and front-end loaders. The company has one 25-cubic metre shovel. An in-pit crushing and conveying system has been installed at one mine. There are 688 dumper trucks ranging in capacity from 35 tonnes to 85 tonnes to transport overburden and remaining coal. Despite the volume of mechanised production, the inventory of available equipment and the average opencast mine size indicate that the scale of mining at opencast sites explain low levels of productivity. The company has the lowest rate of opencast productivity of all Coal India's subsidiaries, but productivity at opencast operations is showing an improving trend. Between 1981 and 1990 productivity growth, at 0.5% annually, was very sluggish, but between 1990 and 1995 the growth rate increased to 5.3% per year. Growth in productivity has slowed to 3.9% annually since 1995. The increase in 1999-2000 was nearly 3.8%.

About 10% of mining is at underground mining operations. The company operates nine mechanised haul dumpers and 16 side-discharge loaders. Most underground mining uses conventional bord-and-pillar mining techniques, although about 2% of production comes from mechanised underground mines. Underground mine productivity is the third-lowest among Coal India's subsidiaries. It declined by 1.8% annually between 1981 and 1990, increased by 0.5% annually between 1990 and 1995, and declined by 3.5% annually between 1995 and 1998.

Table A.8
Coal Washery Capacity

Washery Name	Annual Capacity (Mt)	Type
Kargali	2.80	Non-coking
Kathara	2.90	Coking
Swang	1.00	Coking
Gidi	2.90	Non-coking
Rajrapa	2.45	Coking
Kedla	3.00	Coking
Piparwar	5.53	Non-coking
Total	**20.58**	

Coal Quality and Preparation

Coal produced by Central Coalfields Ltd has high inherent ash content. Coking quality coals in particular often require beneficiation to compete, and to produce coke that does not impugn blast-furnace performance and pig-iron quality. The company operates seven washing plants with a rated capacity of 20.6 Mt per year. Four of the plants, with a capacity of 9.4 Mt per year, are designed to produce coking coal. The remaining three, with a capacity of 11.2 Mt per year, are designed to produce steam coal. The largest plant, Piparwar, which is designed for steam coal production, was added in 2000.

Prior to the addition of Piparwar, Central Coalfields shipped between 4.2 Mt and 7.4 Mt per year of washed coal and middlings. This is significantly below the implied total operational capacity of the plants of 15.1 Mt per year. It is likely that as opencast-mined coal production has increased, the need to wash the coal has decreased. The company has also shifted production from coking coal to steam coal so there is less need to ship fully-washed coal. The recovery rate of washed coal has declined since 1993, from 55% to about 42-43%. At the same time, the middlings recovery rate has increased from 30% to 43%. Thus, although the total recovery rate has remained consistently in the 80% to 85% range, the fraction of middlings has increased significantly and total saleable coal quality has deteriorated. It is not known if this change in coal quality is a result of reaction to changing market requirements or problems with the quality of raw coal feed and washery performance. The addition of the Piparwar washery should significantly increase the company's ability to ship higher-quality steam coal.

Table A.9
Coal Preparation Summary
(Thousand tonnes)

	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
Raw Coal Production	33 978	30 844	30 599	32 113	33 035	32 057	32 402
Raw Coal Feed	8 770	8 420	8 870	8 370	8 590	7 390	4 930
Washed Coal	4 801	4 240	4 498	4 153	3 630	3 082	2 106
Washed Coal Recovery Rate (%)	55	50	51	50	42	42	43
Middlings	2 619	2 511	2 679	2 769	3 331	2 936	2 134
Middlings Recovery Rate (%)	30	30	30	33	39	40	43
Total Recovery Rate (%)	**85**	**80**	**81**	**83**	**81**	**82**	**86**

Production classified by coal quality shows a significant decline in coking coal production since the mid-1990s, along with a significant increase in steam coal production. Total raw coking coal production declined from 15.0 Mt in 1993 to 9.9 Mt in 1998. Within the coal quality ranges, production of lower-grade coking coal has remained consistently above 90% of the total. Production of higher-quality coking coal has declined modestly as a percentage of total production. Shipments of washed coal to the steel sector were 3.9 Mt in 1998.

Table A.10
Coking Coal Raw Production by Grade
(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
Washery-1	126	149	45	9	5	2
Washery-2	1 709	1 201	1 190	1 143	961	750
Washery-3	6 074	5 461	5 479	5 937	5 234	5 091
Washery-4	7 108	6 438	4 736	4 654	6 260	4 077
Total Coking	**15 017**	**13 249**	**11 450**	**11 743**	**12 460**	**9 920**

Steam coal production increased from 19 Mt in 1993 to 22.1 Mt in 1998. As with coking coal, there has been a shift away from higher-quality, lower-ash coals to lower-quality coal. The largest production increase has been in category F.

Nearly all output is sold in Bihar state, where the company is located. About 13% of total raw coal volume is washed and shipped primarily to the steel sector for coke-making. Electric power plants are the largest consumers and receive raw coal. In 1998, over 67% of company shipments were to the power sector. Completion of the Piparwar Preparation Plant should increase shipments of washed thermal coal. Other major consumers include the fertilizer, base metals, brick, cement, paper, and household and commercial sectors.

About 80% of shipments are made by rail, while 13% go by road, leaving 7% shipped by "other means".

Table A.11

Steam Coal Raw Production by Grade

(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
A	2 019	25	104	221	202	119
B	1 737	2 107	1 309	1 529	1 305	1 201
C	1 280	1 484	1 667	1 649	1 649	1 877
D	1 846	1 339	1 380	770	1 195	229
E	12 002	12 559	13 814	14 840	7 742	9 907
F	78	81	858	1 360	8 483	8 806
Ungraded	0	0	17	0	0	0
Total Steam	**18 962**	**17 595**	**19 149**	**20 369**	**20 576**	**22 139**

Financial Performance

Despite possessing a transportation advantage by selling in the state of Bihar, Central Coalfields Ltd has lost money in five out of the six years for which data are available. The government announced in early 2001 that the company was on the "sick company" list, equivalent to declaring bankruptcy. The company's non-coking markets are protected by significant tariffs and imported coking coal prices appear to leave a margin sufficient to make a profit. Nevertheless, the company has reduced its coking coal output, and lowered the quality of its steam coal output.

Table A.12
Financial and Competitive Performance

	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
Profit/(Loss) US$m	22.93	(38.73)	(0.31)	(4.68)	(24.03)	(39.42)	
Profit/(Loss) US$/t	0.67	(1.26)	(0.01)	(0.15)	(0.73)	(1.23)	
Coking Coal Import Cost US$/t[1]				69.23	66.67	65.19	
Non-coking Coal Import Cost US$/t[1]				53.04	41.73	37.38	
Average India Coal Pit-head Value US$/t[2]	14.82	14.10	13.97	15.23	16.16	16.62	
Average Price Paid to Company, US$/t Raw Steam Coal[3]					12.10	10.70	
Average Price Paid to Company, US$/t Raw Coking Coal[3]				20.16	17.41	15.55	
Cost of Labour US$/t						3.83	3.62

1. Landed cost, does not include import taxes.
2. Value for all India steam and coking coal production.
3. Estimated using posted prices for run-of-mine steam and coking coal and raw coal production.

The quality of steam coal production may be a contributing factor to mounting financial losses, as the average price it commands in the market is far below the average pit-head value for all Indian steam coal. It is possible that the company's completion of a large new preparation plant will allow it to ship higher-quality and higher-priced thermal coal into new markets, which could improve financial performance. However, in order to approach world standard scale of operations and productivity at individual mines, enormous investment in equipment and training will be required.

Eastern Coalfields Ltd

Eastern Coalfields Ltd produces primarily thermal coal and a small quantity of coking coal. In the fiscal year 1999, the company produced 26.7 Mt of coal, of which 99% was thermal coal and 1% coking coal. It operates 119 mines and has headquarters in Sanctoria, north-western West Bengal. The company operates mines in the Raniganj coalfield in the state of West Bengal, and in the Mugma and Rajmahal coalfields in Bihar. Of the production in Bihar (10.6 Mt in 1999) most was from opencast operations, whereas most of the production in West Bengal (16.1 Mt in 1999) was from underground operations.

Production reached a peak of 29.6 Mt in 1996, but declined for two successive years to 27.4 Mt in 1997 and 26.7 Mt in 1998. Preliminary statistics for 1999 indicate that production declined again to about 25.1 Mt. Estimates for 2000 suggest total production of about 27 Mt.

Production and Productivity

Over the 1990s, there was a notable shift in production from underground to opencast production. In 1993, opencast mined coal was 8 Mt, about 35% of total production. By 1998, opencast production was 13.8 Mt, 52% of total production. Thermal coal accounts for most of the increase in opencast production. Nearly all opencast mines are mechanised. The company operates one dragline for overburden removal. Most overburden removal and coal production is carried out with shovels. Overburden is drilled and "shot" before bulldozers and shovels remove it. A fleet of 369 trucks of various sizes haul coal and overburden. Productivity at the opencast mines is well below the average for all Coal India operations. Although productivity at opencast operations improved steadily through the 1980s and early 1990s, it has declined steadily since 1997. At 3.64 tonnes per miner per shift in 1998, the performance was the fourth-lowest of all the subsidiaries. Preliminary data for 1999 suggest that opencast productivity declined steeply to less than three tonnes per miner per shift.

Table A.13

Underground and Opencast Production by Method

Production Method	1998-1999 Production (Thousand tonnes)	Proportion of Undergound or Opencast Production (%)	Proportion of Total Production (%)
Conventional Bord and Pillar	10 470	80.9	38.5
Mechanised Bord and Pillar	1 467	11.4	5.4
Conventional Longwall	57	0.4	0.2
Mechanical Longwall	828	6.4	3.0
Other Underground Methods	115	0.9	0.4
Mechanical Opencast	14 224	99.9	52.4
Manual Opencast	2	0.1	0.1
Total	**27 163**		**100.0**

Underground production has declined from 14.4 Mt in 1993 to 12.9 Mt in 1998. Although a major effort has been made since the early 1980s to install mechanised longwall systems, the projects have shown little success. Indeed, despite huge investments in mechanisation, productivity in underground operations has remained flat for the last twenty years. The company still relies upon conventional (manual) bord-and-pillar mining for over 80% of its underground coal production. Mechanised bord-and-pillar techniques are used for about 11% of production. Despite huge investments, longwall production is less than 8% of total underground production.

Coal Quality and Preparation

None of the coal produced is washed. Because the Raniganj coalfield possesses some of the best coal reserves in India, the company has generally been able to ship relatively high-grade crushed and screened coal. About 3% of raw coal production is shipped to steel plants at Durgapur and Burnpur in West Bengal, and Bokaro in Bihar. The remaining raw coal is shipped to thermal coal consumers.

Development of opencast mines, particularly in Bihar, has introduced lower-grade steam coal into the product mix. Much of the coal mined in the Mugma and Rajmahal coalfields was targeted for the electricity sector, where boilers were thought to be able to handle lower-quality, higher-ash coal. However, the dramatic shift from higher-grade steam coals, which comprised 73% of production in 1993, to lower-grade coals, which comprised 37% of production in 1998, was not really accepted by the market. Domestic targets for higher-quality coal have not been met in recent years, while supply of lower-quality coal has exceeded demand.

Table A.14

Coking Coal Raw Production by Grade

(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
Semi-coking 1	186	139	131	145	140	213
Washery-2	0	19	9	1	36	20
Washery-3	370	80	44	48	103	109
Washery-,4	50	195	174	172	73	40
Total Coking	**606**	**432**	**359**	**366**	**352**	**382**

About 90% of the coal is shipped by rail, either by dedicated train or by regular rail. Most of the remainder is shipped by truck. In 1998, 77% of thermal coal output was sold to the power sector. The National Thermal Power Corporation is a major customer and receives coal by dedicated trains at its Khalgaon and Farakaha power complexes in Bihar and West Bengal. Other important consumers include the paper, cement, brick and household sectors.

Table A.15

Steam Coal Raw Production by Grade

(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
A	968	880	1 822	1 734	1 041	1 177
B	10 464	10 138	9 310	9 868	8 965	9 111
C	4 714	5 061	5 529	5 671	6 075	6 132
D	884	1 561	1 307	1 284	1 017	1 053
E	871	904	829	768	849	616
F	4 097	5 873	8 344	9 955	9 138	8 269
Total Steam	**21 999**	**24 417**	**27 142**	**29 281**	**27 086**	**26 358**

Financial Performance

Despite possessing some of the highest-quality coal reserves in India located near major coking and thermal coal markets, Eastern Coalfields Ltd has chronically lost money. The company is currently on the "sick company" list of the Indian government, the equivalent of bankruptcy. In early 2000, the Controller and Auditor-General of India issued a report on the company's performance, which concluded :

"Although the Company owns some of the best coalfields in the country and superior quality coal forms 63 per cent of its total coal reserve it has failed to achieve any of its objectives and stands referred to the Board of Industrial and Financial Reconstruction as a sick company.... Beset with problems of surplus labour, virtually stagnant labour productivity, high (state royalties) and growing competition under the liberalised scenario the woes of the company have been compounded by injudicious investment decisions, poor project planning, inappropriate choice of technology and unexplained coal shortages." [1]

Table A.16
Financial and Competitive Performance

	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
Profit/(Loss) US$m[1]	(477.97)	(659.01)	(780.21)	(341.14)	(541.89)	(560.69)
Profit/(Loss) US$/t[1]	(7.81)	(8.63)	(8.87)	(3.47)	(5.54)	(5.45)
Production Cost US$/t[1]	26.70	25.04	24.40	22.79	25.44	25.35
Coking Coal Import Cost US$/t[2]				69.23	66.67	65.19
Non-coking Coal Import Cost US$/t[2]				53.04	41.73	37.38
Average India Coal Pit-head Value US$/t[3]	14.82	14.10	13.97	15.23	16.16	16.62
Average Price Paid to Company, US$/t Raw Steam Coal[4]					16.16	15.30
Average Price Paid to Company, US$/t Raw Coking Coal[4]				21.86	22.33	18.91

1. Does not include Coal Price Regulation Account subsidy granted in fiscal years 1993, 1994 and 1995.
2. Landed cost, does not include import taxes.
3. Value for all India steam and coking coal production.
4. Estimated using posted prices for run-of-mine steam and coking coal and raw coal production.

In late 1998, the company announced that it would be closing 64 underground operations, primarily in West Bengal, which would result in laying-off of 71 000 workers. The state of West Bengal agreed to reduce its royalty rate from 45% to 25%. Subsequently, Coal India Ltd intervened, and restricted the closures to 20 mines and laying-off of 16 000 workers. Between 1996 and 1999, total company employment declined by nearly 23 000, from 158 918 to 135 957. Nevertheless, coal production costs continue to exceed US$25 per tonne, and the company continues to lose money. The most recent statistics available indicate that the company is losing, on average, between US$ 5 and US$ 6 on each tonne it ships.

1. *Appraisal of Eastern Coalfields Limited*, Report of the CAG on the Union Government, 18 September 2000.

Mahanadi Coalfields Ltd

Mahanadi Coalfields Ltd was formed in 1992 to operate 22 coalmines in the Talcher coalfield and Ib Valley coalfield in the state of Orissa. The company's headquarters are in Sambalpur in the north-east of Orissa. Production of thermal coal in fiscal year 2000 reached 44.8 Mt. About 96% of the company's 1998 production was from surface mines.

Production and Productivity

Between 1992 and 2000, raw coal production increased from 23.6 Mt to 44.8 Mt. Production increased sharply from 1994, as the company moved to supply thermal coal to nearby power plants.

Almost all (96%) of production is at mechanised opencast operations. The company operates thirteen opencast mines with production levels ranging from 0.6 Mt to 7 Mt annually. Average annual production is about 3.3 Mt per mine.

Table A.17

Underground and Opencast Production by Method

Production Method	1998-1999 Production (Thousand tonnes)	Proportion of Undergound or Opencast Production (%)	Proportion of Total Production (%)
Conventional Bord and Pillar	843	50.8	1.9
Mechanised Bord and Pillar	815	49.2	1.9
Mechanical Opencast	41 854	100.0	96.2
Total	**43 512**		**100.0**

Draglines and shovels are used for overburden removal. Coal is mined with shovels and end-loaders. Overburden and coal are hauled by 85-tonne dumpers. The company has the highest opencast productivity of all of Coal India companies. Based on 1999 productivity of 4 200 tonnes per miner per year, and the scale of operations, operational performance at several of the company's opencast mines approaches the standard in some commercially competitive exporting countries. Productivity at opencast operations has increased in every year of operation, with average productivity growing at 4.3% per year between 1995 and 1999. Opencast productivity increased by 8.5% in 1999, the last year for which data are available.

Each year between 1.7 Mt and 1.9 Mt of raw coal is produced from underground mines, but the proportion of underground coal is declining as the company focuses on opencast production. About half the coal is produced at mechanised bord-and-pillar mines, while the remainder is produced at conventional (manual) bord-and-pillar mines. Underground production is concentrated in the Talcher and Orient Areas. Average annual production from underground mines is about 185 000 tonnes per mine, with mines ranging in size from 100 000 to 300 000 annual tonnes. Productivity in the underground operations is slightly above the average for all of Coal India's companies, but heavy reliance on manual labour results in relatively low productivity. Productivity growth at the underground operations has been very sluggish. Average productivity growth between 1995 and 1999 was 0.7% per year. Underground productivity increased by 2.9% in 1999, the last year for which data are available.

Coal Quality and Preparation

Only unwashed coal is shipped. The company has proposed installing washing plants that would enable it to ship washed coal to consumers located a greater distance from the coal-processing sites. The plants are currently proposed as "build-operate-transfer" facilities, but although washing plants would probably improve the company's marketing prospects, no agreed installation project has yet been announced.

Coal from the mines is crushed and sized at coal-handling plants. Six grades of thermal coal are shipped. Approximately 90% of production is the lowest-quality grade F thermal coal, which is supplied to nearby power plants. Production of higher grades, from C to E, has increased since the mid-1990s, but these grades represent less than 10% of total output. Production of the highest grades A and B represent less than 1% of total output.

All coal is shipped to consumers in Orissa. Over 87% of deliveries are by rail. Approximately 8 Mt per year is shipped to power stations using dedicated trains operating between the coal handling plants and power stations. Conventional scheduled trains carry the remaining rail-borne coal. Over 5% of the coal is shipped by conveyor belt to power plants adjacent to the mine sites and the remaining 7% is delivered by truck.

Table A.18

Steam Coal Raw Production by Grade

(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
A	345	339	157	140	127	109
B	62	63	249	228	220	197
C	1 407	1 518	929	923	928	539
D	598	564	1 810	1 825	1 665	1 962
E	286	365	0	0	355	1 274
F	21 604	24 476	29 556	34 249	38 336	39 631
Total Steam	**24 303**	**27 325**	**32 701**	**37 365**	**41 632**	**43 712**

Nearly 84% of the production is consumed by the power sector. Another 8% is shipped as thermal coal to the Rourkela Steelworks. About 4% goes to the residential and commercial sectors. The remaining 4% goes to several industrial consumers, with the paper, fertilizer, cement, base metals and brick sectors being the main markets.

Financial Performance

The company has contributed between 10% and 17% of Coal India's total raw coal production since 1992. In 1992 and 1993, when the company was starting up, it provided between 3% and 7% of Coal India's total profits. Since 1996, the company has provided between 32% and 40% of Coal India's total profits. The company is the best performer of all the subsidiaries.

Table A.19

Financial and Competitive Performance

	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
Profit/(Loss) US$m	7 860	22 144	7 823	98 452	182 046	158 031	141 300
Profit/(Loss) US$/t	0.32	0.80	0.24	2.62	4.35	3.62	3.24
Production Cost US$/t				6.43	6.06	5.79	5.34
Non-coking Coal Import Cost US$/t[1]				53.04	41.73	37.38	
Average India Coal Pit-head Value US$/t[2]	14.82	14.10	13.97	15.23	16.16	16.62	
Average Price Paid to Company, US$/t Raw Steam Coal				9.05	10.41	9.41	8.58

1. Landed cost, does not include import taxes.
2. Value for all India steam and coking coal production.

Although the price for the company's lower-quality coal has not exceeded US$ 11 per tonne in the past four years, improved productivity has kept production costs low, resulting in a gross profit per tonne in the US$ 2.50 to US$ 3.50 range. Although washing facilities would require additional capital and operating expenses, they would also increase the competitiveness of the company's coal in more distant markets, and increase the average price it could charge.

North-Eastern Coalfields Ltd

North-Eastern Coalfields produces a relatively small amount of coal and is directly managed by Coal India Ltd. The following tables give brief summaries of recent performance.

Production and Productivity

Table A.20

Underground and Opencast Production by Method

Production Method	1998-99 Production (Thousand tonnes)	Proportion of Undergound or Opencast Production (%)	Proportion of Total Production (%)
Manual Underground	180	100	28.3
Mechanical Opencast	457	100	71.7
Total	**637**		**100.0**

Coal Quality and Preparation

Table A.21
Steam Coal Raw Production by Grade
(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
A	0	0	0	0	0	557
B	0	0	0	0	0	80
Ungraded	1 198	1 860	1 271	752	687	0
Total Steam	**1 198**	**1 860**	**1 271**	**752**	**687**	**637**

Northern Coalfields Ltd

Northern Coalfields Ltd was formed in 1986, with headquarters in Singrauli in north-eastern Madhya Pradesh. It mines coal in the Singrauli coalfield which straddles the boundary between Madhya Pradesh and Uttar Pradesh. The company operates nine mines, five of which, accounting for about 57% of total production, are in Madhya Pradesh and four, accounting for about 43% of total production, in Uttar Pradesh. Only thermal coal is produced.

Production and Productivity

Between 1993 and 1999, production increased from 31.4 Mt to 38.4 Mt. All of the coal is produced at opencast mines. The average mine size is about 4.3 Mt per year, with a range 2.5 Mt per year to 9.1 Mt per year. The mines are dragline and shovel operations. Overburden is drilled and shot, and draglines and bulldozers used to remove overburden. Dragline bucket sizes range from 1.2 sq m to 24 sq m. Coal production is with shovels, which have bucket sizes ranging from 1.4 sq m to 5.7 sq m. Overburden and coal are hauled in dumpers which range in capacity from 50 tonnes to 170 tonnes. Both the scale of equipment and the scale of these mines suggest world standard mining operations.

Table A.22
Underground and Opencast Production by Method

Production Method	1998-99 Production (Thousand tonnes)	Proportion of Undergound or Opencast Production (%)	Proportion of Total Production (%)
Mechanical Opencast	36 518	100	100
Manual Opencast	0	0	0
Total	**36 518**	**100**	**100**

The company's average productivity has consistently ranked the highest of all of Coal India subsidiaries, and its opencast productivity ranks second. Although productivity, at 2 700 tonnes per miner per year, is below world-class standards for surface mines, these are very high performance mines by Indian standards. Average productivity increased by 1.5% per year between 1995 and 1999, although productivity declined slightly in 1999.

Coal Quality and Preparation

None of the coal is washed. About 90% is crushed and screened at mechanical coal-handling plants and the remainder is cleaned and sized manually. Sampling and analysis is conducted jointly with customers at all major coal-loading points of the company. The company ships about 46% of its volume as relatively high-quality steam coal, and 54% in lower-quality ranges. Production of lower-quality thermal coal has increased from 45% of the total in 1993 to 54% of the total in 1999. Production of higher-quality thermal coal has remained stable at about 17 Mt per year while production of lower-quality coal has increased from 14 Mt per year to 19 Mt per year.

Table A.23

Steam Coal Raw Production by Grade

(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
C	17 371	15 841	17 570	17 335	16 272	17 021
D	2 115	3 152	3 416	3 791	4 577	3 860
E	11 925	13 510	14 217	15 883	16 554	15 637
Total Steam	**31 411**	**32 504**	**35 203**	**37 010**	**37 403**	**36 518**

About 42% of production is consumed in Uttar Pradesh and 58% in Madhya Pradesh. Rail delivers 30.3 Mt or 85%, of which about 25 Mt is by dedicated trains serving electric power stations. Another 2.3 Mt or 6% is transported to nearby power facilities by a ropeway conveyor system. Nearly 96% of shipments are to electric power plants and the rest to the base metal and cement industries, and for household and commercial use.

Financial Performance

Northern Coalfields Ltd has traditionally contributed between 10% and 15% of Coal India's profits, while producing about 15% of the company's raw coal volume. In the past two fiscal years for which data are available, 1998 and 1999, it was responsible for 24% and 31% of profits respectively.

Unit production costs have declined steadily for the past seven years and have remained fairly consistently below US$ 10 per tonne for the last four years. While average sales price has declined somewhat since 1997, gross profit margins have been maintained well above US$ 5 per tonne by reducing costs and increasing shipments of coal. Although rail despatches are currently to nearby power plants where the economics of unwashed coal are viable, these mines would also be possible competitive sources of washed coal for more distant markets. While investment in washing facilities and possibly transportation infrastructure would be necessary to achieve this goal, the company has demonstrated that it can supply thermal coal competitively to the power sector and earn a profit on a sustained basis.

Table A.24

Financial and Competitive Performance

	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
Profit/(Loss) US$m	83 228	62 123	56 727	219 615	212 981	211 737	219 355
Profit/(Loss) US$/t	2.65	1.91	1.61	5.93	5.69	5.80	5.71
Production Cost US$/t	12.65	11.74	12.23	9.58	10.58	9.96	9.55
Non-coking Coal Import Cost US$/t[1]				53.04	41.73	37.38	
Average India Coal Pit-head Value US$/t[2]	14.82	14.10	13.97	15.23	16.16	16.62	
Average Price Paid to Company, US$/t Raw Steam Coal	15.30	13.65	13.85	15.51	16.27	15.76	15.26

1. Landed cost, does not include import taxes.
2. Value for all India steam and coking coal production.

South-Eastern Coalfields Ltd

South-Eastern Coalfields Ltd began operating as an independent subsidiary of Coal India in 1986. The company's headquarters are at Bilaspur in eastern Madhya Pradesh. It operates 67 underground mines and 18 opencast mines in the Korba, Mand-Raigarh, Ramkola-Tatapani and central India coalfields. It produces mainly thermal coal, but also a small volume of coking coal.

Production and Productivity

Production increased from 44.1 Mt in 1991 to 58.6 Mt in 1999. Production from opencast mines has increased more rapidly than underground production. About 73% of production is from opencast operations. Although productivity generally ranks near the top for all Coal India subsidiaries, the company's average productivity declined at both underground and surface operations in fiscal year 1998.

The amount of coal produced from underground mines varies between 14 Mt per year and 16 Mt per year, but has declined steadily as a proportion of total production as opencast production has been boosted. The company operates 67 underground mines ranging in size from 3 570 tonnes per year to 672 000 tonnes per year, averaging 235 000 tonnes per year. About 70% of underground production is mechanised, with mechanised bord-and-pillar mining by far the main means of production. About 4.5% of underground production is by mechanised longwall technology at two mines. Despite a significant penetration of mechanised techniques, manual mining techniques still account for over 30% of the company's underground production. Average productivity is third-highest of Coal India's subsidiaries.

Underground productivity, although the highest among Coal India's subsidiaries, remains at about 300 tonnes per miner per year, which is far below world standard. Underground productivity growth has been sluggish, rising only by 1.6% annually between 1990 and 1995, and slowing to 1.1% annually between 1995 and 1998. Productivity in fiscal year 1998, the most recent year for which data are available, declined by 2.2%.

Table A.25

Underground and Opencast Production by Method

Production Method	1998-99 Production (Thousand tonnes)	Proportion of Undergound or Opencast Production (%)	Proportion of Total Production (%)
Conventional Bord and Pillar	4 813	30.1	8.4
Mechanised Bord and Pillar	10 472	65.4	18.2
Mechanical Longwall	719	4.5	1.2
Mechanical Opencast	41 558	100.0	72.2
Total	**57 562**		**100.0**

Opencast production increased from 33.1 Mt in 1993 to 41.7 Mt in 1998. Capacity of opencast mines ranges from 6 000 tonnes per year to 17.3 Mt per year. The average size of opencast operation is 2.3 Mt per year, but the size distribution falls into two distinct categories. There are nine opencast mines with production above 1 Mt per year and nine with production well below that level. The huge Gevra Mine produced 18 Mt of coal in 1999 and reports productivity of over 6 000 tonnes per man per year. Opencast mining is completely mechanised. Standard equipment at opencast sites includes 10 sq m shovels capacity and 120 tonne dumpers. There are plans to install 40 sq m shovels and 240 tonne dumpers at the Gevra Mine. Opencast productivity is the second-highest of all Coal India subsidiaries and improved at an average 3.1% annually between 1990 and 1995. Between 1995 and 1998, productivity growth slowed to just 0.3% annually. The most recent productivity data indicate a decline of 3.1% for opencast productivity in fiscal year 1998.

Coal Quality and Preparation

Only unwashed coal is shipped. Raw coal is crushed and screened mechanically at coal-handling plants. Although the company produces a modest quantity of coking coal, the main product is thermal coal.

Two grades of coking coal were shipped in the most recent fiscal year for which coal quality data are published. About 0.5 Mt of unwashed coking coal is shipped annually to the Bhillai Steelworks. Coking coal volume, although small, nearly doubled in fiscal year 1998.

Table A.26
Coking Coal Raw Production by Grade
(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
Semi-coking-1	229	225	235	278	290	170
Washery-4	0	0	0	0	0	293
Total Coking	**229**	**225**	**235**	**278**	**290**	**463**

The company's largest market is the power-generating sector. The company supplies seven power companies with combined generating capacity of 10.3 GW. There are plans to increase supplies to the power sector by another 23 Mt per year, when 4.3 GW of additional coal-fired capacity is added to the generating base.

The proportion of higher-grade A, B and C coal has increased from 24% of thermal production in 1993 to 31% of production in 1998. Production of the three lower grades of coal has correspondingly declined as a share of the total ; however, within the lower grades there has been a shift from grades D and E to Grade F.

About 87% of the coal is delivered by rail, of which nearly 16 Mt per year (27%) is shipped on dedicated trains which haul coal exclusively between the mines and designated power plants. About 7% of production is sent directly to nearby power plants by conveyor belt. The remaining 6% of coal is despatched by truck.

Table A.27
Steam Coal Raw Production by Grade
(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
A	388	399	493	451	469	498
B	1 351	1 287	2 161	2 581	2 401	4 965
C	9 393	10 001	11 256	11 313	11 599	12 044
D	7 162	7 967	7 945	8 082	8 117	5 499
E	1 500	896	739	530	698	0
F	27 572	29 358	30 336	32 070	33 030	34 014
Total Steam	**47 366**	**49 908**	**52 930**	**55 027**	**56 314**	**57 020**

Although 83% of production went to the electric power sector, other important consumers include the household and commercial sectors (7%), the cement sector (6%), the fertilizer sector (1%) and the steel sector (1%). Small amounts of coal are also supplied to the paper, textile and brick industries.

Financial Performance

Although the company is typically responsible for about 22% of Coal India's total raw coal production, the company has contributed between 26% and 47% of the holding company's profits. The contribution to profits has declined as a proportion of the total in recent years, but this is due more to rising profits from some other subsidiaries than to declining profits at South-Eastern Coalfields Ltd. In absolute terms, profits have increased strongly since 1995. Production costs, for years where data are published, have been on a downward trend, and a gross profit margin in excess of US$ 3/tonne has been maintained consistently. Although the decline of productivity in 1998-1999 is troubling, the company appears to be generating sufficient return to warrant further investment. Investing earnings in further mechanisation and capacity expansion at competitive mine sites could generate further profits over an extended period.

Table A.28
Financial and Competitive Performance

	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
Profit/(Loss) US$m	51 674	29 883	24 326	175 029	194 430	178 586
Profit/(Loss) US$/t	1.09	0.59	0.46	3.16	3.43	3.11
Production Cost US$/t				15.32	15.82	14.76
Coking Coal Import Cost US$/t[1]				69.23	66.67	65.19
Non-coking Coal Import Cost US$/t[1]				53.04	41.73	37.38
Average India Coal Pit-head Value US$/t[2]	14.82	14.10	13.97	15.23	16.16	16.62
Average Coal Sales Price US$/t				18.48	19.25	17.87
Average Price Paid to Company, US$/t Raw Steam Coal[3]					13.93	12.11
Average Price Paid to Company, US$/t Raw Coking Coal[3]				26.81	23.71	17.65

1. Landed cost, does not include import taxes.
2. Value for all India steam and coking coal production.
3. Estimated using posted prices for run-of-mine steam and coking coal and raw coal production.

Western Coalfields Ltd

Western Coalfields Ltd operates 97 underground and opencast coalmines in Maharashtra and Madhya Pradesh. The headquarters are at Nagpur in eastern Maharashtra. The company also operates a washing facility at Nandan in Madhya Pradesh. In Maharashtra, coal is mined in the Chanda and Wardha coalfields. Mining in Madhya Pradesh is confined to the Kanhan, Pench and Patharkheda coalfields. Most of the coal production in Madhya Pradesh is underground, while most production in Maharashtra is from opencast operations. Coal is delivered mainly to thermal coal consumers in west and north-west India, although the company also produces a small volume of coking-quality coal.

Production and Productivity

Raw coal production increased from the early 1990s until fiscal year 1998, when it declined slightly. Production growth resumed in fiscal year 1999, when output reached 33.9 Mt.

Fifty underground mines produced coal in 1998. Over 51% of underground production is by manual labour at conventional bord-and-pillar operations, while the remaining 49% is mined in mechanised bord-and-pillar operations. Production from underground mines has increased slowly, from 8.5 Mt in 1993 to 9.1 Mt in 1998. The proportion of underground coal has declined, however, as production at surface operations increased more rapidly. Average underground productivity is the third-highest among all Coal India's subsidiaries, but at about 225 tonnes per miner per year it is very low by world standards. Underground mining productivity declined at an annual rate of 1.2% between 1981 and 1990, but increased by 0.3% per year between 1990 and 1995, by 3.2% per year between 1995 and 1998, and by 4.1% in fiscal year 1998. The size of the underground mines varies from just 1 000 tonnes per year to 847 000 tonnes per year, with the average size 182 000 tonnes per year.

Table A.29

Underground and Opencast Production by Method

Production Method	1998-99 Production (Thousand tonnes)	Proportion of Undergound or Opencast Production (%)	Proportion of Total Production (%)
Conventional Bord and Pillar	4 960	51.4	15.6
Mechanised Bord and Pillar	4 738	48.6	14.9
Mechanical Opencast	22 047	100.0	69.5
Total	**31 745**		**100.0**

In 1998, Western Coalfields Ltd operated 29 opencast mines, and five mines which were combined opencast and underground. All of the company's opencast production is mechanised, but no equipment or opencast mining logistics information appears to be published. The average size of opencast mine is 733 000 tonnes per year. Mines vary in size from 2.5 Mt per year to less than 100 000 tonnes per year. Opencast production has increased rapidly, growing from 16 Mt in 1993 to 21.2 Mt in 1998. The proportion of surface-mined coal has increased from 62% in 1993 to 67% in 1998. Opencast productivity has increased steadily since 1981. Productivity increased at an average rate of 1.4% annually between 1995 and 1998 but nevertheless opencast productivity is below the average opencast productivity for all Coal India's subsidiaries, and at about 1 250 tonnes per miner per year, remains well below world standard. Productivity at surface operations declined by 1.7% in fiscal year 1998.

Table A.30

Coking Coal Raw Production by Grade

(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
Washery-2	762	854	755	703	738	654
Total Coking	**762**	**854**	**755**	**703**	**738**	**654**

Coal Quality and Preparation

The company sells both washed and unwashed coal. Washed coal is graded as coking coal, and is delivered by rail to the Bhillai Steelworks in Madhya Pradesh.

Table A.31
Coal Washery Capacity

Washery Name	Annual Capacity (Mt)	Year On-line
Nandan	0.7	Before 1993

The Nandan washery operated by Western Coalfields Ltd achieved a clean coal recovery rate of between 48% and 61% between 1993 and 1999. Clean coal recovery has declined sharply in the last two years for which data are available. Middlings production at the washery, which is sold as a lower-grade thermal coal, has averaged between 28% and 45%. As clean coal recovery has fallen, middlings recovery has increased to the higher end of the range. There is no information on the change in the recovery rate so it is not possible to determine if the washery is responding to a change in market needs or if there are problems with either washery performance or raw coal feed.

Table A.32
Coal Preparation
(Thousand tonnes)

	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
Raw Coal Production	25 749	27 196	27 798	31 225	33 628	31 565	33 860
Raw Coal Feed	610	680	690	650	680	660	620
Washed Coal	369	390	420	410	393	347	297
Washed Coal Recovery Rate (%)	60	57	61	63	58	53	48
Middlings	189	205	197	185	262	292	276
Middlings Recovery Rate (%)	31	30	29	28	39	44	45
Total Recovery Rate (%)	**91**	**88**	**89**	**92**	**96**	**98**	**92**

Thermal coal is not washed. Crushed and screened coal is shipped from coal-handling plants by rail and truck. While coking coal production has shown a slight downward trend for the past seven years, thermal coal production increased steadily to 1997, and then declined by nearly 2 Mt in 1998. Preliminary data indicate that thermal coal production in 1999 increased to about 33.2 Mt, suggesting that the upward trend has resumed.

Western Coalfields Ltd sells six grades of thermal coal, with higher-quality coals, grades A, B and C, accounting for about 15% of raw coal production, and lower-quality coals, 85%. There was a significant change in the proportion of higher-quality coal produced in 1998, with higher-quality coal production declining by nearly 6.5 Mt, and lower-quality coal production up by nearly 4.4 Mt.

The largest proportion of deliveries is by rail, accounting for 68%. Coal is transported both by conventional rail and by dedicated trains hauling coal to power plants. About 26% of coal volume is shipped by truck and another 4% is conveyed directly to generating units by belt. The remaining coal is sent out "by other means".

The largest market is the power sector, which received 24.2 Mt, or 80% of total coal volume in 1998. Nearly 11% of coal is consumed in the household and commercial sectors. Industrial consumption amounts to 9%, including the cement, steel, textile, paper and brick industries.

Table A.33

Steam Coal Raw Production by Grade

(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
A	180	168	151	0	160	0
B	1 763	1 763	719	1 725	1 093	1 227
C	9 277	8 883	7 718	8 634	9 980	3 554
D	8 545	11 322	16 174	17 581	18 877	14 323
E	2 669	2 793	1 547	1 958	2 180	11 249
F	2 553	1 413	736	624	600	513
Total Steam	**24 987**	**26 342**	**27 045**	**30 522**	**32 890**	**30 866**

Financial Performance

Western Coalfields Ltd typically produces about 12% of Coal India's total raw coal production, but returns between 24% and 32% of its profits. However, there was a sharp decline in the company's profits in fiscal year 1998, and the company's share of total Coal India profits dropped to 19%. A profit margin in excess of US$ 4 per tonne was maintained in 1998, and profit growth and acceptable margins were reported in 1996 and 1997. The 1998 decline in profit was over US$ 50 million and is obviously of concern since it was accompanied by declining productivity, an increase in production costs, and a decline in average coal quality.

Table A.34
Financial and Competitive Performance

	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
Profit/(Loss) US$m	11 673	23 303	31 163	158 298	176 224	125 801
Profit/(Loss) US$/t	0.45	0.86	1.12	5.07	5.24	4.01
Production Cost US$/t		14.28	16.77	17.12	17.10	18.16
Coking Coal Import Cost US$/t[1]				69.23	66.67	65.19
Non-coking Coal Import Cost US$/t[1]				53.04	41.73	37.38
Average India Coal Pit-head Value US$/t[2]	14.82	14.10	13.97	15.23	16.16	16.62
Average Coal Sales Price US$/t		15.27	16.84	21.11	20.81	20.48
Average Price Paid to Company, US$/t Raw Coking Coal[3]				22.20	23.71	20.07

1. Landed cost, does not include import taxes.
2. Value for all India steam and coking coal production.
3. Estimated using posted prices for run-of-mine steam and coking coal and raw coal production.

Singareni Collieries Company Ltd

Singareni Collieries Company Ltd is jointly controlled by the Government of India and the state of Andhra Pradesh. The state government acquired a major share in 1956. Andhra Pradesh owns 51% of the share capital and the Government of India 49%. The company manages coalmining in the Khammam, Adilabad, Karimnagar and Warangal regions of Andhra Pradesh. It has headquarters in Kothagudem in north-central Andhra Pradesh. Only thermal coal is produced from both underground and opencast mines.

Production and Productivity

Raw coal production from opencast mines has increased from 10.1 Mt in 1993, while production from underground mines has declined from 15.1 Mt in the same year. In 1998, production from opencast mines was 14.4 Mt or 53% of total output, and 13 Mt from underground mines, or 47% of total output.

Coal Quality and Preparation

While Table A.36 does not show any clear pattern throughout the years, there is some indication that the average quality had started to increase but has then dropped back.

Table A.35
Underground and Opencast Production by Method

Production Method	1998-99 Production (Thousand tonnes)	Proportion of Undergound or Opencast Production (%)	Proportion of Total Production (%)
Conventional Bord and Pillar	10 495	81.0	38.4
Mechanised Bord and Pillar	817	6.3	3.0
Mechanical Longwall	1 642	12.8	6.0
Mechanical Opencast	14 372	100.0	52.6
Total	**27 326**	**100.0**	**100.0**

Table A.36
Steam Coal Raw Production by Grade
(Thousand tonnes)

Grade	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
B	3 036	940	0	77	165	555
C	2 040	5 318	8 238	8 290	6 454	5 775
D	6 518	9 400	7 660	7 900	9 515	7 075
E	8 700	5 593	6 091	6 737	6 549	8 374
F	3 063	3 717	3 977	5 308	5 801	5 028
G	1 862	679	804	422	414	498
Total Steam	**25 219**	**25 647**	**26 770**	**28 734**	**28 899**	**27 304**

ANNEX B

STATISTICS

Table B.1

India's Comparative Performance in the World by Key Statistics

	1997 actual		2020 IEA projection
	Share (%)	Rank (1997)	Share (%)
GDP (US$ in PPP)	4	5th	5.9
Population	16.6	2nd	17
TPES (including CRW)	4.8	5th	6.3
TPES (excluding CRW)	3.1	7th	5.3
Coal Demand	6.8	3rd	10
Oil Demand	2.6	11th	4.6
CRW	18.2	2nd	16.2
Final Electricity Demand	3	8th	5.5
CO_2 Emissions	3.9	6th	6.2

Note : GDP = Gross domestic product ; TPES = Total primary energy supply ; PPP = Purchasing power parity ;
CRW = Combustible renewables and waste. Because of its non-commercial nature and questions related to reliability of data, combustible renewables and waste is shown separately.
Source : *World Energy Outlook 2000*, IEA/OECD Paris, 2000.

Table B.2
Economic and Energy Indicators

	1973	1978	1985	1990	1995	1998	1999
Population (million)	586.20	656.90	765.20	849.50	929.40	979.70	997.50
GDP (using exchange rates), 1995 US$ billion	120.90	154.20	202.30	275.10	353.20	421.70	449.10
TPES (including CRW), Mtoe	193.72	228.23	293.93	359.11	438.84	471.34	480.42
TPES (excluding CRW), Mtoe	67.38	86.65	131.60	183.30	250.19	276.05	282.40
Total Production of Energy (including CRW), Mtoe	**177.30**	**211.43**	**278.74**	**333.82**	**385.22**	**409.72**	**409.79**
of which :							
Production of Coal, Mtoe	39.86	52.14	76.38	106.06	136.79	150.41	147.28
Production of CRW	126.34	141.58	162.33	175.82	188.65	195.28	198.02
Total Net Imports of Energy, Mtoe *of which :*	**17.04**	**19.17**	**16.80**				**70.00**
Net Imports of Coal, Mtoe	0.24	0	1.15	3.09	7.65		10.76
Total Electricity Generation, TWh	**72.80**	**110.10**	**183.40**	**289.40**			**527.30**
Total Electricity Consumption, TWh	**59.90**	**90.70**	**149.10**	**238.20**			**417.60**

Source : *Energy Balances of Non-OECD Countries,* IEA/OECD Paris, 2001.

Table B.3
India's Primary Energy Supply, excluding Combustible Renewables and Waste

	1997		1999		2020 IEA Projection	
	Mtoe	%	Mtoe	%	Mtoe	%
Coal	153	57	157	56	336	47
Oil	88	33	94	33	243	34
Gas	18	7	21	7	111	16
Nuclear	3	1	3	1	10	1
Hydro	6	2	7	2	15	2
Other	0	0	0	0	1	0
Total	**268**	**100**	**282**	**100**	**716**	**100**

Source : *World Energy Outlook 2000*, IEA/OECD Paris, 2000.

Table B.4
Energy Balance of India, 1999, including Combustible, Renewables and Waste
(Thousand toe)

Supply and Consumption	Coal	Oil	Gas	Nuclear	Hydro	CRW	Electricity	Total
Indigenous production	**142 276**	**33 237**	**20 754**	**3 409**	**7 093**	**198 018**	**-**	**409 788**
Import	11 134	61 760	-	-	-	-	119	73 013
Export	-377	-2 604	-	-	-	-	-28	-3 009
International Marine Bunkers	-	-88	-	-	-	-	-	-88
Stock changes	-864	1 579	-	-	-	-	-	715
TPES	**157 169**	**93 884**	**20 754**	**3 409**	**7 093**	**198 018**	**92**	**480 418**
Electricity plants	-112 159	-2 376	-7 894	-3 409	-7 093	-	45 351	-87 581
Other transformation	-14 636	-1 370	-3 016	-	-	-	-	-31 934
Total Final Consumption	**30 374**	**90 138**	**9 844**	**-**	**-**	**198 018**	**32 529**	**360 903**
Industry Sector	30 113	22 164	9 166	-	-	22 559	13 857	97 859
of which : Iron and steel	11 752	718	-	-	-	-	2 518	14 988
Transport Sector	14	43 784	-	-	-	-	676	44 475
of which : Road	-	39 256	-	-	-	-	-	39 256
Other Sectors	247	19 576	678	-	-	175 459	17 995	213 955
of which : Residential	247	18 703	498	-	-	175 459	5 874	200 781
Non-energy Use	-	4 614	-	-	-	-	-	4 614

CRW = combustible renewables and waste.
Source : *Energy Balances of Non-OECD Countries*, IEA/OECD Paris, 2000.

Table B.5
Commercial Energy Profile

	1971	1990	1997	1971-90*	1990-97*
TPES (Mtoe)	63	184	268	5.8	5.5
Coal (Mtoe)	38	106	153	5.6	5.4
Oil (Mtoe)	22	60	88	5.5	5.6
Gas (Mtoe)	0.6	10	18	16	8.4
Final Electricity (Mtoe)	4	19	30	7.8	7.1
Industry (Mtoe)	19	65	83	6.8	3.6
Transport (Mtoe)	15	26	42	3.1	6.7
TPES/GDP (toe per US$)	0.16	0.20	0.20	1.2	0
TPES per Capita (toe)	0.11	0.22	0.28	3.5	3.7
CO_2 Emissions (Mt)	208	600	881	5.7	5.6

Note : "Commercial" energy is taken to be energy supply excluding combustible renewables and waste.
* Average annual growth rate, %.
Source : *World Energy Outlook 2000*, IEA/OECD Paris, 2000.

Table B.6

India's Electricity Generation and Capacity

	1997		1999		2020	
	GW	TWh	GW	TWh	GW	TWh
Coal	66	339	na	397	193	1 008
Oil	3	12	na	6	6	32
Gas	9	28	na	29	47	216
Nuclear	2	10	na	13	6	39
Hydro	22	75	na	81	50	171
Other Renewables	1	0	na	1	6	18
Total	**103**	**463**	**na**	**527**	**309**	**1 483**

na = not available.
Sources: *World Energy Outlook 2000*, IEA/OECD Paris, 2000 ; *Energy Balances of Non-OECD Countries*,IEA/OECD Paris, 2001.

Table B.7

Hard Coal Reserves in the States (Mt) to a depth of 1 200 metres as at January 2001

State	Proven Reserves	Indicated Resources	Probable Resources	Total
Andhra Pradesh	7 529.4	3 363.8	2 781.7	13 674.9
Arunachal Pradesh	31.2	11.0	48.0	90.2
Assam	259.4	26.8	34.0	320.2
Bihar	34 147.6	28 444.2	5 582.8	69 174.6
Madhya Pradesh	14 017.3	22 102.1	8 199.7	44 319.0
Maharashtra	4 388.5	1 301.7	1 605.4	7 295.6
Meghalaya	117.8	40.9	300.7	459.4
Nagaland	3.4	1.4	15.2	19.9
Orissa	11 307.7	23 728.5	16 535.1	51 571.3
Uttar Pradesh	766.0	295.8	0	1 061.8
West Bengal	10 845.6	10 925.7	4 147.3	25 918.5
Total	**84 413.9**	**90 241.8**	**39 249.8**	**213 905.5**

Source: Geological Survey of India in Ministry of Coal and Mines, *Annual Report 2000/01*.

Table B.8
India's Hard Coal Reserves by States and Deposits

State	Share of Proven Reserves (%)	Coalfields
Andhra Pradesh	9	Godavari Valley
Bihar	42	Jharia, East and West Bokaro, North Karanpura
Madhya Pradesh	16	Korba, Mand Raigarh, Hasdeos-Arrand
Maharashtra	5	Wardha Valley, Kamptee.
Orissa	14	Talcher, Ib Valley
Uttar Pradesh, Arunachal Pradesh, Assam, Meghalaya and Nagaland	1	No deposits
West Bengal	13	Raniganj

Source : R.K. Sachdev, *Overview of the Energy Sector and Importance of Coal*, CoalTrans India, Conference Proceedings, New Delhi, March 1997.

Table B.9
Coal Reserves by Type, 1 January 2001 (Mt)

Coal Quality	Proven Reserves	Total Resources
Coking Coal, *of which* :	16 390.2	30 546.7
Prime Quality	4 614.4	5 313.1
Medium Quality	11 267.7	23 625.8
Low Quality	482.2	1 607.9
Steam Coals (non-coking)*	68 023.7	183 358.8
Total	**84 413.9**	**213 905.5**

*including coals of the North-Eastern Region.
Source : *Annual Report 2000/01*, Ministry of Coal and Mines.

Table B.10
Quality Grades of Steam Coal

Quality	Premium			Medium	Low		
Grade	A	B	C	D	E	F	G
Ash Content (%)	<13.5	13.5-17.9	17.9-22.7	22.7-28.0	28-34.1	34.1-41.1	41.1-49.1
Calorific Value (kcal/kg)	>6 200	5 600-6 200	4 940-5 600	4 200-4 940	3 360-4 200	2 400-3 360	1 300-2 400

Source : *Relative Economics of Fuels in Power Generation*, Tata Energy Research Institute (TERI), New Delhi,1997.

Table B.11

Production of Coal and Lignite, India (Mt)

	1975-76	1980-81	1985-86	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
Coking Coal	27.4	31.7	35.2	44.9	45.80	45.21	44.66	41.97	39.91	40.5	43.80	39.18	33.25
Non-coking Coal	72.3	82.3	119.1	169.0	187.00	196.8	204.02	215.8	233.5	245.5	253.33	257.33	270.78
Total Coal[1]	**99.7**	**114.0**	**154.3**	**213.9**	**232.80**	**242**	**248.68**	**257.77**	**273.42**	**286.1**	**297.20**	**296.51**	**304.03**
Lignite	3	5.1	8.0	14.1	15.99	16.62	18.1	19.31	22.15	22.6	23.1	23.42	22.12
Total Coal and Lignite	**102.7**	**119.1**	**162.3**	**225.7**	**245.40**	**255.11**	**266.78**	**277.08**	**295.56**	**308.7**	**320.20**	**319.93**	**326.15**
Soft Coke	2.7	2.3	1.7	0.9	0.73	0.48	0.43	0.25	0.17	0.1	-	-	-
Beehive Hard Coke	0.8	0.6	0.3	0.1	0.17	0.13	0.12	0.08	0.06	0.1	0.1	-	-
By-product Hard Coke	0.6	0.4	0.4	0.3	10.48	10.6	10.58	10.93	10.86	11	10.60	10.8	11.4
Washed Coal	11.4	11.6	11.6	11.2	12.5	12.8	12.14	11.75	11.92	10.9	10	9.7	9.1
Middlings	3.9	4.3	4.3	5.6	6.07	6.46	6.64	6.3	6.8	6.8	7.6	7.2	6.2

1. Includes Meghalaya figures for the unorganised sector.

Sources : *Coal Directory of India* (various issues), Calcutta ; Coal Controller's Organisation ; Ministry of Coal and Mines. Quoted in Tata Energy Research Institute (TERI) *Energy Data Directory and Yearbook 2000/01*.

Table B.12

Coal Production of Various States (Mt)

State	1975-76	1980-81	1985-86	1990-91	1995-96	1999-00	2000-01**
Andhra Pradesh	7.4	10.1	15.7	17.7	25	29.6	30.3
Assam	0.6	0.6	0.9	0.7	0.8	0.6	0.7
Bihar	41.8	46.6	54.3	67.3	74.6	76.5	75.4
Madhya Pradesh	20.5	25.9	42.6	65.2	79.8	87.9	92.7
Maharashtra	3.7	5.8	11.6	16.9	22.8	27.7	28.8
Meghalaya	-	-	-	2.2	3.3*	4.1	-
Orissa	2.2	3.2	6	16.2	32.7	43.6	44.8
Uttar Pradesh	-	1.8	3.9	10.5	14.8	16.2	16.9
West Bengal	23.7	20	19.4	17.2	17.9	17.6	20.1
India	**99.8**	**114**	**154.4**	**213.9**	**273.5**	**304**	**309.6**

* Figure for the unorganised sector.
** Provisional data from Coal Controller's Organisation.
Sources : *Coal Directory of India* (various issues), Kolkata ; Coal Controller's Organisation ; Ministry of Coal and Mines.

Table B.13

Coal Production of Various Companies (Mt)

Company	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-2001*
Coal India Ltd	**216.10**	**223.07**	**237.28**	**250.65**	**261.01**	**256.49**	**260.58**	**268.19**
Eastern Coalfields Ltd	22.61	24.85	27.80	29.65	27.44	27.16	25.12	28.02
Bharat Coking Coal Ltd	29.04	28.75	27.81	27.14	30.92	27.18	27.90	26.02
Central Coalfields Ltd	33.51	31.21	30.76	32.21	33.10	32.18	32.40	31.76
South-Eastern Coalfields Ltd.	47.53	50.00	53.17	55.30	56.63	57.56	58.75	60.33
Mahanadi Coalfields Ltd	24.29	27.33	32.70	37.37	42.16	43.51	43.55	44.80
Western Coalfields Ltd	26.50	27.24	29.01	31.23	32.51	31.74	33.86	35.20
Northern Coalfields Ltd	31.41	32.50	35.20	37.01	37.56	36.52	38.43	41.40
North-Eastern Coalfields Ltd.	1.20	1.19	0.82	0.75	0.69	0.64	0.57	0.66
Singareni Collieries Company Ltd	25.58	25.65	26.77	28.73	28.94	27.33	29.56	30.27
Jammu and Kashmir Minerals Ltd	0.02	0.02	0.02	0.02	0.01	0.01	0.03	0.03
Damodar Valley Corporation	0.07	0.29	0.23	0.29	0.36	0l.37	0.37	0.37
Bengal Emta Coal Mines Ltd	-	-	-	-	0.71	1.80	2.17	2.41
Bihar State Mineral Development Corporation Ltd	-	-	-	0.26	0.20	0.19	0.29	0.40
Indian Iron and Steel Company Ltd	0.72	1.04	0.99	0.86	0.72	0.84	1.03	1.24
Tata Iron and Steel Company Ltd	3.96	4.16	4.90	5.30	5.23	5.22	5.16	5.28
Jindal Strip Pvt Ltd	na	na	-	-	-	0.04	0.78	-
Meghalaya Pvt Ltd	na	na	3.25	3.24	3.23	4.24	4.06	-
Total	**na**	**na**	**273.42**	**289.32**	**300.40**	**296.51**	**304.03**	**308.19**

* Provisional data from Coal Controller's Organisation.
na = not available.
Sources : *Coal Directory of India* (various issues); Coal Controller's Organisation; Ministry of Coal and Mines, Kolkata.

Table B.14

Offtake of Coal from Coal India Ltd, Singareni Collieries Company Ltd and others, 1997-98 to 2000-2001 (Mt)

	1997-98	1998-99	1999-2000	2000-01
Power Stations + Washery Middlings	212.92 3.62	204.68 3.02	222.63 2.11	234.60 2.49
Steel Plants and Cokeries (raw coking coal)	23.61	24.98	21.40	19.98
Railways	0.05	0.03	0.01	0.01
Cement Plants	10.13	8.61	9.50	10.33
Fertilizer Plants	4.64	4.11	3.37	3.18
Soft Coke Manufacturing	0.04	0.01	-	-
Export	0.06	0.79	0.07*	0.04*
Brick Kilns, Textiles, Chemical	49.45	43.17	44.91	45.27
Paper and Other Industries + Washery Middlings	2.10			
Colliery Consumption	3.06	2.95	2.50	2.20
Total Offtake **+ Washery Middlings**	**296.96** **5.72**	**288.58** **3.02**	**304.39** **2.11**	**315.61** **2.49**

Note : Since change in consumer stocks is not monitored, offtake is generally accepted as consumption. Does not include Meghalaya Coal.
* Coal India Ltd only.
Source : *Annual Report 2000/01*, Ministry of Coal and Mines, New Delhi.

Table B.15

Coal Movement by Transport Mode

	1977-78		1995-96		1996-97		1997-98		1998-99		1999-2000		2000-2001*	
Mode	Mt	%	Mt	%	Mt	%	Mt	%	Mt	%	Mt	%	Mt	%
Rail	78	78	156	56	165	57	176	57	164	55	179	56	136	57
Road	17	17	54	19	52	18	54	18	53	18	54	17	38	16
Belt	2	2	6	2	6	2	9	3	11	3	8	3	6	2
Ropeway	1	1	6	2	5	2	6	2	6	2	10	3	6	2
Dedicated Rail	2	2	56	21	59	21	63	20	65	22	69	22	54	23
Total	**100**	**100**	**280**	**100**	**287**	**100**	**308**	**100**	**299**	**100**	**320**	**100**	**240**	**100**

* April-December.
Source : *Annual Report 2000/01,* Ministry of Coal and Mines, New Delhi.

Table B.16
Transported Coal Quantities by Distance

	Transported Quantities			
	1994-95		1996-97	
Distance (kilometres)	Mt	%	Mt	%
Up to 200	91.1	54.3	103.8	55.4
200 – 500	12.3	7.3	12.8	6.8
500 – 1 000	16.0	9.5	15.9	8.5
>1 000	48.4	28.9	55.0	29.3
Total	**167.8**	**100**	**187.5**	**100**

Source : Ministry of Coal and Mines, 1998.

Table B.17
Coal Imports (Mt)

	1980	1990	1995	1996	1997	1998	1999	2000[e]
Coking Coal	550	5 000	9 370	9 780	10 650	9 640	11 285	15 431
Steam Coal	-	100	3 140	4 530	6 560	6 000	8 191	9 066
Total Coal Imports	**550**	**5 100**	**12 510**	**14 310**	**17 210**	**15 640**	**19 476**	**24 497**

e = estimate.
Source : *IEA Coal Information*, IEA/OECD Paris, 2001.

Table B.18
Coal Imports and Exports (Mtce)

	1980	1990	1995	1996	1997	1998	1999	1980-98 Average annual percent change	1998-99 Average annual percent change
Coal Imports	0.5	4.5	11.0	12.6	15.1	13.7	15.9	20.4	15.8
Coal Exports	0.1	0.1	0.1	0.1	0	0	0.5	5.7	-

Note : Includes steam and coking coal. Quantities have been converted to Mtce units using calorific values. The IEA classifies coal for injection into blast-furnaces as steam coal (except in the case of Japan). Statistics in this table may differ from those reported elsewhere in this report where coal for pulverised coal injection is shown as coking coal.
Source : *IEA Coal Information*, IEA/OECD Paris, 2001.

Table B.19

Productivity in Opencast and Underground Mining

(Tonnes per Manshift)

	1975-76	1980-81	1985-86	1990-91	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-2001
All Coal Mining										
Coal India Ltd	0.65	0.70	0.92	1.30	1.75	1.86	1.93	2.03	2.11	2.23
Singareni	0.69	0.70	0.92	0.96	1.23	1.19	1.31	1.31	1.42	1.39
Opencast										
Coal India Ltd	0.90	1.50	2.24	3.31	4.73	5.12	5.07	5.52	5.46	5.95
Singareni	0	0	3.54	4.74	3.66	2.96	3.50	3.92	4.42	5.49
Underground										
Coal India Ltd	0.60	0.50	0.53	0.53	0.56	0.57	0.57	0.59	0.61	0.63
Singareni	-	-	0.87	0.65	0.74	0.72	0.76	0.75	0.75	0.77

Note : Singareni = Singareni Collieries Company Ltd. The output per manshift for Singareni Collieries Ltd is calculated by the Coal India Ltd formula of 1987-88.
Source : *Annual Report 2000/01*, Ministry of Coal and Mines, New Delhi.

Table B.20

Average Cost of Production, Coal India Ltd and Singareni Collieries Company Ltd

(Rupees per tonne)

Year	Coal India Ltd	Singareni Collieries Company Ltd
1993-94	364.4	487.00
1994-95	380.5	543.00
1995-96	412.7	643.00
1996-97	442.1	731.56
1997-98	480.8	775.78
1998-99	502.4	826.30
1999-2000	540.1	–

Source : *Annual Report 1999/2000*, Ministry of Coal and Mines, New Delhi.

Table B.21

Average Pit-head Prices, Coal India Ltd and the Singareni Collieries Company Ltd

(Rupees per tonne)

Date of Revision	Coal India Ltd	Singareni Collieries Company Ltd
27 December 1991	322.00	388.00
19 June 1993	381.00	452.00
17 June 1994	401.00	503.00
12 November 1996	498.54	529.42
01 October 1997	559.02	710.59
29 August 1998	586.19	753.31
19 September 1999	595.84	775.62
Average for 1999-2000	581.46	–

Source : *Annual Report 1999/2000*, Ministry of Coal and Mines, New Delhi.

ANNEX C

INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

The Member countries* of the International Energy Agency (IEA) seek to create the conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants.

In order to secure their objectives they therefore aim to create a policy framework consistent with the following goals:

1 **Diversity, efficiency and flexibility within the energy sector** are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2 Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3 **The environmentally sustainable provision and use of energy** is central to the achievement of these shared goals. Decision-makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should where practicable have regard to the Polluter Pays Principle.

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

4 **More environmentally acceptable energy sources** need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA Members wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5 **Improved energy efficiency** can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6 **Continued research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7 **Undistorted energy prices** enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8 **Free and open trade** and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9 **Co-operation among all energy market participants** helps to improve information and understanding, and encourage the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at their 4 June 1993 meeting in Paris.)

ANNEX D

GLOSSARY

AFBC	Atmospheric fluidised bed combustion
Bcm	Billion cubic metres
BSES	Bombay Suburban Electric Supply
Bt	Billion tonnes
Btoe	Billion tonnes of oil equivalent
°C	Celsius
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CFBC	Circulating fluidised-bed combustion
DGCI&S	Directorate-General of Commercial Intelligence and Statistics
DMT	Deutsche Montan Technologie
Dwt	Deadweight tonne
ESMAP	Energy Sector Management Assistance Programme
ESP	Electrostatic precipitators
GAIL	Gas Authority of India Limited
GDP	Gross domestic product
GW	Gigawatt
ha	Hectare
IBCF	Indo-British Coal Forum
ICGCC	Integrated coal gasification combined cycle
IGCC	Integrated gasification combined cycle
kcal	Kilocalorie
kg	Kilogram
km	Kilometre
kWh	Kilowatt per hour
LNG	Liquefied natural gas

Ltd.	Limited liability company
mg	milligram
MGR	Merry-go-round, railway dedicated to coal delivery
mm	Millimetre
Mt	Million tonnes
Mtoe	Million tonnes of oil equivalent
MW	Megawatt
NCDC	National Coal Development Corporation
NETL	National Energy Technology Laboratory
NHPC	National Hydro Power Corporation
NTPC	National Thermal Power Corporation
OIL	Oil India Limited
ONGC	Oil and Natural Gas Corporation Limited
pa	Per year
PCI	Pulverised coal injection – steam coal injected into blast-furnaces
PFBC	Pressurised fluidised bed combustion
PFC	Power Finance Corporation
Powergrid	Power Grid Corporation of India
ppm	Parts per million
PPP	Purchasing power parity
PV	Photovoltaic
REC	Rural Electrification Corporation
SAIL	Steel Authority of India Limited
SEB	State Electricity Board
SERC	State Electricity Regulatory Commission
SPM	Suspended particulate matter
sq m	Square metres
TERI	Tata Energy Research Institute
TNEB	Tamil Nadu Electricity Board
toe	Tonne of oil equivalent
TPES	Total Primary Energy Supply
TWh	Terawatt-hour
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Program
USAID	US Agency for International Development
WEC	World Energy Council

ANNEX E

REFERENCES

Bundesanstalt für Geowissenschaften und Rohstoffe, XVII Reserven, *Ressourcen und Verfügbarkeit von Energierohstoffen 1998*, Hanover 1998.

Coal Controller's Organisation*, Coal Directory of India* (various issues), Ministry of Coal and Mines.

Clark, L., Walker, S. and Montfort, O., *Coal Prospects in India,* IEA Coal Research, IEAPER/37, London, 1997.

IEA *Coal Information 2000*, IEA/OECD, Paris, 2000.

IEA, *World Energy Outlook 2000*, IEA/OECD, Paris, 2000.

IEA, *World Energy Outlook 2001*, IEA/OECD, Paris, 2001.

IEA, *Energy Balances of Non-OECD Countries 2000*, IEA/OECD, Paris, 2001.

Ministry of Coal and Mines, *Annual Report 1999/2000*, New Delhi, 2000.

Misra, B.C., "Indian Coal Development Programme", in *Coal Trans India, Conference Proceedings*, New Delhi, 10/11 March 1997.

Planning Commission, *Report of the Committee on Integrated Coal Policy*, New Delhi, 1996.

Sachdev, R.K., "Overview of the Indian Energy Sector and Importance of Coal", in *Coal Trans India, Conference Proceedings*, New Delhi, March 1997.

Shahi, R.V., "The Role of the Existing Utilities", in *Coal Trans India, Conference Proceedings*, New Delhi, March 1997.

Tata Energy Research Institute, *Energy Data Directory* & *Yearbook, 2000/2001*, TERI, New Delhi, 2001.

Wardell, C., "India's Coal Sector Development, Issues and Options", in *Coal Trans India, Conference Proceedings*, New Delhi, March 1997.

World Bank, *India – Coal Sector Rehabilitation Project*, Staff Appraisal Report, Energy Sector Unit, South Asia Region, Washington, 1997.

ORDER FORM

IEA BOOKS

Fax: +33 (0)1 40 57 65 59
E-mail: books@iea.org
www.iea.org/books

INTERNATIONAL ENERGY AGENCY
9, rue de la Fédération
F-75739 Paris Cedex 15

I would like to order the following publications

PUBLICATIONS	ISBN	QTY	PRICE		TOTAL
☐ **Coal in the Energy Supply of India**	**92-64-19799-0**		**$80**	**€88**	
☐ World Energy Outlook - *2001 Insights*	92-64-19658-7		$150	€165	
☐ International Emission Trading - *From Concept to Reality*	92-64-19516-5		$100	€110	
☐ Russia Energy Survey	92-64-18732-4		$150	€165	
☐ Electricity in India	92-64-19724-9		$125	€137	
☐ Distributed Generation in Liberalised Electricity Markets	92-64-19802-4		$75	€82	
☐ Security of Supply in Electricity Markets - *Evidence and Policy Issues*	92-64-19805-9		$100	€110	
☐ Energy Policies of IEA Countries - The United States - 2002 Review	92-64-19762-1		$75	€82	
		TOTAL			

DELIVERY DETAILS

Name Organisation
Address

Country Postcode
Telephone E-mail

PAYMENT DETAILS

☐ I enclose a cheque payable to IEA Publications for the sum of $________ or €________

☐ Please debit my credit card (tick choice). ☐ Access/Mastercard ☐ VISA ☐ American Express

Card no:
Expiry date:
Signature:

OECD PARIS CENTRE
Tel: +33 (0)1 45 24 81 67
Fax: +33 (0)1 49 10 42 76
E-mail: distribution@oecd.org

OECD BONN CENTRE
Tel: +49 (228) 959 12 15
Fax: +49 (228) 959 12 18
E-mail: bonn.contact@oecd.org

OECD MEXICO CENTRE
Tel: +52 (5) 280 12 09
Fax: +52 (5) 280 04 80
E-mail: mexico.contact@oecd.org

You can also send your order to your nearest OECD sales point or through the OECD online services: www.oecd.org/bookshop

OECD TOKYO CENTRE
Tel: +81 (3) 3586 2016
Fax: +81 (3) 3584 7929
E-mail: center@oecdtokyo.org

OECD WASHINGTON CENTER
Tel: +1 (202) 785-6323
Toll-free number for orders:
+1 (800) 456-6323
Fax: +1 (202) 785-0350
E-mail: washington.contact@oecd.org

IEA PUBLICATIONS, 9, rue de la Fédération, 75739 PARIS CEDEX 15
Photo PIX - Printed in France by Jouve
(61 02 23 1P1) ISBN 92-64-19799-0 2002