
# World Market for Hard Coal

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**Content**

# Summary

This study describes the growing importance of hard coal in covering the world's energy needs. It deals in particular with the contribution to the energy supply made by international coal trading, which has been rising for some years now, and at an especially strong rate in the last four years. It discusses the structure and functioning of world trade in hard coal and examines the chief hard coal exporting countries with their export potential in terms of output and infrastructure as well as the crucial players.

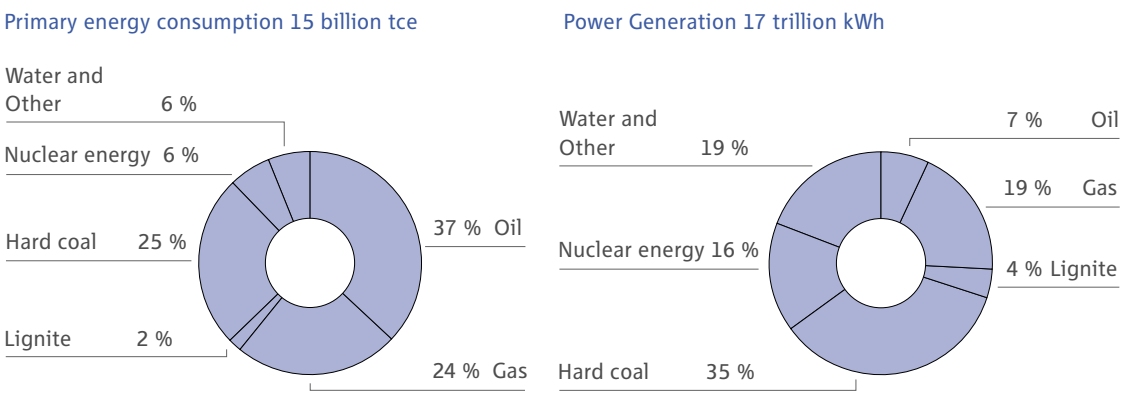
At present, hard coal accounts for 3.65 bn t of coal equivalent (bn tce) or 25 % of global energy consumption. In the last few years, hard coal has been able to steadily increase its share in the world energy mix, this being due primarily to the rapid expansion of coal production in China. Over 70 % of worldwide coal output goes into power generation, covering 35 % of the world's electricity requirements.

All key forecasts assume ongoing growth in coal production and world trade, though with developments varying between consumption sectors and between world regions. In steam coal, coal's importance for use in power plants will increase, whereas volume sales in the heat market will continue to decline. Coking coal consumption will grow in step with pig iron production, and world trade in coking coal, too, will move forward again after years of stagnation, because supplier and customer structures are shifting and demand is rising.

The Asian region boasts the greatest growth dynamism in consumption and production, whereas Europe will in future report falling trends in consumption and production. The cutbacks in uneconomic domestic production are being partly offset by coal imports. Gas and renewable energy will gain further market shares.

North, Central and South America are growth markets in both consumption and production terms. In the US, in particular, hard coal is growing in significance in view of the greater scarcity or declining availability of domestic oil and gas reserves.

**World energy mix, 2004**




Source: BP Statistical Review of World Energy, June 2005 (Primary energy consumption)
RWE World Energy Report 2005 (Estimate for power generation)

With the Kyoto Protocol signed and in force, the coal industry is faced with the challenge of reducing greenhouse gases from the use of coal. This gauntlet has been taken up and is being met with a technology offensive. New research and development projects on behalf of "clean coal", for example, have been launched in a number of countries. The aim here is to reduce $CO_2$ intensity in coal use by improving efficiency rates and by launching $CO_2$ capture and storage.

In covering the world's growing demand, international hard coal trading has been playing an ever greater role in recent decades. In the last few years, the world market for hard coal has been increasing in dynamism. Since 1999, the trading volume has been expanding by a good annual 7 % or 210 mill. t in all. In 2004, cross-border trade in hard coals totalled 755 mill. t. Of this, 685 mill. t was accounted for by maritime trade, split between 505 mill. t for steam coals and 180 mill. t for coking coals. 70 mill. t trading volume was handled by land – mainly between neighbouring countries. In worldwide hard coal output of 4.6 bn t, cross-border trading in 2004 had a share of 16.5 %. Of this total, maritime trade made up 15 percentage points and trading by land 1.5 percentage points.

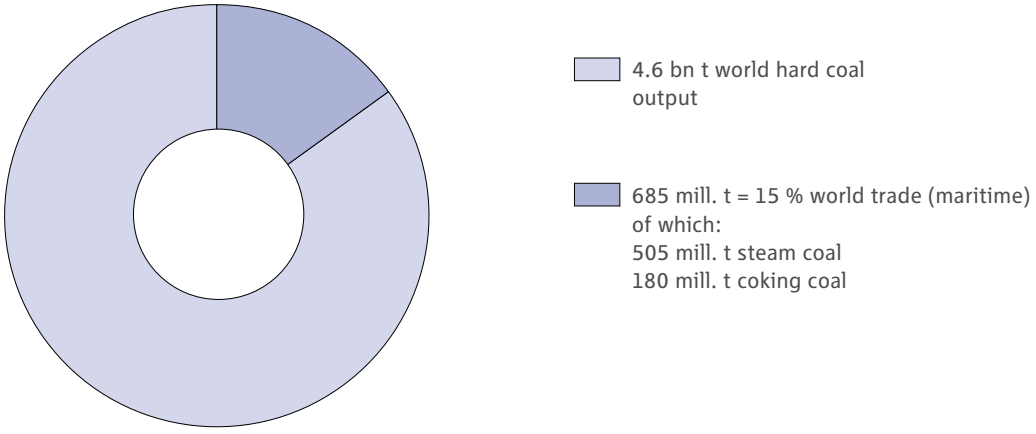
The background of this steep growth is still the price edge that world market coal has as against domestic coal (e.g., in Europe) as well as the energy requirements for power generation, above all in Asian economies.

The strong growth in world coal markets during recent years and, parallel to this, in the iron ore market has led for the first time to strains in the international transport chain, with substantial fluctuations in freight rates. Harbour capacities, too, however, have revealed bottlenecks in the shipping of coal and ores. The bulk carrier fleet has been massively enlarged in the meantime, with the expansion of shipping capacities being tackled, and the planning of cargo space optimized in order to avoid queuing. In this respect, logistics is adapting flexibly to the new market situation, and an efficient, low-cost and effective coal transportation chain can be expected in the future as well.

Besides the traditional Asian and European demanders for imported coal, a growing need for imported coal for coastal regions can be detected in the world's two biggest coal producers, China and the US. These requirements reached a volume of over 40 mill. t in 2004 and are expected to go on rising. In Central and South America, too, coal is increasingly being used in power plants.

On the supply side for steam coal, the greatest gains are being scored in the Pacific area by Australia and Indonesia, and in the Atlantic area by

**World hard coal output and maritime trade, 2004**



Colombia. South Africa's exports are stagnating. Thanks to the higher world market prices, Russia, too, has been able to expand its offerings and Poland has held its potential. In the case of coking coal, Australia has extended its position with 65 % market share. The US and Canada, too – prompted by the high price level – are stepping up their exports.

In international trade in steam coal, the ongoing trend is toward commoditization, and many contracts are concluded on the basis of price indices. Purchasing is largely a function of electricity sales and is based on short-term supply agreements. Increasingly, physical purchasing is being secured by financial instruments.

Following the growth push of recent years, an increase in world trade volumes is expected in the next few years as well. In the wake of the recent substantial price rises for oil, gas, coal and coke, the entire energy price level has increased. It remains to be seen how $CO_2$ trading in Europe will impact the competitive situation for coal.

However, further expansion in world steam coal trading, following decades of falling real coal prices, would require a price level that induces companies to invest in replacement and additional capacities. The international mining potential is widely dispersed in geopolitical terms and is still in a position to make a growing contribution toward meeting the world's energy and raw material requirements.

# Markets for hard coal in the world energy mix

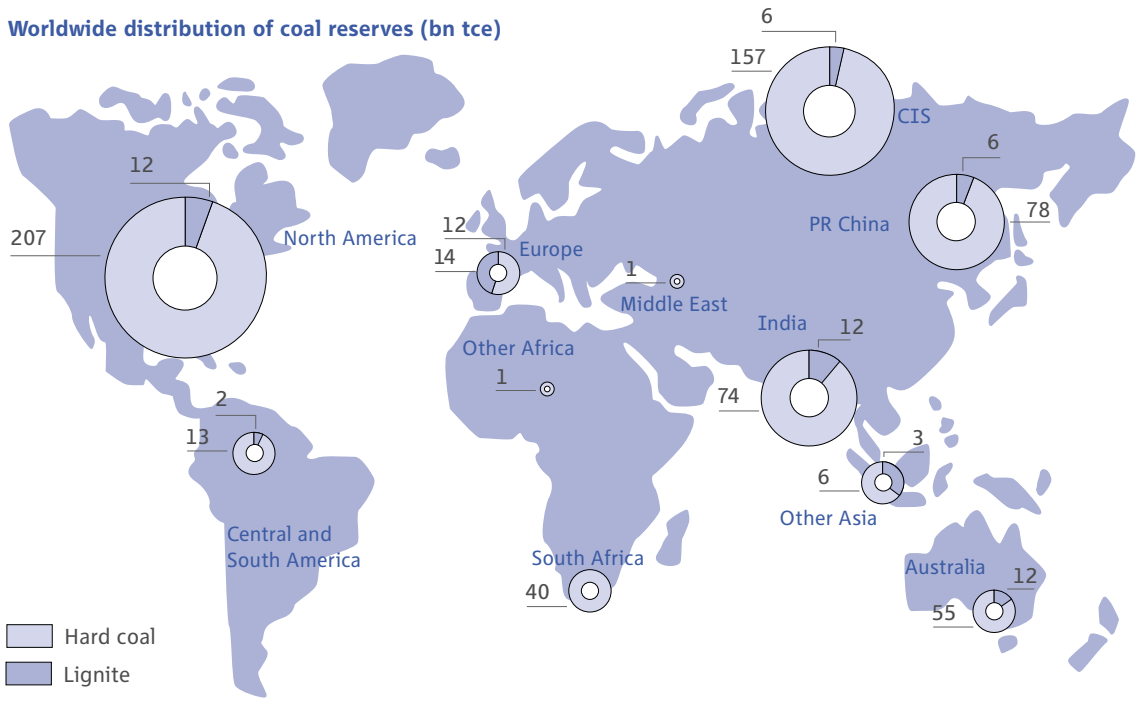
**Definition**

Coal, a product of plant substances, is a fuel and raw material available in abundant quantities throughout the world. Its various evolutionary conditions date back up to 400 million years in places. In earth's history, a wide range of coal types with differing properties has emerged. Depending on the degree of carbonization and, hence, on its energy intensity, this energy source is classified as anthracite, bituminous or sub-bituminous coal, and lignite. Anthracite coal is marked by a high carbon content coupled with very low moisture. In the case of lignite – young in earth's history – the converse is the case. Bituminous and sub-bituminous coals are located between the two, with fluid boundaries to lignite. In line with international practice, this study classifies anthracite, bituminous and the majority of sub-bituminous coals as hard coal. Depending on the use and quality of hard coal, reference is made to metallurgical or coking coal and steam coal.

**Reserves/output**

Estimates of reserves are subject to regular updating. Also, such estimates are not made across the world at the same times. Current estimates on the basis of our present knowledge of economically minable reserves are 990 bn t, equivalent to approx. 709 bn tce. These most recent estimates have been made by the Federal

**Worldwide distribution of coal reserves (bn tce)**




Total: 709 bn tce
Of which: Hard coal: 642 bn tce
Of which: Lignite: 67 bn tce
Source: Federal Institute for Geosciences and Natural Resources (BGR), Hanover, 2005

Institute for Geosciences and Natural Resources (Bundesanstalt für Geowissenschaft und Rohstoffe, BGR).

According to the Energy Information Administration (EIA) of the US Department of Energy (DOE), the global coal reserves consist of 53 % anthracite and bituminous coals, 30 % sub-bituminous coals and 17 % lignite.

Unlike oil and natural gas deposits, coal reserves are widely scattered geographically, with a focus on the US, Russia and China. For the rest, India, Australia, South Africa, Ukraine and Kazakhstan, in particular, have significant coal reserves.

Even the economically minable hard coal reserves referred to earlier, i.e. without proven resources of some 6,000 bn t will last, at current consumption levels, for approx. 180 years.

Reserves and mining levels do not always match. This is particularly true of the former Soviet Union, where only limited use is made of mining opportunities owing to the great distances involved between the deposits and the consumer centres and to the ample availability of oil and gas. In China, by contrast, coal dominates the energy market owing to the still slow mobilization of competing energy sources. The same is true of the "Far East" region, where India – likewise with high coal intensity – is the crucial hard coal producer, followed by Indonesia.

**Quality requirements**

Coal is a heterogeneous energy source. The quality parameters, like calorific value as well as sulphur and ash content, vary considerably between the various deposits and even within single coal seams.

The various deployment areas for hard coal require different qualities and properties. On economic efficiency grounds, for example, the key quality parameter of imported steam coal for power plants is the highest possible net calorific value (NCV > 6,000 kcal/kg), which is ensured by having low moisture and ash content (total < 25 %). On top of this come a low sulphur content (< 1 %) and specific requirements for the chemical composition of the resulting ash and its melting behaviour. A low share of volatile components (< 20 %) is a drawback for combustion in modern power plants. The imported coal used in power generation is supplied as fine coal, i.e. with a grain size of 0 - 50 mm.

**Reserves and output of hard coals, by region**

| Region | Reserves[1] Position 2005 bn t | % | Output 2004 mill. t | % | Reach in years |
|---|---|---|---|---|---|
| Europe | 14 | 1.8 | 184 | 4.0 | 76 |
| CIS | 192 | 24.5 | 360 | 7.8 | 533 |
| Africa | 50 | 6.4 | 252 | 5.5 | 198 |
| North America | 253 | 32.2 | 962 | 20.9 | 262 |
| South America | 16 | 2.0 | 67 | 1.5 | 238 |
| PR China | 96 | 12.2 | 1,956 | 42.5 | 48 |
| Other Asia | 97 | 12.4 | 549 | 11.9 | 177 |
| Australia/New Zealand | 67 | 8.5 | 270 | 5.9 | 248 |
| Total | 785 | 100.0 | 4,600 | 100.0 | 170 |
| Total in bn tce | 642 | | 3,650 | | 180 |

[1] Source: Federal Institute for Geosciences and Natural Resources (BGR), Hanover, 2005

Different quality requirements must be met by the steam coal that goes into the industrial area mainly to produce steam and process heat. The combustion technology deployed there usually calls for specific grain sizes (range: 6-80 mm) in graded, i.e. sized, lump coal. Here, too, low moisture (3-6 %) and ash content (3-5 %) with a low sulphur share is expected.

Private consumers and households, too, are supplied with graded coal (smalls, cobbles) of varying grain sizes between 8-80 mm and with low moisture, ash and sulphur contents. A significant share here is accounted for by anthracite coal with volatile matter of < 14 %.

A narrower quality-parameter bandwidth applies to the hard coking coal used in coking plants. The resulting product, coke, is mainly used in the steel industry, but also in nonferrous metal working. Deployment as blast furnace coke requires, first of all, a raw material that is low in both ash and sulphur, i.e. the coal mixture used in coking plants is subject to limits set for these of max. 8 % and 1 % resp. Other coking properties, too, are called for in the coal, incl both the content of volatile components (27+7 %) and, in particular, its coking behaviour as measured by the free swelling index of 4-7, as well as the coke strength (CSR value), which has continued to gain in importance owing to the fall in specific coke consumption. As a general rule, blast furnace coke is not made from one single type of coking coal, but from a mixture of different origins with an average volatile component content of approx. 27 %.

But coking coal with a lower swelling index, too, i.e. 1-3, is used in making coke, so-called soft coking coal. By itself, this produces coke of low, i.e. inadequate, strength. However, steam pretreatment or mechanical compaction when the coal is fed into the coke oven – along with hard coking coal – enables this coal type to be used on a considerable scale, above all in Japan, to make high-quality blast furnace coke.

Growing use is now also being made of hard coal in the metallurgical area in pulverized coal injection (PCI). Intended as substitute fuel in the 1980s for the by-then costly heavy oil, pulverized coal or fine-grain coal, injected into the furnace as PCI coal, is now largely ousting blast furnace coke, which has become relatively expensive. Here, all hard coals with a low sulphur and ash content are suitable, with the quality spectrum ranging from the increasingly preferred anthracite coal all the way to highly volatile steam and semi-soft coking coal. It is the latter in particular that is also used in Japan as PCI coal, although its share of just under 50 mill. t p.a. in global energy consumption is modest.

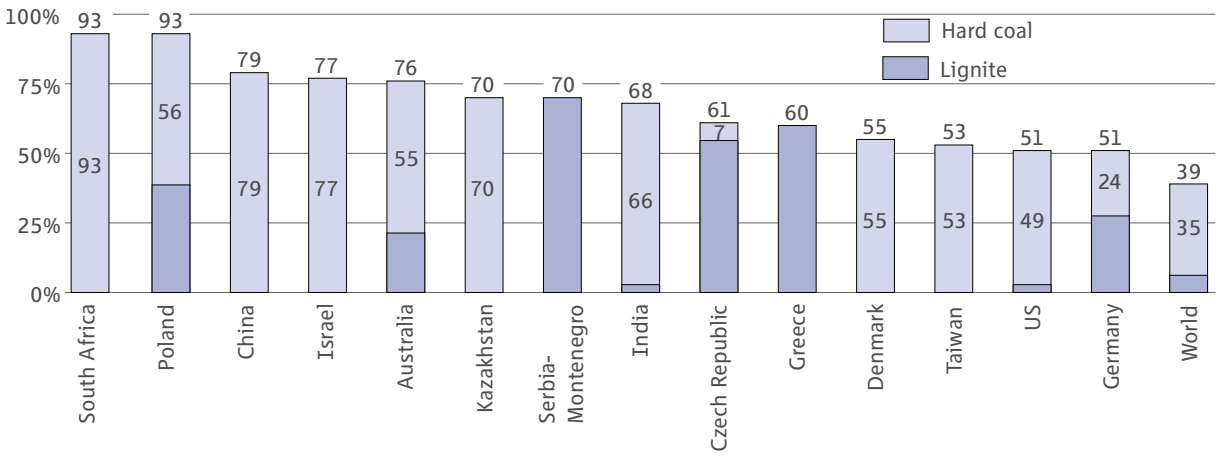
**Consumption, by use**

Hard coal consumption worldwide grew by some 750 mill. tce (+ 26 %) from 2.9 bn tce in 2001 to 3.65 bn tce in 2004. This makes hard coal no. 2 in the list of important energy sources – after oil, but before natural gas. Hard coal's share in worldwide primary energy consumption in 2004 was some 25 %. The recorded increase is mainly accounted for by China, although other mining regions, too, have pressed ahead. However, the dynamic global trend of recent years does not apply equally to all applications and world regions.

World hard coal output was some 4,6 bn t, equivalent to 3.65 bn tce in 2004. This can be subdivided between approx. 4.1 bn t (88 %) steam coal and 550 mill. t (12 %) coking coal. Most of the steam coal goes into power generation. The share is about 3.4 bn t or 73 % of world hard coal consumption. Some 35 % of power generation worldwide is based on hard coal.

The heat market – i.e. customers outside the electricity sector and the steel industry – comprises, e.g., cement works, paper mills and other industrial consumers. Also, there is a domestic fuel segment, which is still significant in Eastern Europe and Turkey and in China and North

**Contribution of coal to power generation, 2003**




Source: IEA, Electricity Information 2005

Korea. This market is put at 700 mill. t worldwide, although its share contracted from 43 % in 1980 to about 15 % of world hard coal consumption in 2004, and further decline is expected. In view of high oil and gas prices, however, the pace of decline could slow down.

The metallurgical area, with a share of 12 % or 550 mill. t has grown by some 50 mill. t since 2001. The increase in the consumption of coking coal was noted, above all, in China and, partly, in Russia and was largely satisfied from domestic output in each case. The blast furnace process for the production of pig iron is the method chiefly employed in China, since alternative processes are not feasible owing to a scarcity of scrap. In view of the present high prices for coking coal and coke, work is proceeding on optimizing the blast furnace process, and the technology for injecting pulverized coal has received a new boost in a bid to save coke.

**Consumption, by region**

Most hard coal is used in the proximity of its deposits. The reason is its low energy content compared with oil and gas. Long and often costly transportation by land can place an extra burden on the cost-effectiveness of any remote use. Although ocean freight rates soared to unimagined levels in 2003/2004 owing to short-term bottlenecks, normal low-cost maritime transport can be expected again in the long run, so that hard coals from mines with low extraction costs and logistically favourable locations relative to seaports will definitely become competitive again for overseas consumers.

In recent years, world maritime trade has grown to 685 mill. t and, in spite of high ocean freights at times in 2004, has increased by 46 mill. t. This is equivalent to a 15 % share of maritime exports in world hard coal mining.

The most important market for hard coals is the Asian/Pacific economic area. Hard coal consumption in this region in 2004 was 2.6 bn t. This is

**World hard coal consumption, by sector, 1980 and 2004**

| | 1980 | | 2004 | |
|---|---|---|---|---|
| | bn t | % | bn t | % |
| Total | 2.80 | | 4.60 | |
| of which | | | | |
| Power plants | 1.00 | 36 | 3.35 | 73 |
| Steel industry | 0.60 | 21 | 0.55 | 12 |
| Heat market | 1.20 | 43 | 0.70 | 15 |

[1] Source: Association of Coal Importers (Verein der Kohlenimporteure)

**Developments in world energy consumption, by energy source (in bn tce)**

| | 1980 | 1985 | 1990 | 1995 | 2000 | 2004 |
|---|---|---|---|---|---|---|
| Mineral oil | 4.35 | 4.05 | 4.48 | 4.71 | 5.13 | 5.46 |
| Natural gas | 1.86 | 2.15 | 2.52 | 2.81 | 3.18 | 3.51 |
| Nuclear energy | 0.24 | 0.50 | 0.74 | 0.76 | 0.85 | 0.90 |
| Hydropower | 0.64 | 0.67 | 0.73 | 0.82 | 0.89 | 0.92 |
| Hard coal | 2.50 | 2.85 | 2.82 | 2.90 | 2.79 | 3.70 |
| Lignite | 0.42 | 0.42 | 0.38 | 0.34 | 0.33 | 0.33 |
| Totals | 10.01 | 10.64 | 11.67 | 12.34 | 13.17 | 14.82 |
| Share of hard coal, % | 25.00 | 26..80 | 24.20 | 23.50 | 21.20 | 25.00 |
| Share of lignite, % | 4.20 | 3.90 | 3.30 | 2.80 | 2.50 | 2.20 |
| Share of coal, total, % | 29.20 | 30.70 | 27.40 | 26.30 | 23.70 | 27.20 |
| Share of mineral oil, % | 43.50 | 38.10 | 38.40 | 38.20 | 39.00 | 36.80 |
| Share of natural gas, % | 18.60 | 20.20 | 21.60 | 22.80 | 24.10 | 23.70 |
| Share of nuclear energy, % | 2.40 | 4.70 | 6.30 | 6.20 | 6.50 | 6.10 |

1) Source: BP Statistical Review of World Energy, own calculations

equivalent to more than one half of worldwide hard coal consumption. Especially dynamic consumption developments were noted in China, where the main driver behind the growing demand for coal, as in other Asian states, is the striking rise in electricity needs. In the drastic increase in consumption reflected in the statistics, it must be borne in mind that, although the dependability of the figures for past years is subject to uncertainties, the quality of the Chinese figures is tending to improve, so that the data for recent years (2002 to 2004) can be classified as sounder.

The most important hard coal consumer after China is India, where over two thirds of the coal consumed is for power generation. Coal needs are mostly covered by domestic output.

The situation in "mature" Asian/Pacific markets, especially in Australia and Japan, differs fundamentally from conditions in China and India. Australian coal is mainly exported, although a substantial quantity of domestic coal is used in Australia itself. More than three quarters of power generation in the country is based on domestic coal.

Along with China, the US, India, Russia and South Africa, Japan is one of biggest hard coal consuming countries, covering practically its entire coal needs with imports, mostly from Australia. Some 44 % of the coal consumed in Japan is used in the steel industry; Japan is the world's second largest steel producer (after China). Also, coal in Japan makes a considerable contribution to power generation, with more than one quarter of the country's power supply being based on imported hard coal. Between 2001 and 2004, 8,700 MW of new coal-fired power plant capacities went on stream in Japan.

Other important hard coal consumers in the Asian/Pacific economic area are South Korea, Taiwan, Indonesia and Thailand. Whereas Indonesia is in a situation comparable with that of Australia (net exporter in the case of hard coal), the other states named mainly depend on supplies from the world market.

The second largest hard coal consumer region – after the Asian/Pacific economic area – is North America. Over 90 % of hard coal consumption in North America totalling some 1 bn t is accounted for by the US. There, more than 50 % of power generation is based on coal.

In Central and South America, coal in the past was not counted among the central pillars of the energy supply, and coal's share in the region's total energy consumption is a mere 4 %. More than 60 % of coal consumption in Central and South America is accounted for by Brazil, the country with the world's eighth largest steel industry. The other main coal consumers are Colombia, Chile, Argentina, Peru and Venezuela.

Africa has a 4 % share in coal consumption worldwide. The crucial market there is South Africa, which accounts for over 90 % of coal consumed by the entire continent. Demand is covered by domestic output. South Africa is also one of the world's major exporters of hard coal.

Consumption and mining in the former Soviet Union are concentrated on Russia, Ukraine and Kazakhstan. Coal needs in each case are covered by domestic output. In all of these states, coal makes a significant contribution toward power generation. Developments in consumption in the last ten years – after recorded falls in consumption owing to restructuring inside these economies – are marked by consolidation.

In Western and Central Europe, the requirements of environmental and, specifically, climate protection are increasingly acting as a damper on the use of coal in its chief deployment area, power generation. Also, wide sections of Europe's hard coal mining industry are unable to compete with world market conditions. Some of the fall in output is offset by imports. The chief consumer countries in this region are Germany, Poland, UK, Spain, Turkey, Italy and Denmark.

**Perspectives in consumption developments**
According to the International Energy Outlook 2005, which DOE/EIA submitted in August 2005, the following perspectives are indicated until 2025.

In the strongly growing Asian economies, a doubling of coal consumption is to be reckoned with in the next two decades, with more than three quarters of the expected increase in the world consumption of hard coals being accounted for by newly industrialized countries in Asia. The main driver behind this development is to be found in the electricity markets of China and India, for which future growth of 3.3 % p.a. (China) and 2.2 % p.a. (India) is expected. The chief reason given for the growing use of coal in power generation is that these states intend to maintain a wide spread in the supply of fuels for their power plants. This goal is even cited for states which have ample reserves of natural gas like Thailand, Malaysia, Indonesia and the Philippines.

Whereas slight growth in coal consumption is expected for Australia/New Zealand in future as well (+ 1 %/year), stagnation is assumed for Japan. The main reasons given for the constant level of coal consumption in Japan are the decline in the population, moderate economic growth and the increasing use of other input energies in power generation like natural gas, renewables and nuclear energy.

The largest absolute rise in consumption in the case of hard coal is expected – after China – for the US. DOE/EIA is expecting that, in 2025, more than half of the country's power generation will still be based on coal. This is also due, in particular, to rising gas prices after 2010, which must be set against comparatively stable prices for coal, free domestic mines, and a slight fall in domestic freights in the transportation of domestic coal.

In South America, future developments will be marked in particular by the situation in Brazil. In view of the expected capacity extensions in the steel sector and the planned construction of new coal-fired power plants, an increase in coal consumption by nearly 3 % p.a. until 2025 is expected there.

The strong rise in the demand for electricity in South Africa has led to a decision to recommis-

sion three big – already closed-down – coal-fired power plants with a total capacity of 3,800 MW between 2005 and 2008. Also, there is thought of building new coal-fired power plant capacity, viz. not only in South Africa, but also in Zimbabwe, Tanzania, Swaziland and Botswana. Accordingly, a rise in coal consumption can be expected in Africa, viz., at a rate of 1.6 %/year.

Russia's energy strategy aims, inter alia, at setting up coal-fired power plant capacity with progressive technology, especially in the coal-rich region in the centre of the country. Associated with this is a rise in coal consumption at a rate averaging 1 % p.a. In the other CIS states – in view of the expected greater use of existing coal-fired power plants – a rise in the demand for coal by an average 0.6 % p.a. is expected.

For Western and Central Europe, a decline in coal consumption by about 1 % p.a. is forecast for the next few decades. Crucial factors affecting this development are: increased use of natural gas and renewables in power generation, the dismantling of subsidies for domestic hard coal mining as well as a relatively moderate increase in total energy consumption.

**Hard coal consumption, by region**

| | 1980 | | 2004 | |
|---|---|---|---|---|
| | mill. t | % | mill. t | % |
| Asia | 900 | 32.4 | 2.610 | 56.7 |
| of which China | 626 | 22.5 | 1.700 | 37.0 |
| North America | 633 | 22.8 | 1.000 | 21.7 |
| South-/Central America | 16 | 0.6 | 50 | 1.1 |
| Europe | 571 | 20.5 | 400 | 8.7 |
| CIS | 529 | 19.0 | 290 | 6.3 |
| Australia/New Zealand | 36 | 1.3 | 80 | 1.7 |
| Africa | 95 | 3.4 | 170 | 3.7 |
| World | 2,780 | 100.0 | 4,600 | 100.0 |

Source: IEA Coal Information, BP Statistical Review, own calculations

**Environmental aspects – Clean coal technology**

For years now, the environmental debate has centred on worldwide preventive climate protection.

The assumption is that emissions of greenhouse gases (GHGs) are increasing the temperature of the Earth's atmosphere and, in this way, could give rise to climate change. At the World Climate Summit in Kyoto (the third conference of the treaty states on this subject) specific obligations for reducing GHG emissions were defined for the first time. For the initial commitment period from 2008 to 2012, 38 industrialized countries agreed to reduce such emissions by 5.2 % compared with 1990 (EU: -8 %; US: -7 %; Japan: -6 %). Developing countries have not yet given any specific undertakings to reduce emissions, but are integrated by way of clean development mechanism (CDM) measures. The Kyoto Protocol targets the following gases: carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride ($SF_6$).

The meeting in Japan was followed by further talks on the practical implementation of the various commitments and measures resolved in Kyoto. With the compromises obtained, the way was paved for ratification of the Agreement by the treaty states.

Although the US and Australia had declared that they would not ratify the Kyoto Protocol, Russia's ratification has helped meet the requirements for the Protocol to come into force, as it did on 16 February 2005, when the Protocol became binding in international law.

The coal industry advocates measures designed to reduce environmental impact as part of preventive climate protection, while heeding the principle of proportionality. It has also been actively pursuing such measures itself.

In coal mining, environmental aspects are increasingly being heeded in developing coun-

tries as well; this involves measures for recultivating depleted mines. According to the definition of the International Maritime Organization, coal – unlike oil and gas – is not among the environmentally hazardous goods transported by sea. A further contribution toward preventive climate protection is the use of methane-containing ventilation currents, which have to be suctioned off continuously from the mines on safety grounds. These currents, which in the past were discharged unused into the atmosphere or were torched, are increasingly being used today in power generation at near-mine power plants.

On the use side, the strategy for $CO_2$ reduction has three horizons. Horizon 1 concerns the worldwide use of state-of-the-art technologies in replacing old or building additional new power plants. In horizon 2 the very latest in power plant technologies is further developed. Both horizons back $CO_2$ reduction by enhancing efficiency. This primary measure combines sparing use of resources and preventive climate protection.

Virtually zero-$CO_2$ power generation on the basis of fossil energy sources, which is not entirely obtainable by increases in efficiency, is only possible using the secondary measure of $CO_2$ capture and climate-neutral $CO_2$ storage. The appeal lies, above all, in the fact that, for the energy source coal, which has the largest reserves by far and is of the greatest importance for world power generation, horizon 3 paves the way for virtual zero-$CO_2$ power generation. The technologies required for this largely build up on existing developments. Long-term safe $CO_2$ storage with adequate acceptance will be the basic precondition for use of this technology.

The successive renewal of the oldest coal-fired power plants, with average efficiencies of 29 % using state-of-the-art technology with an efficiency of 44 to 45 % (horizon 1) yields a specific $CO_2$ reduction of more than one third.

The focus in the further development of steam power plant technology on the basis of hard coal is on a further increase in the process parameters. The developments under way in this area suggest that, in commercial use, the 50 % efficiency limit for coal-fired power plants can be exceeded (horizon 2) by 2020.

Furthermore the integrated gasification combined cycle (IGCC) power plant technology will be of increasing interest in the longer term, not only because of its efficiency potential of 52 to 55 %, but also on account of its technologically better preconditions for $CO_2$ capture, above all for power plant concepts featuring $CO_2$ capture (horizon 3).

In principle, three technical process types for $CO_2$ capture can be distinguished:

- **Flue gas scrubbing in conventional power plants:** For conventional steam power plants, only $CO_2$ capture downstream of combustion is feasible. In this process, the dedusted and desulphurized flue gas has its $CO_2$ separated in an additional scrubbing stage under atmospheric pressure. Although old plants can be refitted in principle for this technology, the additional high space requirements set narrow limits to the implementation of this concept in existing power plants. Also, the enormous flue gas volumes and the low $CO_2$ content make this process very costly. Finally, the considerable energy needs translate into a drastic lowering of power plant efficiency.

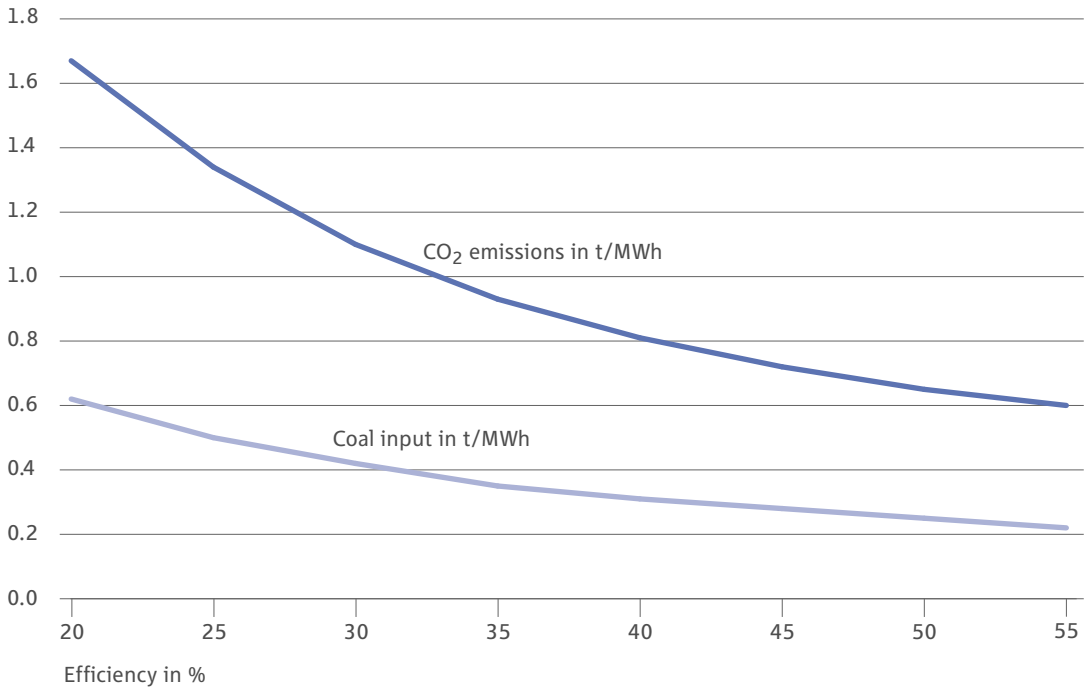
- **Oxyfuel process:** In the concept for the Oxyfuel process, combustion is with a mix of oxygen and recirculated $CO_2$. The flue gas, consisting mainly of $CO_2$ and steam, is cooled after scrubbing, so that, following condensation of the steam portion, $CO_2$ is obtained without an additional scrubbing stage.

- **Integrated gasification combined cycle (IGCC) process:** In the combined cycle power plants, $CO_2$ capture is possible upstream of combustion. The fuel gas, which is as a rule under pressure, has a 100-fold lower volume, and suitable capture technologies are widely known from the chemical industry. One new development is the gas turbine with a combustion chamber for $H_2$-rich fuel gas. The "zero"-$CO_2$ combined cycle power plant technology can be implemented both for coal (IGCC) and for natural gas (IRCC, with a natural gas reformer).

One disadvantage of all the technologies named is lower efficiency and, hence, higher fuel consumption than in the case of technologies without $CO_2$ capture. The technologies differ in this respect: Whereas conventional power plants with $CO_2$ capture reach only 28 % efficiency, the figure is 37 % in the case of Oxyfuel and as much as 42 % in the case of the IGCC process with $CO_2$ capture, putting it close to the efficiency level of today's modern power plants. $CO_2$ capture using the IGCC process is also, relatively, the lowest-cost method, even if specific investment costs are still 80 % above those for a conventional power plant. Hence, this process has the greatest potential among the options for $CO_2$ capture. Also, it has already been widely explored in both technical and operational terms.

With a time horizon from 2020 on, $CO_2$ capture and storage can make substantial contributions toward obtaining a zero-$CO_2$ energy supply. The $CO_2$ avoidance costs in such a concept are some €30/t $CO_2$, as things look today. Further technical developments offer cost cutting potential, with climate protection goals being capable of economically meaningful achievement.

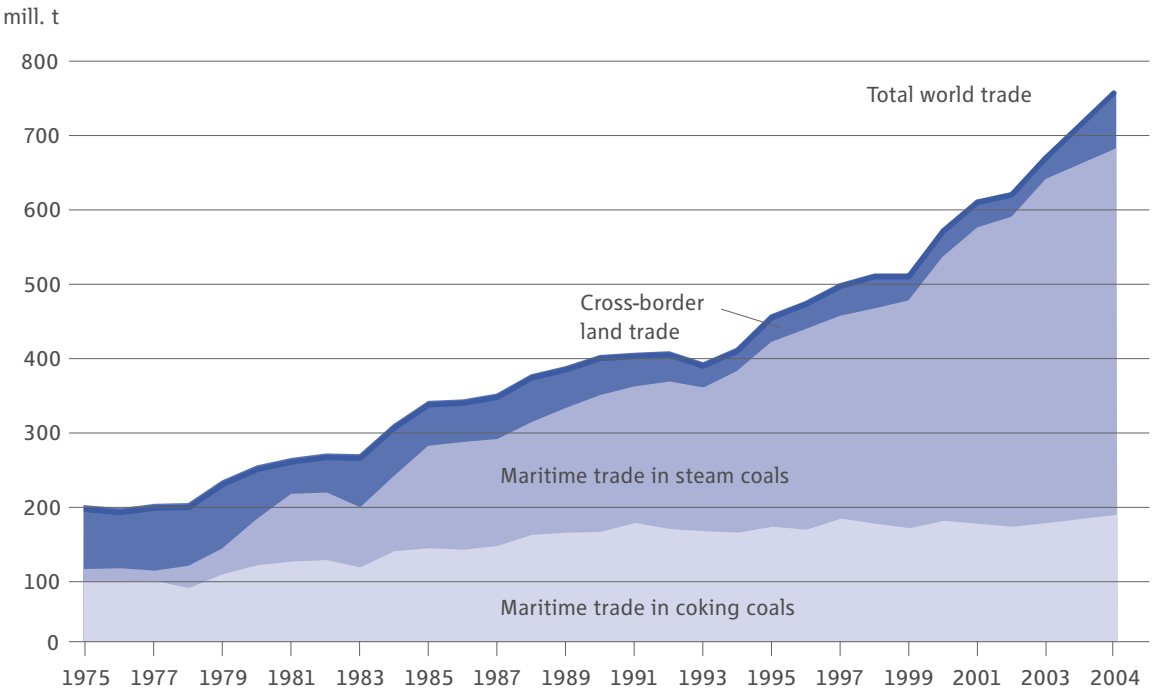
**Emission reductions due to improved efficiency**




Source: Association of the German Hard Coal Mining Industry (Gesamtverband des deutschen Steinkohlenbergbaus)

# World trade

**Developments in world hard coal trade, 1975-2004**




Source: Association of Coal Importers (Verein der Kohlenimporteure)

The beginnings of the world hard coal trade date back to the middle of the century 19th, when – with the beginning of steamship navigation – depots had to be built in all world ports to store bunker coal. Since supplies from a nearby mine were not always possible, some coal had to be fetched across oceans and by sailing ship, e.g. from England to Cape Town and Suez, or from Australia to Dhaka (India/Bangladesh). Coal gained world market maturity for the supply of overseas consumers as well when the efficiency of ocean shipping grew after the switchover to oil between the two world wars, although sustainable expansion in the international national hard coal trade only set in after the second oil crisis in 1979/80.

**Demand**

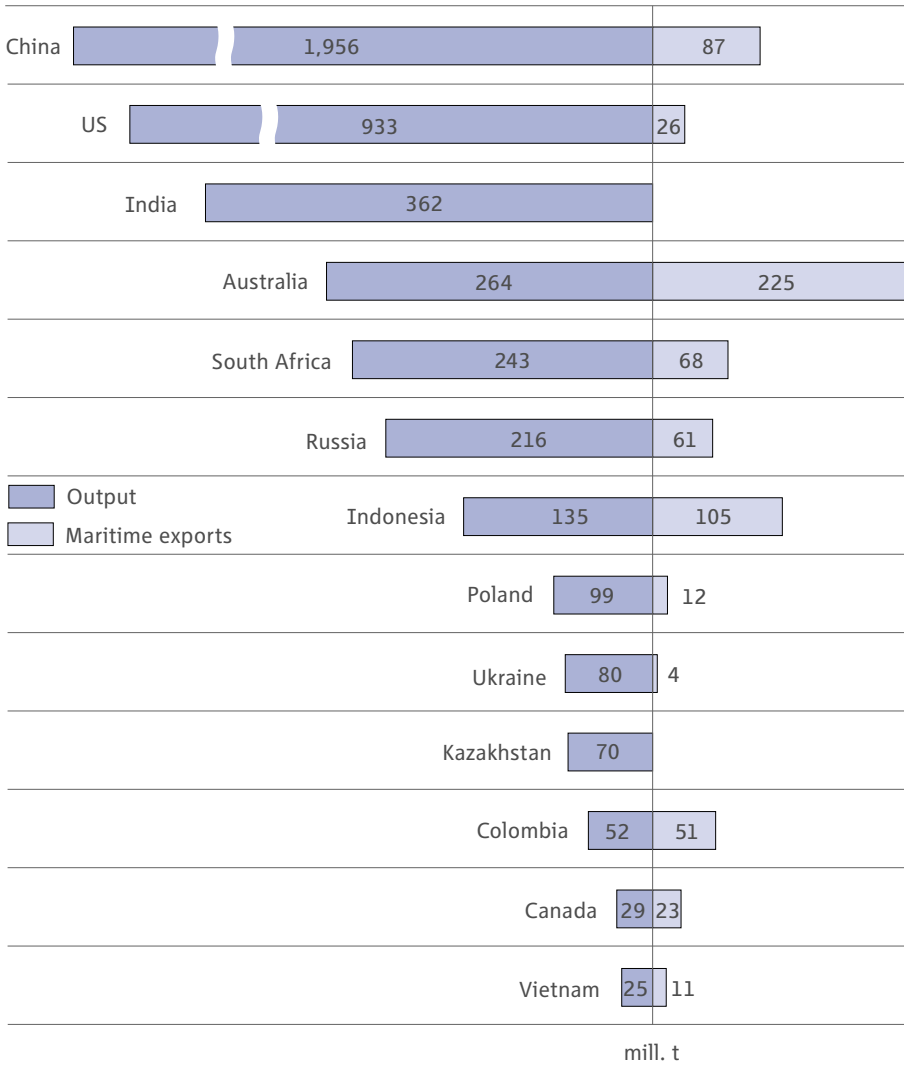
In recent years, both mining and world trade have been evolving at faster rates than were observed in the past. World trade has grown in the last 5 years by 210 mill. t to the present 755 mill. t. The world market can be broken down into

- Maritime trade 685 mill. t
- Cross-border land trade 70 mill. t

Domestic trade is subject to stable developments and is based mainly on traditional supply relations between neighbouring countries. This brochure deals primarily with maritime coal trading, because this is where most of the growth in world trade takes place.

The maritime hard coal world market is broken down into the following submarkets, viz.

**Output and maritime exports of hard coal, 2004**




Source: Association of Coal Importers (Verein der Kohlenimporteure)

**World land trade in hard coal, 2004**

| | mill. t |
|---|---|
| US – Canada | 16.0 |
| Canada – US | 2.5 |
| Mongolia – China | 1.5 |
| North Korea – China | 1.5 |
| Poland – EU countries | 7.5 |
| CR – EU countries | 4.0 |
| Russia – CIS (Ukraine) | 10.0 |
| Russia – outside CIS | 4.5 |
| Kazakhstan – Russia | 22.0 |
| Other (EU-internal) | 0.9 |
| Total | 70.4 |

Source: Association of Coal Importers (Verein der Kohleimporteure)

- Steam coal market, total 505 mill. t
  - Atlantic steam coal market 208 mill. t
  - Pacific steam coal market 297 mill. t
- Coking coal market 180 mill. t
- Maritime world trade, total 685 mill. t

The breakdown into two steam coal markets is determined by the supply side in the markets. A key demarcating factor is the level of freight rates, which may enable Atlantic and Pacific producers to supply more distant customers at competitive prices.

The coking coal market, by contrast, is a unitary world market. A few suppliers serve a dispersed clientele worldwide.

The vigorous expansion of international trade has two main causes

- Covering the growing demand for raw material and energy
- Substitution of uneconomically mined quantities.

Most of the expansion is in steam coal, whereas the coking coal market has fluctuated in recent years in a bandwidth of 165-180 mill. t, depending on cyclical developments in the steel industry. The increase in global steel and pig iron production could herald a new growth phase, however.

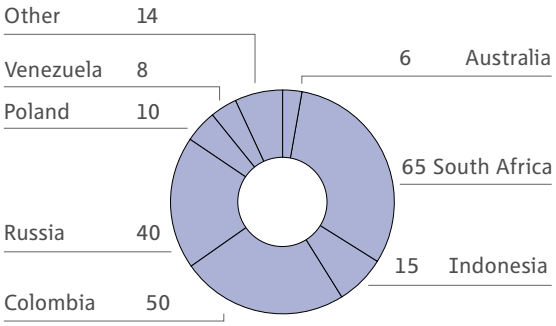
As for the submarkets, the following applies. In the Pacific market for steam coal imports (59 % of total steam coal trading), the chief growth engine is the rising electricity needs in nearly all economies and in China, and, to a very slight extent, the closing of mines in South Korea and Japan. Growing populations in South-East Asia and high rates of increase in the gross national product mean that the Pacific steam coal market will go on prospering in future as well.

The Atlantic steam coal market (41 % of the total steam coal market) deserves a differentiated look in growth terms. In Europe and the Mediterranean area, the growth in imported coal is mainly an offset for the discontinuation of uneconomic mining. However, there are growth countries as well like, e.g., Italy, Turkey, Morocco and Israel.

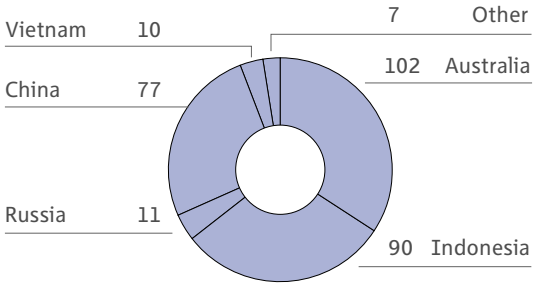
In South and Central America, it is primarily rising electricity needs that are boosting demand. The US has in recent years evolved into an important importer on the Atlantic market, primarily for its coastal or near-coastal power plants. After all, the US share of the Atlantic market amounts to 12 %; further growth is foreseeable.

The world coking coal market is basically powered by crude steel and pig iron production. In 2004, crude steel output reached 1,025 mill. t, and pig iron output, on which coke consumption largely depends, 700 mill. t. Until 2003, China was largely able to cover the growth in its pig iron production with its own coking coals; since 2004, however, China has had to import smaller additional quantities and, at the same time, reduce its own exports. This has led to tensions on the market, since the supplier structure has shifted further in Australia's favour. Altogether, growing steel production is reckoned with in the Asian and South American area, so that, with stagnating demand in North America and

**Overseas trade in steam coal, 2004, in mill. t**




Atlantic: 208 mill. t

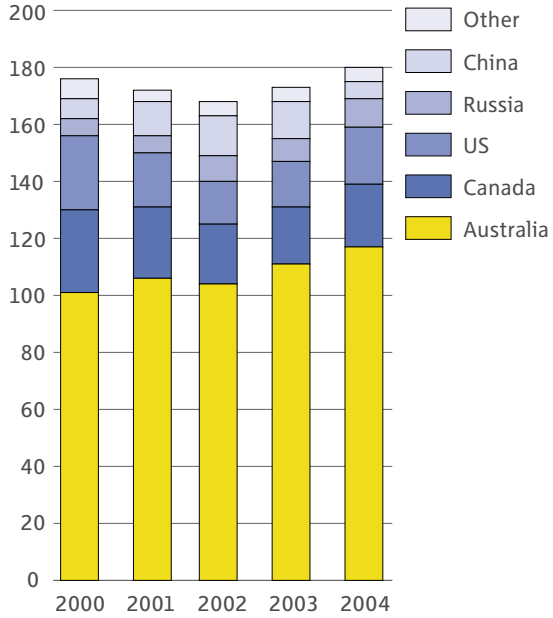



Pacific: 297 mill. t

Source: Association of Coal Importers (Verein der Kohlenimporteure)

Europe, the future could bring somewhat higher growth in world coking coal trading.

**Shares in coking coal market – Overseas trade (in mill. t)**




Source: Association of Coal Importers (Verein der Kohlenimporteure)

## Supply

Due to the low world market prices in recent years, capacities in coking coal and steam coal have seen only modest expansion. In part, utilization of capacities for steam coal in South Africa and Colombia has been reduced, since earnings were inadequate. Owing to a number of special factors, however, the market was subject to tensions in 2003. Besides "normal growth", 2003 also brought additional demand for steam coal thanks to the hot summer in Europe and the shutdown of nuclear power plants in Japan. As a result, demand volume and supply capacity converged more closely and led to a steep rise in prices, which peaked in fob prices of USD 68-70/t (6,000 kcal/kg) in mid-2004. By mid-2005, prices had fallen again to a level of USD 50-52/t. Nonetheless, the world market was able to supply the demanded quantities at all times.

In the Pacific steam coal market, worth 297 mill. t in 2004, the situation continued to be dominated by Australia, Indonesia and China, which accounted for 90 % of supplies. Smaller quantities were shipped by Russia and Vietnam. In 2004, Atlantic suppliers-South Africa and Colombia – supplied only about 7 mill. t (2 %) to the Pacific market. Pacific production exceeds requirements in this area and in 2004 provided some 26 mill. t for the Atlantic market. Indonesian coal, in particular, enjoys growing acceptance in North America and Europe (e.g. Italy) on account of its low price and low sulphur content.

Considerable expansion potential can be seen in Australia and Indonesia. China is hard to assess, owing to its own heavy demand, but wishes to export steam coals at least on the present scale of 75-80 mill. t. The trend in domestic Chinese logistics is toward improvement and could eventually lead to the dismantling of excessively high safety stockpiles and greater flexibility.

Vietnam, too, has ambitious expansion plans and intends to increase exports to 20 mill. t in the next few years. The exported quantities – primarily semi-anthracites – are sold in Southern China to power plants and cement works which are accustomed to these qualities. Russia, too, is expanding its mining and logistics capacities in the Far East to share in the Pacific steam coal market. At present, Russo-Chinese talks, too, are being conducted to supply Russian coal by land to Northern China.

In the Atlantic steam coal market, worth 208 mill. t in 2004, South Africa, Colombia and Russia play the leading role and supply 75 % of the market. Besides Pacific supplies of 26 mill. t, Poland, Venezuela, the US and smaller suppliers like, e.g., Spitzbergen serve the Atlantic market. The expansion potential in Atlantic suppliers refers to Colombia, South Africa und Russia.

Whereas there is a steady uptrend in Colombia's exports, South Africa is stagnating. The export terminal Richards Bay currently has a capacity of

**Hard coal maritime trade, by export and import country/region, 2004 (in mill. t)**

| Export country | Coking coal | Steam coal | Total |
|---|---|---|---|
| Australia | 118 | 107 | 225 |
| Indonesia | 0 | 105 | 105 |
| PR China | 6 | 81 | 87 |
| South Africa | 1 | 67 | 68 |
| Russia | 10 | 51 | 61 |
| Colombia | 0 | 51 | 51 |
| US | 20 | 6 | 26 |
| Canada | 22 | 1 | 23 |
| Poland | 2 | 10 | 12 |
| Vietnam | 0 | 11 | 11 |
| Venezuela | 0 | 9 | 9 |
| Other | 1 | 6 | 7 |
| Exports | 180 | 505 | 685 |

| Import country/region | Coking coal | Steam coal | Total |
|---|---|---|---|
| Europe | 52 | 166 | 218 |
| EU-25 | 47 | 163 | 210 |
| Asia | 110 | 304 | 414 |
| Japan | 56 | 124 | 180 |
| South Korea | 15 | 64 | 79 |
| Taiwan | 0 | 60 | 60 |
| Hong Kong | 0 | 12 | 12 |
| India | 15 | 18 | 33 |
| Latin America | 16 | 11 | 27 |
| Other | 2 | 24 | 26 |
| Imports | 180 | 505 | 685 |

Source: Association of Coal Importers (Verein der Kohlenimporteure)

72 mill. t and is to be expanded to 86 mill. t. At present, however, only some 65 mill. t of capacity is being used, since the railway infrastructure is not functioning. The mining potential exists, however, and the problems in land-bound transportation should be capable of solution in the foreseeable future.

The present high world market prices are enabling Poland to export largely at cost-covering prices and to maintain its export volume of some 10 mill. t. A serious dip in world market prices is a severe threat to volumes, however. Russia, too, is able to exploit its export potential against a background of high world market prices and has increased its market share. Russia, however, has to bridge the greatest distances (over 4,000 km) of all states in domestic transportation to Baltic seaports, but has developed very cost-effective opencast mining for exports. So it, too, is dependent on a relatively high price level, but does have expansion potential.

The US has the logistics in place for higher exports but, in spite of high world market prices, American steam coal mines are obviously aiming at better net-back earnings, free mine, for its coal on the North American market than in exports.

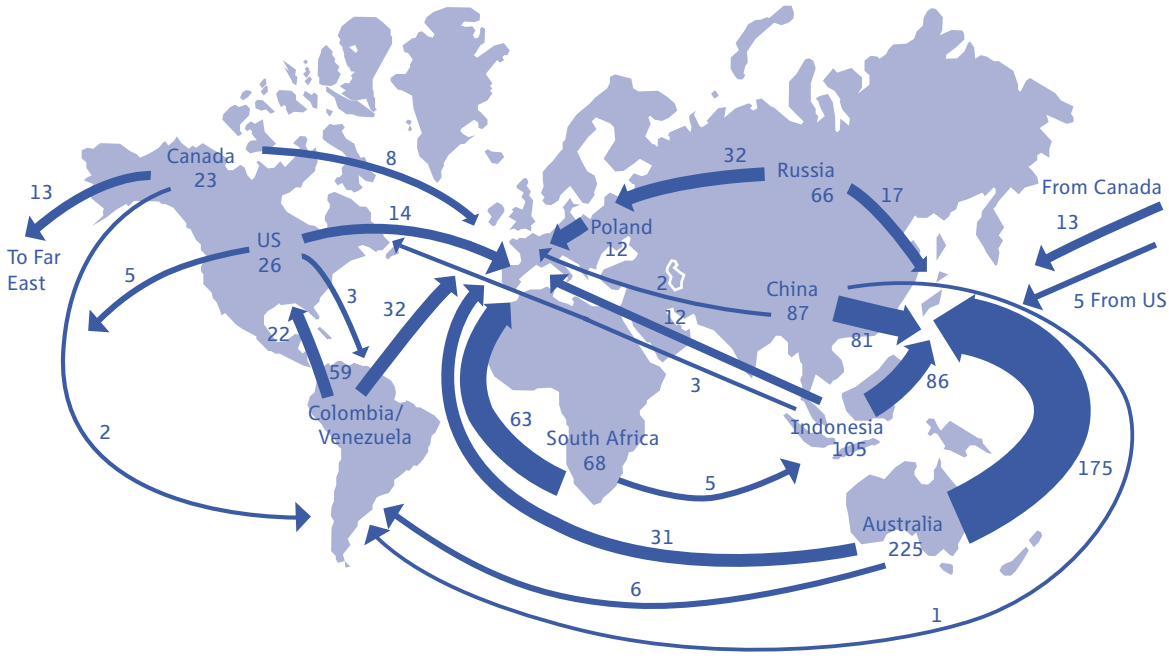
The worldwide coking coal supply of 180 mill. t in 2004 involves a few countries. Australia has a market share of 65 %, making it the outstanding supplier. In 2004, China moved, on balance, from exporter to importer of coking coal, trend rising. In view of China's foreseeable exit as coking coal exporter, the range of suppliers, besides Australia, is largely confined to the US, Canada and Russia. Canada has announced a number of expansion projects, which will yield additional quantities in 2005/2006 already. The US has also been able to increase its supply. Some steam coals are being made available for the coking coal market by better processing, since coking coal contract prices of USD 125/t fob more than cover the extra costs involved.

Australia has the greatest expansion potential in coking coal and reports a project volume of 80-100 mill. t. The country is making great efforts to overcome the present bottlenecks in its ports and railways and is likely to hold, and possibly even extend, its market position.

The supply of steam and coking coals on the world market is kept attractive by producers' continuous increases in output. Hence, Western countries' output per man and year is between 5,000 and 8,000 t in underground mining and between 10,000 und 20,000 t/a in opencast mining.

Maritime transport costs, too, will return to normal in the long run and then underpin the competitive position of world market coal. In mid-2005 already, freight rates fell significantly and, on the route Richards Bay – ARA, are USD 9-12/t (capesize).

**Main trade flows in maritime hard coal, 2004 (in mill. t)**




**Maritime trade: 685 mill. t**
Of which: 505 mill. t steam coal
180 mill. t coking coal

Source: Association of Coal Importers (Verein der Kohlenimporteure)

The bulk carrier fleet is being expanded, and tonnage is increasing from 327 mill. dwt at end-2004 to a good 390 mill. dwt at end-2007. In this respect, some 70 mill. dwt is assumed in the way of new construction, with 10 mill. dwt scrapped (according to Clarkson).

Supply conditions for world market producers crucially depend on the geological formation of the deposits and on productivity in mining operations. In principle, it may be assumed that the favourably located deposits are used up first. Once they are depleted, recourse must be had to resources that are geologically less favourable or, due to their geographical situation, more difficult to develop. Here, the drawbacks of having to switch to poorer deposits can be more than compensated by productivity gains. This has been the case in recent years.

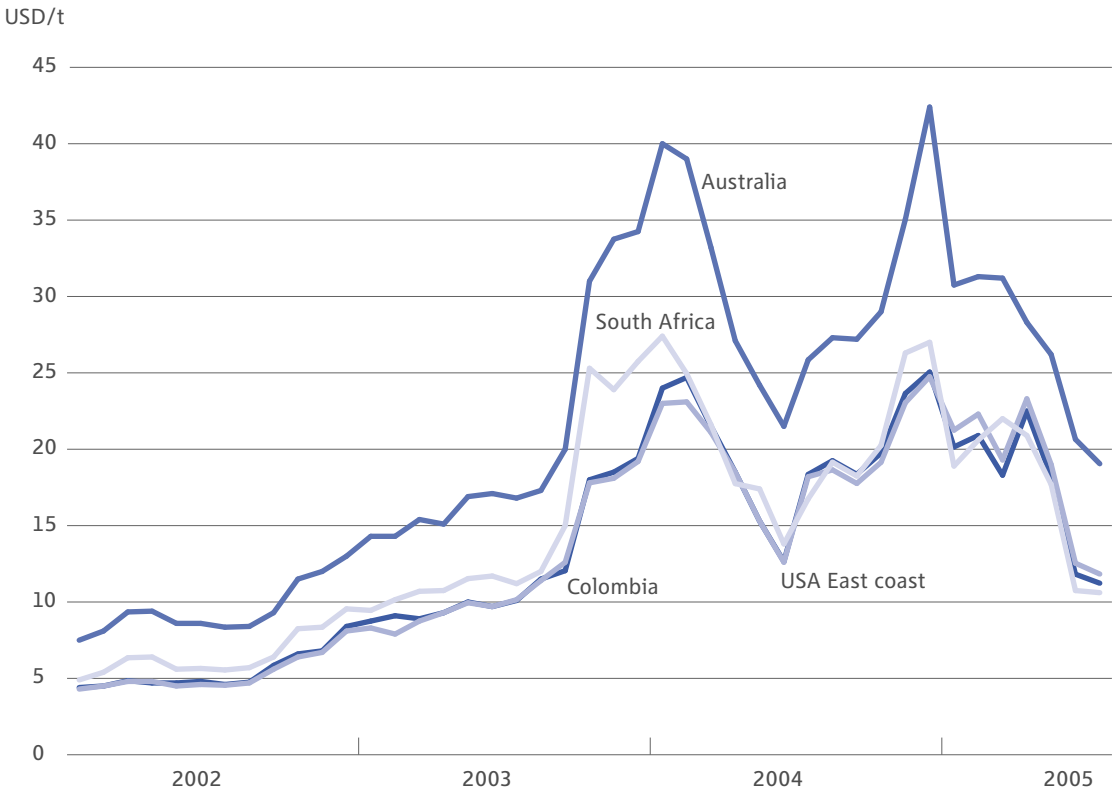
**Extensions to bulk carrier fleet, in mill. dwt, 2004 - 2007**

| | End-2004 | Additions 2005 | 2006 | 2007 | End-2007 |
|---|---|---|---|---|---|
| Capesize | 111 | 9 | 12 | 19 | 151 |
| Panamax | 82 | 6 | 4 | 6 | 98 |
| Handysize | 134 | 6 | 5 | 6 | 151 |
| Scrapped, overall | | -3 | -3 | -3 | -9 |
| Total | 327 | 18 | 18 | 28 | 391 |

Source: Clarkson, Freight Report

Accordingly, in a buyers' market, the long-term marginal costs in mining are the key determinant for the price trend in ex-mine hard coal. Prices fluctuate in cycles around a trend defined by long-term marginal costs. Here, price swings

**Freight rates for hard coal**




Source: Frachtkontor Junge

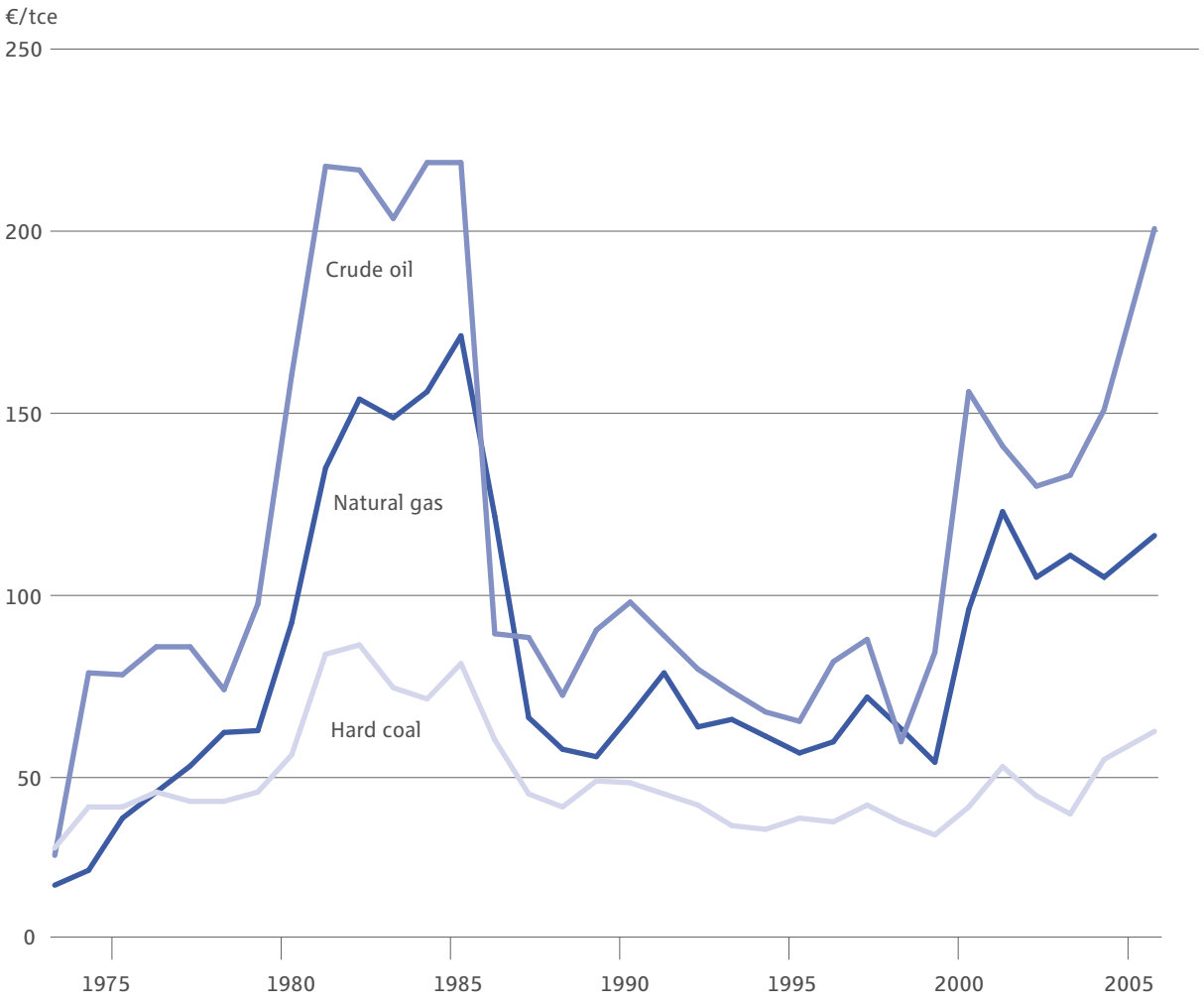
depend crucially, inter alia, on the course of demand, which is, in its turn, determined by the utilization of existing export capacities and – to a lesser extent – by price movements affecting the market leader, crude oil.

In a sellers' market, on the other hand, the full costs and margins of the most expensive supplier required to cover the demand determine the world market price.

Close interdependencies exist between these factors. The second oil crisis in 1979/80, for example, led to an increase in the demand for hard coal and, hence, to better utilization of supply capacities. The result was a rise in hard coal prices, which, in turn, triggered a mobilization of existing, and the development of new, export capacities.

There followed further market cycles with prices first rising and then falling again, viz. between 1973 and 1987, 1988 and 1993, 1994 and 1999. Prices peaked in 2000/2001 at USD 42/t cif ARA, and dipped again to USD 28/t cif ARA in 2002. With a simultaneous weaker dollar rate, these prices were hardly capable of absorption by steam coal mines in South Africa. In 2003/2004, however, the special factors identified triggered leaps in demand, which led to peak prices of

**Price developments for imported energies (free German border)**




Source: Federal Office of Economics and Export Control (BAFA)

USD 78/t cif ARA. In the meantime – mid-2005 – prices are USD 60-62/t cif ARA. The present price level offers incentives for producers to increase their supplies to meet market demand in order to maintain and extend the supply range.

**Re-formation of markets**

The international hard coal market has seen profound structural change in recent years, marked, first, by ongoing supplier consolidation in Western exporting countries and, second, by a rise in the importance of the former state-trading countries and the current transformation states as world market suppliers. With their structural adjustments and the modernization of their coal industries, the latter are increasingly assuming the role of the traditional exporters that have ensured balanced markets until now.

At the same time, in line with the trend toward globalization, cross-country mergers and acquisitions among coal companies have been on the up, and oil firms like Exxon Mobil and Shell have retreated from coal business.

The only oil company operating in South Africa has been Total. The big four – BHP, Anglo, Rio Tinto, Glencore/Xstrata – have opened new mines or bought interests, e.g., Anglo's interest in Paso Diablo, or Glencore/Xstrata's further mining rights in Colombia. In Russia, four big companies have formed in the main on a private-sector basis and control the Russian coal sector, while China, too, is aiming at creating 8-10 big companies with 50-100 mill. t and more production volume, and they are to be privatized in the long run. China's WTO accession will tend to make commitments by external company groups in China possible. India and China are increasingly showing an interest in coal and iron ore interests overseas in order to secure their raw material bases. CVRD – the biggest Brazilian iron ore producer – is planning the development of a coking coal mine for an eventual 6 mill. t in Mozambique.

The world hard coal market is now served by an estimated 400 export mines, with some 120 producers operating in this sector in 2004. The ten biggest privately-organized hard coal companies accounted for a 21 % share of global output in 2004, and for 48 % of output outside the transformation states. Five of these operators even have a 32 % share in the maritime hard coal trade.

Where only a few years ago the activities of producers were largely focussed on one country, they now extend from Australia via South Africa and Indonesia all the way to North and South America and, recently, to China as well.

What has also changed are the contractual relations in international coal business. To a growing extent, hard coal trading is being handled between producers and consumers directly. The big producers, like BHP, Anglo und Glencore/Xstrata have set up their own sales companies and are distributing steam coal and coking coal – partly from different countries – on a one-stop basis. This example is also being followed by the biggest privatized Russian producers, meaning that dealers are losing their once-important position as contractually involved intermediaries between producers and consumers. In view of this trend, their remit is changing and is increasingly focussing on more opaque markets and on handling/distribution. Also, more dealers are acting as agents for big producers, providing assistance in arranging contracts and customer care. In Europe, a number of trading houses are increasingly performing agency functions. Specific mention must be made of the following companies:

- RAG Trading
- RWE Trading
- Constellation
- EDF Trading
- Coeclerici

**World's largest hard coal producers, 2004 – private-sector companies**

| Companies in: | Shareholders | Output, mill. t | Exports mill. t |
|---|---|---|---|
| Peabody Energy Corp.*<br>US, Australia, Venezuela | 57 % Lehmann<br>Merchant Banking Partners** | 176 | 14 |
| Rio Tinto Plc.<br>Australia, Indonesia, US | listed | 157 | 30 |
| Arch Coal, Inc.<br>US | listed | 143 | 3 |
| Anglo Coal<br>South Africa, Australia,<br>Venezuela, Colombia | listed | 90 | 42 |
| BHP – Billiton Plc.<br>South Africa, Australia,<br>Indonesia, US, Colombia | listed | 84 | 68 |
| Consol Energy, Inc.*<br>US, Canada, Australia | listed | 61 | 10 |
| Xstrata Plc.<br>Australia, South Africa | listed | 60 | 47 |
| Foundation Coal,<br>US | listed | 56 | – |
| Sasol Mining (Pty) Ltd.<br>South Africa | listed | 51 | 3 |
| Massey Energy Co.<br>US | listed | 38 | 6 |
| | | 916 | 220 |

Source: own investigations

A strong position in the Far-Eastern coal trade is occupied by more than 10 Japanese trading companies that mainly handle the supply contracts concluded between the steel industry or the power sector and the exporters, and some have considerable stakes in various export mines. The most important here are:

- Mitsubishi
- Mitsui
- Itochu
- Nichimen
- Nobel

In the US, AMCI is one of the leading trading houses. In China, most coal exports are handled by the state-run Chinese National Coal Import and Export Corp. (CNCIEC), and, in Poland, by the likewise state-owned firm WEGLOKOKS. In Russia, KRUTRADE is by far the most important trading company.

**Representative costs in the coal chain**

In the competition between primary energies, it is the costs in the coal chain, i.e. in the various stages from export mine to consumer that are crucial.

One important component in mining costs is the expenditure on developing the deposits. In the case of new mining capacities for export coal, i.e. for prospection and exploration as well as the development of new mines, these costs currently amount worldwide to USD 45-50/t p.a. of mining capacity. This figure also includes the costs of extending already operating mines (World Energy Investment Outlook 2003). For mines that cannot be linked to the available infrastructure (transport links/water and energy supply/personnel available on the spot), specific investment rises substantially, however, and may double. Compared with gas and oil, coal is the least capital-intensive. The World Energy Invest-

ment Outlook of the IEA, for example, has identified the following order (converted into tce):

| | |
|---|---|
| Coal | USD 3.4/tce |
| Oil | USD 15.4/tce |
| Gas | USD 19.6/tce |

The figures are based on the accumulated investments throughout the entire supply chain of the energy concerned in the period 2001-2030, divided by the accumulated production growth in each case. Hence, coal has lower entrepreneurial risks than gas and oil.

The highest specific outlays for the erection of mining capacities are involved in the development of completely new coalfields or large-scale operations, plus infrastructure, in remote and undeveloped areas (greenfield projects), which may require amounts of over USD 100-120/t p.a. By contrast, where new mines are being developed or existing mines extended in areas with an already developed infrastructure (brownfield projects), the specific investment is within a bandwidth of a mere USD 30-60/t p.a. of mining capacity. In this respect, there are some substantial differences between deposits at long

**Representative costs in the coal chain (2004/5), cif ARA**

| Export country | Region Extraction method | Costs free mine USD/t | Transport domestic USD/t | Port handling USD/t | Sea freight Aug 05 USD/t | Total costs free ARA port USD/t |
|---|---|---|---|---|---|---|
| **1. Steam coals** | | | | | | |
| Australia | Queensland Opencast | 11-32 | 6-14 | 2-3 | 14 | 33-63 |
| | New South Wales Underground | 19-31 | 3-10 | 2-3 | 17 | 41-61 |
| | New South Wales Opencast | 17-29 | 3-10 | 2-3 | 17 | 39-59 |
| South Africa | Opencast | 16-24 | 6-10 | 1.5-2 | 9 | 32.5-45 |
| Colombia | Opencast | 22-24 | 2-3 | 3-5 | 9 | 36-41 |
| Russia | Opencast | 15-16 | 10-20 | 2-3 (6-8)* | 8 | 35-47 (39-52)* |
| China | Underground | 29-36 | 6-9 | 2-3 | 12 | 49-60 |
| Indonesia | Opencast | 14-26 | 2-7 | 2-4.5 | 12 | 30-49.5 |
| Venezuela | Opencast partly plus transit/post-treatment | 16-20 | 5-6 | 3-5 | 9 | 33-40 |
| **2. Coking coals** | | | | | | |
| Australia | Queensland Underground | 22-33 | 8-10 | 2-3 | 14 | 46-60 |
| | Queensland Opencast | 20-28 | 6-9 | 2-3 | 14 | 42-54 |
| | New South Wales Underground | 20-40 | 4-6 | 2-3 | 17 | 43-66 |
| | New South Wales Opencast | 22-27 | 5-7 | 2-3 | 17 | 46-54 |
| Canada | British Col. Opencast | 26-36 | 20-22 | 3-5 | 17 | 66-80 |
| US/Central-Appalachians | Underground | 30-48 | 15-26 | 2-3 | 10 | 57-87 |

* incl-transit, post-treatment
Source: International Energy Agency, Coal Information, own calculations

and short distances from the coast, between opencast and underground mining, or the extraction of coking and steam coal. Assuming an average mine life of some 20 years, depreciation is approx. USD 2.5-3.0 per mined tonne, and debt service USD 3.5/t on the basis of a 10 % rate of return.

The total costs in the coal chain, with a breakdown by the various interacting links, are specified for the various exporting countries in the Table (page 26).

Bandwidths of representative costs are given. In operational logistics, in particular, from the mine to the ocean-going ship, conditions differ, depending on the country. For example, significant differences exist when coals have to be transported from the mine directly to an export terminal with loading of capesize ships or are conveyed by barge to ships in the roads.

The income earned on the world market in 2004 not only ensured full cost coverage for producers; it also brought the highest profit margins in the past decade. The boom in the coal industry, however, is also leading to rising costs, since labour is demanding higher wages, and the industry supplying mining equipment has reached its capacity limits in places and is able to push through higher prices. The logistical costs of the overall supply chain have substantially increased owing to recent price rises for fuel. This affects particularly opencast mines using truck and shovel operation.

**Price formation**

The world's hard coal market for steam coal has been expanding since the 1980s, although the market initially lacked maturity. This implies, above all, price competition that is governed by supply and demand. Until 1990, supply was – just – able to satisfy steadily growing demand, but has tended to run ahead of demand since then. With hindsight, it is now clear (see Diagram) that a hefty excess supply evolved for the first time between 1990-1992 which, with demand rising, did not contract again until 1995 to an extent that could prompt a further investment cycle with renewed excess supply. In 2003/2004, moderate investment activity in the previous years was now followed by high capacity utilization and, hence, price peaks.

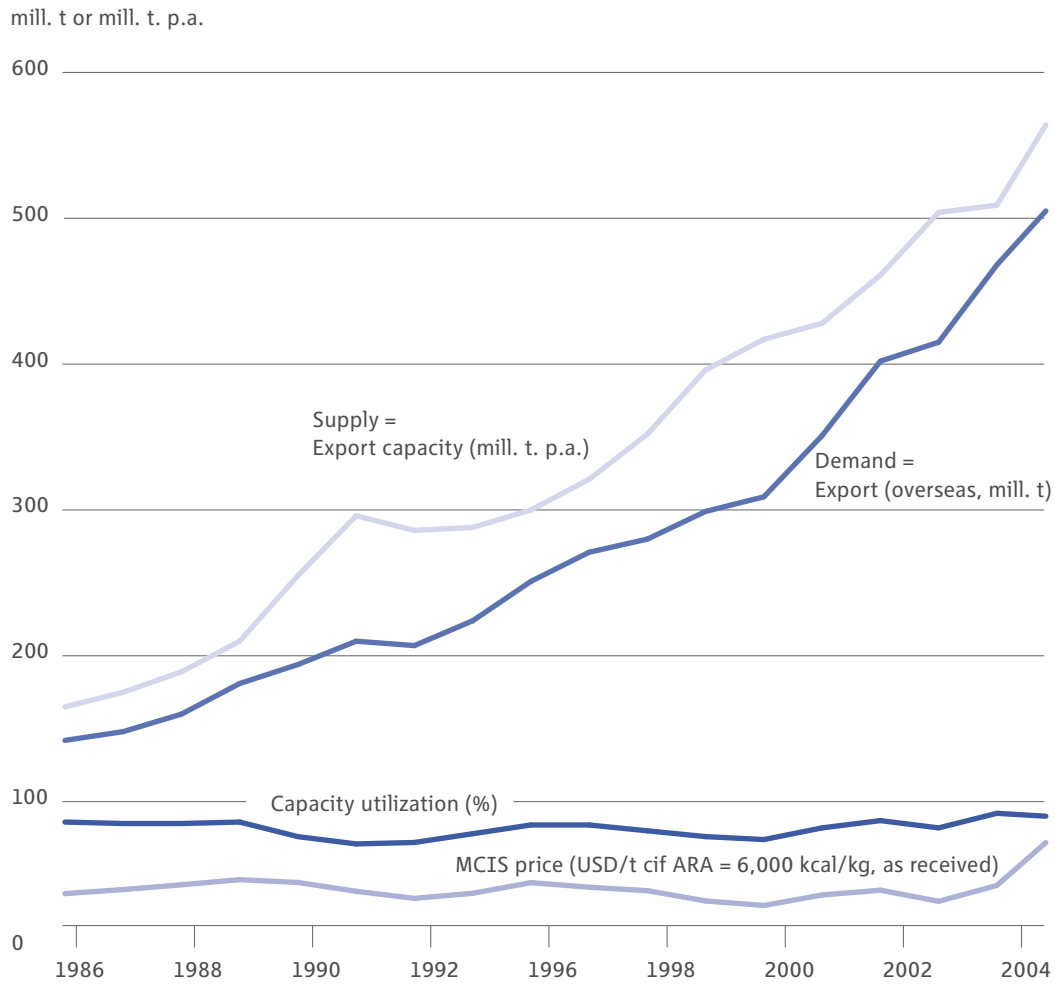
The successive phases of excess supply and relative shortages are triggering intense price competition. One main – and leading – indicator of price developments in this respect has proved to be the utilization of the mining capacities available for exports. The degree of capacity utilization in export mines is in sync with steam coal price rises and falls.

This is also true of the recent past, when demand for both steam coal and coking coal has come up against capacity limits with corresponding price fluctuations in an upward direction. Whereas in the case of steam coal it has still been possible to mobilize certain capacity reserves, which led to a moderate dip in prices, coking coal prices rose by over 100 % to USD 125/t fob shipping port due to a lack of elasticity in the supply.

As mentioned earlier, the world market for the ocean-going hard coal trade in steam coals involves two segments. These are Europe incl the neighbouring Mediterranean countries and North, Central and South America, and the Pacific market, which also extends to the Asian riparian states along the Indian Ocean, although it mainly serves Asian consumers. This division is mainly a matter of different transport costs, but also involves different pricing mechanisms. Nevertheless, deliveries may occur from one market segment to the other, provided that the obtainable cif prices are still competitive. The extra transportation costs (e.g. Australian coal to ARA) are borne by the supplier. Such exports are often contracted on a cif basis.

The competitiveness of more distant suppliers tends to rise when freight rates are low and to fall when they are high. Some interdependencies

**MCIS price and capacity utilization for steam coal**




Source: Kopal, C.: Weltmarkt Steinkohle, Hanover, 2005

exist with the coking coal market. Hence, more highly volatile coking coals are also used in places as steam coal, and certain steam coal qualities can be marketed, after better preparation, as more highly volatile coking coals. Producers decide according to the price situation which variant earns the highest "net-back" price, free mine.

The volume of exchange quantities on both markets in 2004 was 33 mill. t or just under 7 % of the entire steam coal market of 505 mill. t. With markets often taking different courses, price formation, too, is generally a separate process in the two regions. Still, market linkages do ensure largely synchronous price trends, which are also reflected in the MCIS (McCloskey Coal Industry Services) price indices for NW Europe and East Asia.

In view of their high market shares, the price leaders are generally South Africa for the Atlantic market and Australia for the Pacific market. However, since considerable quantities are now being traded on a spot basis, the market leaders have to include in their thinking the prices of their next-higher competitors (e.g., Colombia and Russia in Europe or Indonesia and China in East Asia), if they are not to lose market share. The crucial factor in this respect is the cif price at

the port of destination. The price level formed in this way is the benchmark for the negotiation of long-term prices.

A new element in price developments, at least in the European section of the Atlantic market, is $CO_2$ certificate trading. This affects primarily the use of gas or coal in power plants. With gas prices low, the $CO_2$ certificates curb the demand for coal; when they are high, coal can be competitive in spite of the impact of the $CO_2$ factor. Power plant operators decide on use by referring to the margins that they achieve with a given electricity price by deploying gas or coal, including the $CO_2$ factor. The system has only recently been up and running and is not yet installed Europe-wide, so that it is necessary to await the effect it will have on coal use.

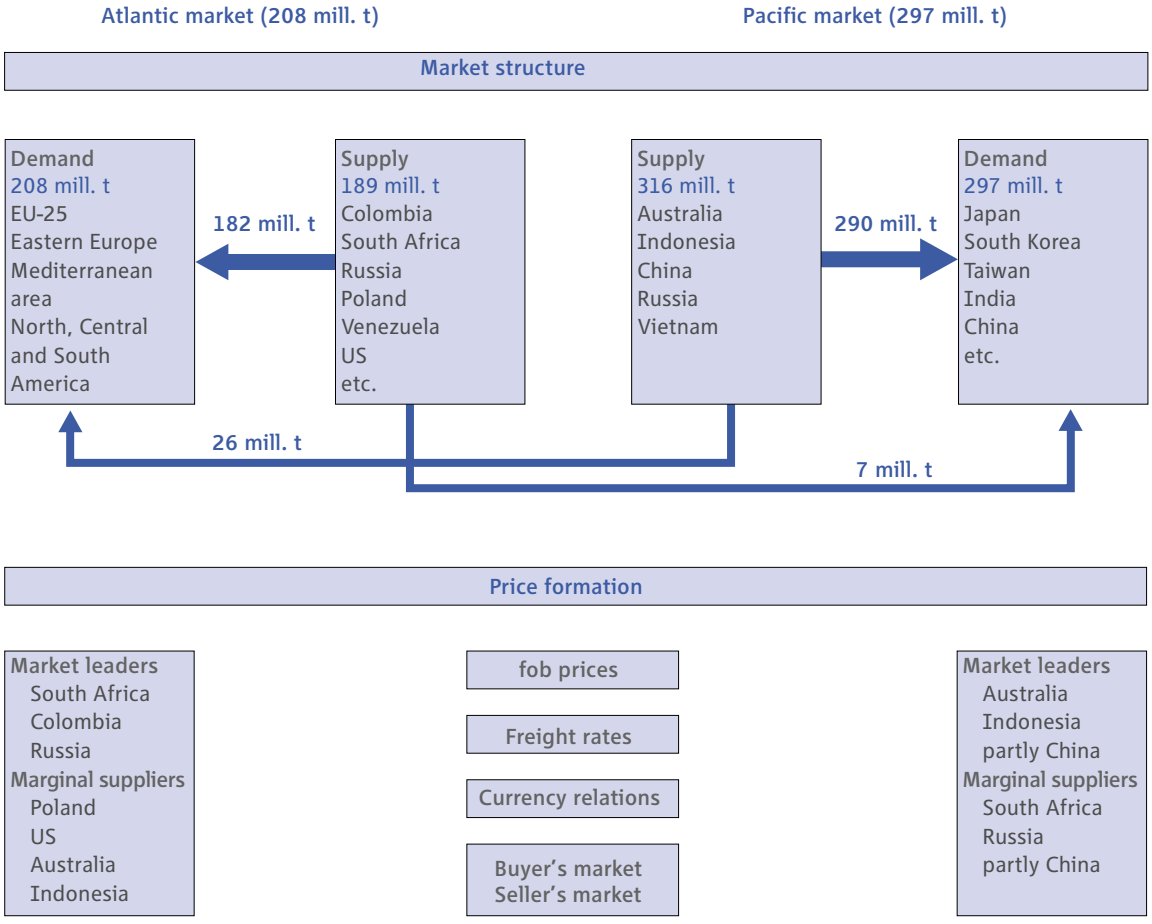
**Contract forms in international coal trade**

On the world hard coal market, both long-term supply contracts and spot transactions are usual. By concluding spot contracts, consumers seek to maintain a particularly close alignment to the current market situation. In such deals, buyers are guided by the following considerations:

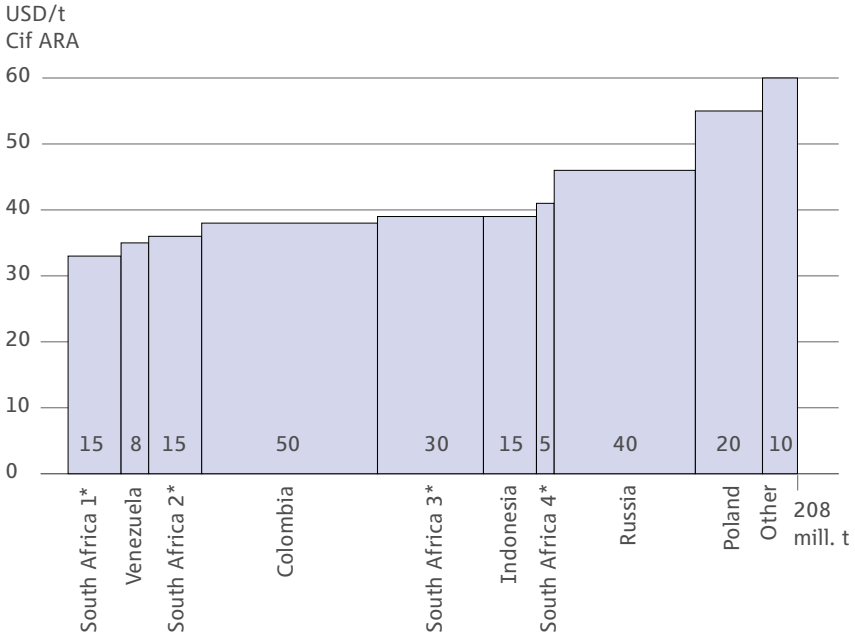
- close linkage to the electricity market
- exploiting of price changes wherever possible,
- procuring "small" quantities at favourable terms, and
- cover for consumption peaks that go beyond the various planning horizons.

Also, it is now virtually the rule that medium-term requirements, too, are covered on the spot market at the expense of longer-term contracts.

**Mechanisms of price formation for steam coal** (Total market 2004: 505 mill. t)



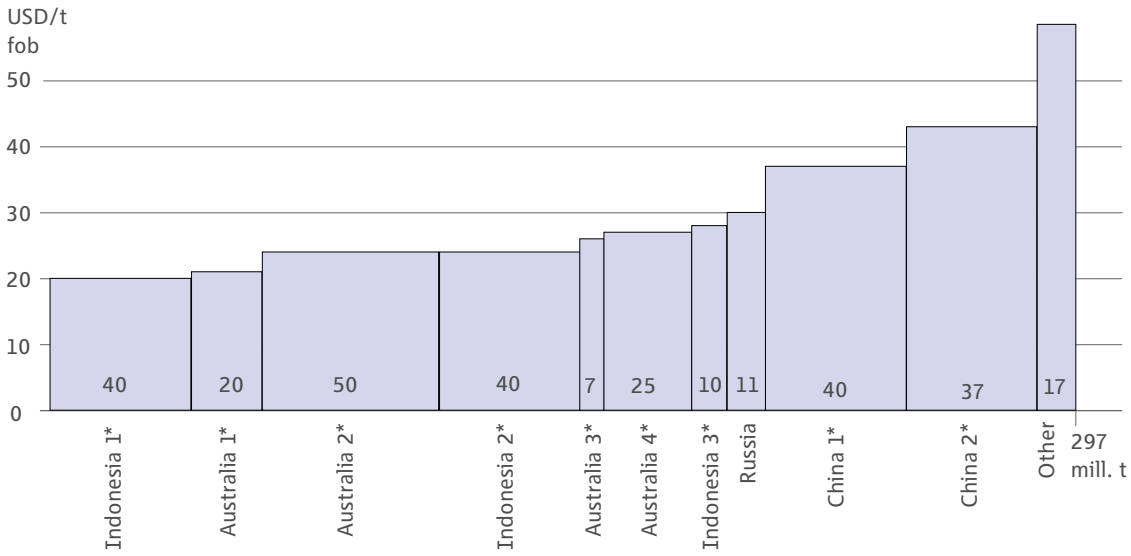
**Order of suppliers of steam coal, by production costs on the Atlantic market incl ocean transport, 2004**




* Mines with differing production costs in South Africa

Source: Association of Coal Importers (Verein der Kohlenimporteure)

**Order of suppliers of steam coal, by production costs free port of shipment on the Pacific market, 2004**




* Mines with differing production costs

Source: Association of Coal Importers (Verein der Kohlenimporteure)

One variant of spot purchases is the growing number of tender deals, i.e. purchases which are preceded by a bidding procedure, with the best bid winning the contract. Deliveries agreed in this way generally involve larger volumes than single deals, and the time frame mostly extends across several quarters. In short-term business, option quantities, too, can be traded if the intention is to secure additional quantities, while wishing to wait and see how markets and prices develop.

One feature of spot transactions is that, when the market situation is tense, mark-ups are charged on long-term contract prices. Conversely, when the market situation eases, price reductions are allowed. Hence, the spot prices in buyers' markets, such as those that existed in the early 90s and after the mid-90s, were generally below long-term contract prices. Another characteristic of spot prices is that they have an impact on the contract prices of future deliveries, for which they perform a pilot function.

Spot deals are no longer arranged and handled exclusively between producers or dealers and consumers in the traditional manner. In the case of steam coal, these functions are increasingly being performed by firmly established trading platforms, commodity markets and the brokers who work for them.

Long-term contracts were once concluded for periods of up to 10 years directly between producer and final consumer. They defined the annual quantities to be purchased, incl buyer and seller options, as well as the fixed prices for the current year. The annual pricing to be agreed possibly had to consider any cost rises that had occurred in the meantime – a practice that was mostly discontinued in the 1980s already. The contract year, in this respect, was the calendar year or, in East Asia, often the Japanese fiscal year (1 April to 31 March). Today, long-term contracts are encountered, if at all, only on domestic markets, e.g. for supplies to near-mine power plants or steel mills, or where long-term mutual dependencies exist between producer and consumer.

On the world market, by contrast, the character of long-term contracts has changed considerably in the meantime under the growing pressure of spot transactions, especially for steam coal. Today, their terms rarely go beyond five years, and they are merely used to underpin long-term cooperation between the contracting parties within the scope of potential selling or purchasing rights for specific contract quantities (incl buyer options) wherever it is possible to agree on a purchase price. On the basis of the current spot price, the contracting partners submit their offers for a quarter and, where no agreement comes about, the supply envisaged for that quarter ceases to apply. In East Asia, it is true, there are still annual contract or marker prices, but with a steep fall in the number of deals, above all for steam coals.

**Lead times in coal logistics for imports to Germany (in weeks)**

| | Reporting period | Loading time window | Sea trip | Domestic transport | Total |
|---|---|---|---|---|---|
| Australia | 4 | 2 | 6 | 1 | 13 |
| Indonesia/ China | 4 | 2 | 6 | 1 | 13 |
| South Africa | 4 | 2 | 3 | 1 | 10 |
| Colombia | 4 | 2 | 2 | 1 | 9 |
| Poland/ Russia | 4 | 2 | 1 | 1 | 8 |

Source: Kopal, C.: Weltmarkt Steinkohle, Hanover, 2005

One new variant for long-term pricing is that futures, too, are now being offered by trading platforms and commodity markets for spot quantities. These prices can be agreed in advance.

In physical procurements, account must be taken of the lead times needed between contracting and arrival at the power plant. The Table included shows some lead times for the German market.

**Influence of electricity markets**

As of late, electricity markets in Europe, the US and the Far East have undergone radical change. Liberalization, deregulation and the associated abandoning of secure supply regions have abolished traditional market structures and launched free competition among power producers. What matters for the power suppliers now is that they offer competitive electricity prices by making optimal use of their own power plant fleet or buy-ins to underpin or extend their market share. This is forcing power plant operators to reduce their fuel costs as well, which is true especially of plants whose primary energy supply is impacted by high transport costs, e.g., for imported coal. They then try to pass on market pressures to the coal suppliers. This pressure exists in particular when it is the marginal costs of power production in the mid-merit load that determine power prices.

Decisions to build new hard coal-fired power plants are much riskier on liberalized and, hence, short-term oriented energy markets than in case of demarcated supply regions with statutory supply duties. Coal-fired power plants are investment goods that are only able to earn their capital costs across very long amortization periods: 20 or more years are needed to obtain a reasonable ROI. Thereafter, it is true, they usually have a "golden end", unless technical innovation or new requirements, e.g., in environmental protection, put a premature end to these plants. Otherwise, service lives of 35-40 years or more are nothing unusual.

By contrast, gas-fired power plants can be erected more quickly than coal-based plants and require only half the investment total needed for a hard coal-fired unit. Capital costs are correspondingly lower. This advantage in competition can be compensated only by low operating costs, i.e. lower fuel costs in the main. So overseas coal producers must quote export prices that offset the handling and combustion advantages of gas and the lower impact of $CO_2$ certificates involved. On the other hand, it must not be forgotten that wide sections of the world steam coal market need not bear any $CO_2$ certificate costs at all. In the case of a seller's market, international coal producers will sell their products in those markets where they obtain the best net–back price, free mine. What is more, a decision on the erection of a hard coal-fired power plant presumes electricity prices that permit long-term full cost coverage. Also required, especially in Germany, are stable framework conditions for the use of coal-fired power plants. Pinpointed subsidies for renewables-based and distributed generation concepts are disrupting the development of a market economy-oriented electricity supply and, hence, the emergence of an optimized power plant fleet, including hard coal plants.

Decisions to construct coal-fired power plants and the conditions for using coal are less complex in East Asian industrialized countries. There, imported coal still enjoys a considerable price advantage relative to imported liquefied gas, although this could be jeopardized by future gas pipelines from Indonesia or Russia. There, however, preconditions are not in place – as they are in Europe, say – for the creation of a joint and integrated grid, since Japan, Taiwan and South Korea will remain stand-alone markets in the foreseeable future.

**Risk management**

In view of the more complex conditions applying to hard coal trading, increasing use is being made, in coal procurements and in securing sea

freights and exchange rates, of the risk management techniques that have been used for some time now in other commodity markets.

Hedging – deals designed to avoid the financial losses associated with supply and charter contracts – now helps underpin the traditional coal and ocean freight trade. In fact, they often enable such transactions in the first place and help safeguard them. Here, the players involved think less in physical than in paper categories. Since volatility in both coal trade and freight business has risen significantly, the prerequisites – along with other underlying conditions – have now been created not only for initiating additional deals by using speculative tools like swaps, futures or options, but also, in this way, for handling a growing number of transactions that used to come about in the conventional manner.

The biggest obstacle to an innovative coal trade in the past was the heterogeneous quality spectrum encountered in coal as a commodity. Unlike other raw materials on whose markets risk management methods, standardized contract forms and forward trading are already the rule, such activities are still hampered in the coal sector by the existence of a large number of measurable quality parameters and the different ways they are assessed by customers, especially in the case of coking coal.

On the other hand, steam coal is now well on track to become an accepted and traded commodity worldwide on commodity markets and international trading platforms. The physical preconditions for this have been created recently by a number of "coal indices" that precisely define and standardize provenance, quality, place of delivery and conditions; they are replacing the subjective assessments and interpretations of market participants that were usual in the past. Among these coal indices we currently find the following:

TFS API #2
NAR CIF ARA

Basis: South African coal ex Richards Bay in the case of capesize freight to ARA ports with a net calorific value of 6,000 kcal.

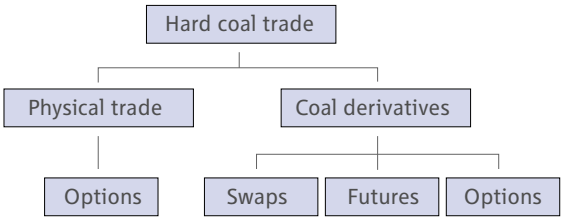
TFS API #4
NAR FOB RBCT

Basis: South African coal fob Richards Bay with a net calorific value of 6,000 kcal.
McCloskey publishes 2 price indices,

- Northwest European „steam coal marker"
- Asian "marker price"

which are based on fob prices Richards Bay (South Africa) or Newcastle (Australia), likewise for standard quality 6,000 kcal/kg, and are partly employed as a basis for price estimates. Recently, the EU has also been publishing average import prices again for steam coal and coking coal. Besides these indices, there are also special quotations for US coal at the NYMEX and for the Powder River Basin.

Unlike conventional "physical" coal trade with contracts and options at fixed prices, the coal indices now also permit trade on commodity markets and trading platforms involving coal derivatives, i.e. paper transactions with temporally fluctuating over-the-counter (OTC) – i.e. bid and offer – prices. Here, deals on a swap, futures and options basis are possible.




The OTC prices, which are published at least on a weekly or monthly basis, have created an unheard-of transparency on the world hard coal market, and now largely determine the spot

trade in steam coal and its price trends on the Atlantic and, increasingly, on the Pacific market as well. For medium-term deliveries, too, the price then to be paid is increasingly established on the basis of the course taken by a specific index in the meantime. The price determinants are fixed upon contracting. Also, market players have the option of hedging their coal purchases price-wise.

Such deals are handled by broker firms (e.g. TFS) or trading platforms like the digital platform globalCOAL set up at year's end 2000 by coal producers and consumers. As an ideal medium for its latest variant, Internet trade offers ready access to updated market data with fast response times. It has certainly speeded up commodity trade in coal and ensured quick acceptance. Liquidity is still low, however.

**Outlook**

**Demand**

Actual developments in recent years have exceeded all expectations about the growth of the world coal market. Nonetheless, in the wake of the stormy growth of the steam coal market by a good 200 mill. t in the last five years, a rather more moderate development is expected. On the other hand, after years of stagnation, the coking coal market might find the growth trail again in view of the strong demand from China.

In the International Energy Outlook 2005, DOE/EIA assumed that world trade in steam coal would grow in the period 2003 to 2025 by an average annual 1.5 %. For the coking coal trade, growth of 1.3 %/year is assumed for the same period.

The main drivers cited for growth in steam coal trading are rising imports in the Asian economic area, above all to cover the fuel needs of new coal-fired power plants. The increase in coking coal exports is explained by growing demand in China, South Korea, Taiwan, India and Brazil. For these states, an expansion of steel production capacity is expected.

Besides foreseeable developments in demand owing to the construction of new coal-fired power plants and the increase in pig iron production, the competitive situation relative to other energy sources plays an important role, of course. In view of the worldwide rise in the demand for oil and gas, the prices of all primary energy sources and their products have risen enormously and have kept the competitive situation of coal stable, in spite of likewise substantial price rises. Price risks – especially those attaching to natural gas as alternative fuel in power plant use – have moved forcefully into public awareness, and coal is being viewed as the chief element in the energy mix for many economies.

In the European area, stable overall demand for imported, steam and coking coal is expected, since domestic capacities in hard coal mining continue to be decommissioned in Germany, Spain and the UK.

The high oil prices are also encouraging the use of PCI technology. Growing in significance is the Mediterranean area, where more coal is now being sold in Italy, Israel and Turkey.

In America, besides the traditional coking coal importers, many Central and South American consumers are discovering world market steam coal as an attractive product for their power plants. The US, too, has for some years now been reporting growing imports of steam coals, above all in coastal regions.

The Asian area will remain the growth driver for steam coal and coking coal. In all Asian economies, electricity requirements and, hence, the demand for steam coal will rise. In addition to the traditional big importers Japan, South Korea and Taiwan, growing quantities are being demanded by China (for coastal and border regions), Malaysia, the Philippines, Thailand and India.

China has changed from coking coal exporter to coking coal importer. Chinese steel production is based largely on pig iron production using the blast furnace process, so that it needs growing quantities of first-class coking coal from the world market.

**Supply**

The Pacific market is supplied with steam coal from Australia, Indonesia and China. Smaller producers, e.g., Vietnam, have been added in recent years, like Russia via Far East ports. South Africa has practically lost its market position on the Asian market. Only India might in future remain as an outlet for South Africa in view of the relative short distances involved. All Pacific producers have expansion potential and are continuing to develop their export infrastructures. Indonesia is also increasingly exploiting market opportunities on the Atlantic market.

The Atlantic market is supplied by South Africa, Colombia and, to an increasing extent, by Russia. Smaller quantities come from Venezuela, Poland, the US and Spitzbergen. Colombia, Venezuela and Russia have considerable expansion potential. In principle, South Africa, too, has growth potential although, in spite of the planned extensions to the Richard Bay terminal to take 86 mill. t, export volumes are stagnating at present, since the railway infrastructure is not being developed to keep pace.

The US and Poland have the highest production costs among the Atlantic suppliers and can only compete where world market prices cover costs. The export infrastructure is also being extended in the Baltic, in Colombia and Venezuela. The Atlantic market will also be dependent in the foreseeable future on additional quantities from Pacific producers – primarily Australia and Indonesia.

The coking coal supply is marked by the outstanding market position of Australia, which also has enough expansion potential to serve a growing world market.

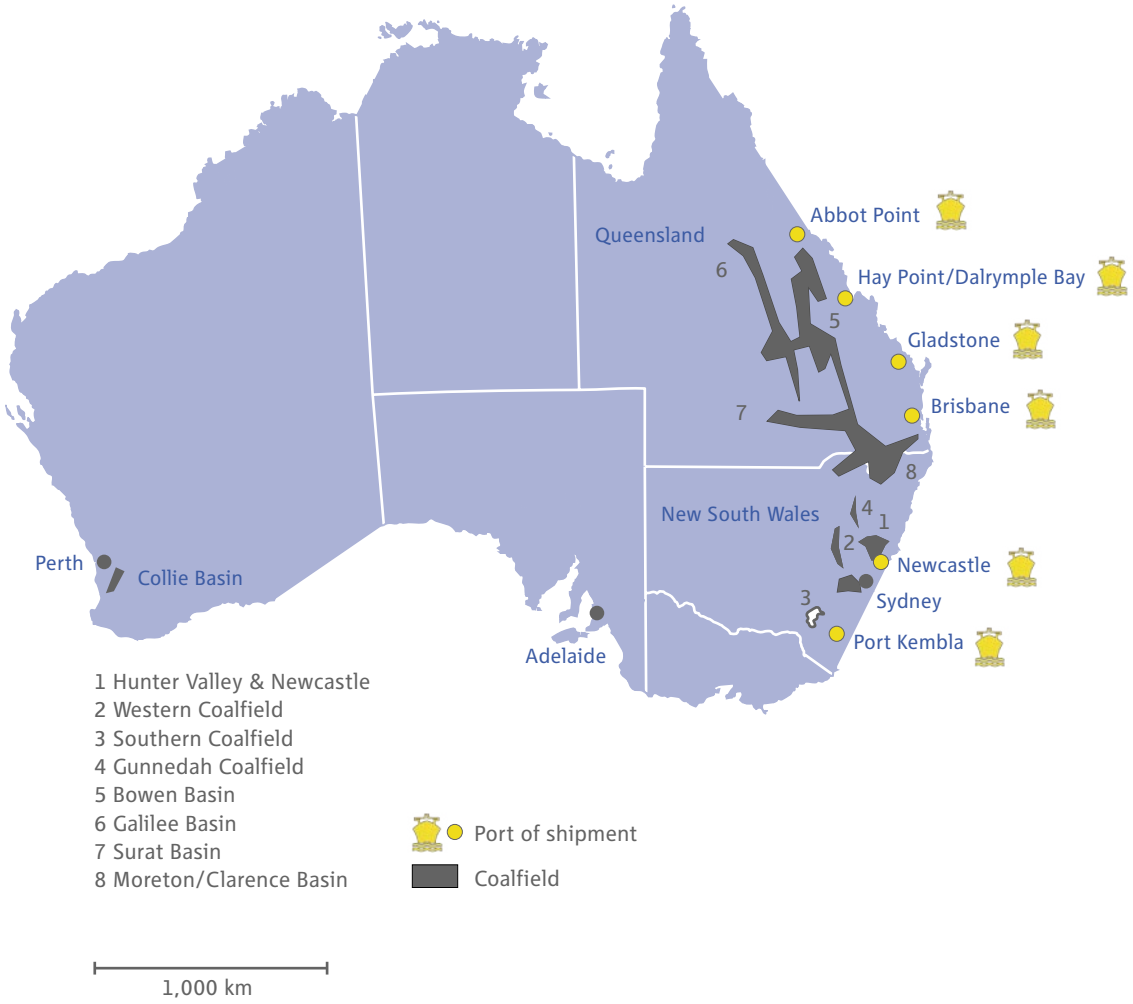
Canada, prompted by high world market prices, has launched a number of projects but, like the US, is dependent on high earnings in view of its cost situation. With China ceasing to be a coking coal supplier in future, the market position of the US and Canada is strengthened, above all from the angle of diversification in sourcing. Russia supplies smaller coking coal quantities, and it, too, has expansion potential.

The heavy demand for steam and coking coal is requiring expansion and replacements as well as the development of additional mining capacities. The necessary quantities will be offered by producers on a sustainable basis only if cost coverage is ensured by world market prices.

The trend is for coals from more distant deposits to be transported to the exporting ports. Opencast mining's share will decline in the long run in favour of underground mining.

# Coal exporting countries

**Australia**




**General**

Australia is a democratically governed federation within the Commonwealth of Nations with firmly established legal structures. It is among the world's most important producers and exporters of minerals and energy raw materials. In view of the vast undeveloped reserves of the sparsely populated continent and the strong rise in demand among Asian emerging markets, the Australian government is promoting the development of mining activities and the exploration of further deposits. The Department of Mineral and Petroleum Resources reckons with much higher exports of coal, iron ore, gold, aluminium and nickel. Coal already features large in the country's exports.

**Reserves/output**

According to figures supplied by Barlow Jonker, Australia has over 114 bn t of proven and assumed reserves. The most important coal

reserves at present are located in the states New South Wales (NSW) and Queensland (QL). The proven reserves in NSW total some 19 bn t, with 50 % each being extractable in opencast and underground mining. The proven reserves in QL total some 33 bn t, with approx. 55 % to be extracted in opencast mining, and 43 % in underground mining.

Altogether, therefore, the reserves in these two states are some 52 bn t. With hard coal mining now running at 340 mill. t/a, the reach is approx. 156 years.

In addition to Eastern Australian hard coal production, about 66-67 mill. t/a lignite (Murray Basin) are mined in NSW, and about 6 mill. t/a in Western Australia.

The chief mining areas in New South Wales include the Hunter River and Newcastle areas with their highly volatile (> 30 %) steam and soft coking coal. To this must be added the southern coalfield with low-volatile (22-25 %) coking and the western and Gunnedah coalfield with highly volatile steam coal. In Queensland, the Bowen Basin with low- to medium-volatile (18-28 %) coking and steam coal, but also anthracitic (12-18 %) semi-soft coking coal, is of outstanding importance. On top of this come the Moreton and Tarong basins with highly volatile steam coal. Australian hard coal is mainly rich in ash and requires processing. It is usually low in sulphur (< 1.0 %).

Hard coal output in Australia reached some 264 mill. t in 2004. Production is divided between 115 mill. t from NSW and 149 mill. t from QL. Steam coal output was 139 mill. t, coking coal output 125 mill. t. Of the hard coal output, 39 mill. t went into domestic consumption, while 225 mill. t was exported. The export share has increased steadily in recent years.

Australia produces some 3.5 mill. t of coke, most of which is used by the country itself. The four biggest coal producers mine and export a good 80 % of Australia's hard coals. 24 % (63 mill. t) is extracted in underground mining operations and 76 % (201 mill. t) in opencast mines. In all, more than 90 bigger and smaller hard coal mines are operated, incl 51 in NSW, 42 in QL and six in South and West Australia and Tasmania. Of the mines, 37 are underground and 62 opencast. The share of opencast mines has steadily increased in recent years.

In opencast pits, with depths of down to 70 m, both draglines (one to two seams) and trucks and shovels (several seams) are used. In underground mines, which can reach depths of 200 m, longwalling has arrived and ousted the former board and pillar method.

At end-2004, Australia's hard coal mining operations employed a workforce of 25,000, incl 8,000 underground and 17,000 in opencast mines.

Consolidation in Australia's mining sector is ongoing. The four chief Australian producers and exporters are now:

- BHP Billiton Ltd.
- Rio Tinto Ltd.
- Xstrata Plc
- Anglo Coal Australia Pty Ltd.

These four companies produce a good 200 mill. t of Australia's entire hard coal. Productivity in Australia's pits, measured in marketable tonnes per man-year, is very high and reached the following values in 2004 (Barlow Jonker):

| | Opencast | Underground |
|---|---|---|
| New South Wales | 15,000 t | 8,000 t |
| Queensland | 15,500 t | 10,500 t |

The costs differ between underground and opencast mining and between coking coals and steam coals, and can only be given in bandwidths. (Representative costs according to Barlow Jonker)

| | Opencast in USD/t | Underground in USD/t |
|---|---|---|
| Steam coals | | |
| Queensland | 11-32 | 18-27 |
| New South Wales | 17-29 | 19-31 |
| Coking coals | | |
| Queensland | 20-28 | 22-33 |
| New South Wales | 22-27 | 20-40 |

Due to the weakening US dollar, Australia's mining operations came under considerable pressure in the 2003/2004 result, since fewer Australian dollars were earned with constant US dollar values.

Transport costs, depending on distance, range between USD 4/t and USD 14/t; port handling costs are between USD 2/t and USD 3/t.

Australia's hard coal mining operations have steadily increased their exports in recent years, without materially raising production. This led to a high utilization of export capacities.

**Australia's biggest hard coal producers**

| Company | No. of mines | Output, 2004 mill. t | Exports, 2004 mill. t |
|---|---|---|---|
| BHP-Billiton Ltd. | 14 | 70 | 58 |
| Rio Tinto Ltd. | 8 | 57 | 46 |
| Xstrata PLC | 22 | 55 | 45 |
| Anglo Coal Australia Pty Ltd | 8 | 31 | 20 |
| Total | 52 | 213 | 169 |
| % of Total output, Australia 2004 | | 80<br>264 | 75<br>225 |

However, the current price situation in 2004/2005 has provided an incentive for a whole host of new projects for steam coal and coking coal, and Australia will – provided that its infrastructure grows in sync – be able to effortlessly hold its world market share of 33 % in coal exports.

**Infrastructure**

The recent strong growth in the world coal market and the special claims on Australia as coking coal exporter has led to bottlenecks at Australia's ports, and its railway system is increasingly coming under tension.

Queensland's hard coal mining operations are connected via a 2,000-km long railway network to the seaports. Five special lines connect 40 mines to the export seaports. New South Wales has two coal lines with 1,050 km and 26 loading stations.

Australia has a number of coal exporting ports in NSW and QL. In 2004, exports of 225 mill. t were handled by the following ports:

**Export ports, Australia**

| | | Exports, 2004 mill. t |
|---|---|---|
| NSW harbours | Newcastle | 78.0 |
| | Port Kembla | 7.3 |
| Queensland harbours | Dalrymple Bay | 47.5 |
| | Hay Point | 34.0 |
| | Gladstone | 42.0 |
| | Abbot Point | 13.0 |
| | Brisbane | 3.0 |
| Australia, total | | 224.8 |

The ports of Newcastle and Dalrymple Bay, in particular, were very heavily utilized and unable to cope with the export quantities in places. Against the background of the infrastruc-

ture problems, Australia's authorities have announced massive extension plans. The following extension plans exist (according to information from McCloskey), in mill. t:

**Extension plans for Australian ports**

| | Current capacity mill. t | Short-term increase mill. t | Medium-term extensions mill. t |
|---|---|---|---|
| Newcastle | 89.9 | 102.0 | 120.0 |
| Port Kembla | 14.0 | 14.0 | 14.0 |
| Dalrymple Bay | 55.5 | 60.0 | 85.0 |
| Hay Point | 35.0 | 39.5 | 60.0 |
| Gladstone | 43.0 | 70.0 | 130.0 |
| Abbot Point | 15.0 | 18.0 | 25.0 |
| Brisbane | 4.0 | 4.5 | 5.0 |
| Total | 255.5 | 308.0 | 439.0 |

Australia's railways are supporting the extensions to the coal chain. State-run Queensland Rail, which operates the coal railways in Queensland, has announced a major programme of extensions that provides for new connecting lines, a doubling of the tracks in certain sections, and the purchase of more powerful locomotives in order to increase transport efficiency and flexibility.

**Exports**

Australia has steadily expanded its exports in recent years to the present 225 mill. t/a. Steam coal exports rose to 107 mill. t/a, and coking coal exports to 118 mill. t/a. Specifically in the case of coking coal, Australia, with a market share of 65 %, has achieved an outstanding position and will be able to maintain this in the long term as well thanks to favourable mining costs and high reserves. For quality reasons, Australia's coking coals are used in all countries that produce pig iron around the world:

**Hard coal exports, 2004**

| | Coking coal in mill. t | Steam coal in mill. t |
|---|---|---|
| Asia | 80 | 98 |
| Europe/Mediterranean/ Africa | 30 | 6 |
| North-, Central- and South America | 8 | 3 |
| Total | 118 | 107 |

Australia's steam coals have their sales focus in Asia and, due to the long sea routes involved, can only compete with Colombian and South African coal if the freight-rate differences are very low.

In coking coals, Australia is price leader and, here, BHP/Mitsubishi. So, due to tight supply, it was possible at the turn of the year 2004/2005 to boost the world market price level for hard coking coal to USD 125/t fob. The smaller exporting countries demanded similar prices.

In steam coals, Australia faces broader competition and has stronger rivals, above all in Asia with China, Indonesia and, increasingly, Vietnam and Russia.

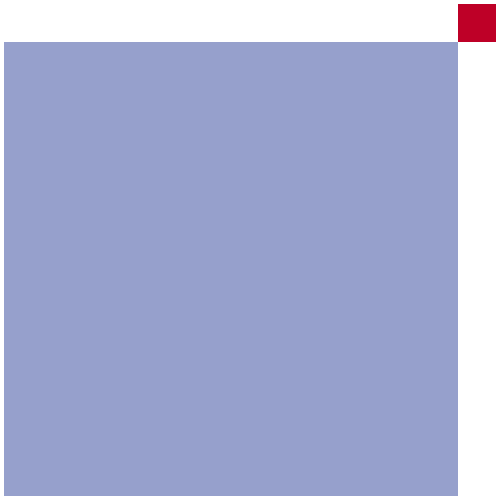
**Export developments, Australia, 2002 - 2004**

| | 2002 mill. t | 2003 mill. t | 2004 mill. t |
|---|---|---|---|
| Hard coal output | 263.0 | 257.0 | 264.0 |
| Hard coal exports | 204.0 | 215.0 | 225.0 |
| Steam coal | 100.0 | 104.0 | 107.0 |
| Coking coal | 104.0 | 111.0 | 118.0 |
| Export rate, in % | 78.0 | 84.0 | 85.0 |
| Chief import countries/regions | | | |
| EU-15/after 2004: EU-25 | 27.2 | 28.2 | 27.2 |
| Other European countries* | 4.4 | 5.3 | 3.7 |
| Japan | 91.6 | 95.3 | 101.9 |
| South Korea | 21.4 | 22.5 | 30.1 |
| Taiwan | 14.8 | 14.0 | 18.8 |
| India | 14.1 | 12.8 | 16.6 |

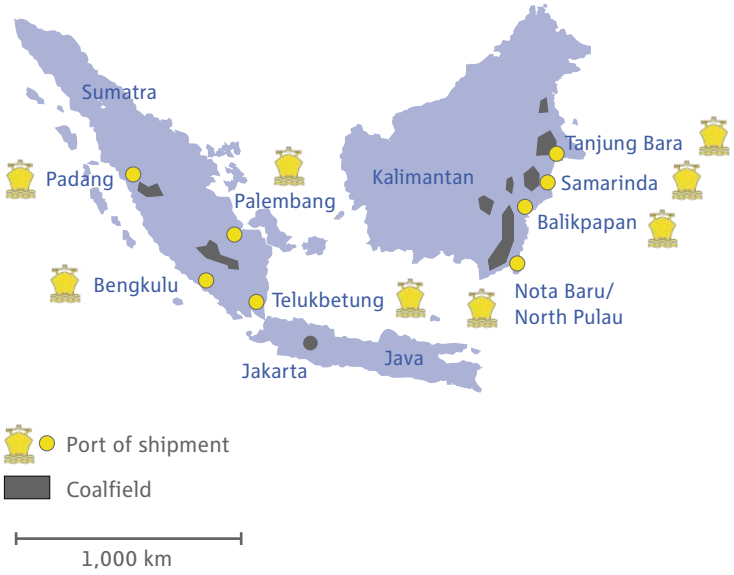
*incl. riparian Mediterranean countries

**Outlook**

Australia is facing the challenges of a growing world market for coal. Thanks to the strong demand for coking coal, Australia will come into its own, above all in the case of hard coking coal. However, it has the potential in production and infrastructure to meet the requirements. Between 2005 and 2007, however, there could still be bottlenecks in the logistics chain, especially in the ports.



## Indonesia




### General

The latest player on the international coal stage, alongside China, is Indonesia. This, the world's fourth-largest nation is among the growth regions, even if the pace of growth has significantly slackened. Due to inadequate legal reforms, and questionable privatization measures (indonesiazation of inward investment), foreign investors currently give preference to China as a country for investing in. To that extent, Indonesia suffers from a lack of long-term investment capital in particular.

Nonetheless, coal production has not only been maintained, but even extended and increasingly channelled into exports.

Coal mining has evolved on "green-field" sites and under the control of what used to be the Ministry of Mining and Energy or its Directorate-General for Mining. By 1999, state-owned coal reserves had been offered in 3 tranches for international development under a bidding procedure, the first tranche in 1981 with 11 "Coal Contracts of Work" (CCOWs), the second in 1993 with 17, and the third in 1997 with 114. The "contractors" undertake to prospect for and explore the coal deposits located in their concession area, possibly to engage in mining development and, in return, are granted exclusive rights for a term of 30 years subject to a royalty (free mine) of 13.5 % of proceeds. The contractors are also obligated to offer Indonesian investors at least 51 % of the mining stock after a 10-year operating period. In 2001, this provision affected two foreign investors (Rio Tinto/BP and BHP-Billiton).

Most of the companies are based on generation-I CCOWs, representing over 80 mill. t, generation-II CCOWs with about 40 mill. t, and generation-III CCOWs with a mere 10 mill. t.

The contracts have been implemented as follows so far (Barlow Jonker):

| | Active | Completed | Total |
|---|---|---|---|
| CCOW I | 10 | 1 | 11 |
| CCOW II | 15 | 2 | 17 |
| CCOW III | 64 | 50 | 114 |

Indonesia's coal policy, for the time being at least, prevents the international consolidation movement from spreading to Indonesia. To that extent, Indonesia's hard coal mining sector is an important element for healthy competition on the world market.

Besides foreign and local investors, the state-owned P.T. Tambang Batubara Bukit Asam, too, has developed production on Sumatra mostly for domestic consumption. This company is to be privatized in a second attempt.

**Reserves/output**

The country's coal resources were recently put at 38.8 bn t by the Directorate-General for Mining, incl some 17 bn t on Sumatra and approx. 21.1 bn t on Kalimantan, although only some one third consists of bituminous and sub-bituminous coals, the rest being lignite. According to Barlow Jonker (2003), the measured reserves total about 5 bn t, with Sumatra accounting for some 3 bn t and Kalimantan for 2 bn t.

In quality terms, Indonesian coals are generally low in ash and sulphur, but, on account of their low rank, they have a high content of volatile components and moisture. All the same, the raw coal does not generally require preparation, and simple crushing and screening suffice to make a marketable product. The coal has no, or only minimal, coking properties, so that – with few exceptions – it can only be used as steam coal. Only some higher ranking types are also suitable as PCI coal. The qualities for export generally have a 37-47 % share of volatile components, with 1-10 % ash and mostly 15-22 % moisture. The sulphur content is below 1 % and, in extreme cases, as low as 0.1 %. The high moisture translates into a relatively low calorific value mostly well below 6,000 kcal/kg (as received). One impediment to the coal's use in power plants is its high grinding hardness of 40-50 HGI.

In 2004, 135 mill. t coal – almost entirely hard coal – was produced (+18 %); mining was by 22 mostly "first-generation" producers operating 44 mines. Production is concentrated on East and South Kalimantan. These are also the export locations. Domestic requirements of 36 mill. t are composed of 24 mill. t for power generation, 6 mill. t for making cement, and 6 mill. t to cover the needs of the rest of industry.

The six major companies produce 95 mill. t, i.e. some 70 % of official total output of 135 mill. t. In addition to the official mining operations, illegal local producers are estimated to mine 4-6 mill. t, operating in a "free zone", so that total output of about 140 mill. t may be assumed.

In the development of Indonesian coal mining, two different concepts are pursued by the contractors. The one option – as in the case of Kaltim Prima – involves all investment being borne by the mining firm using conventional methods

**Indonesia's biggest hard coal producers**

| Company | Output, 2004 mill. t | Exports, 2004 mill. t |
|---|---|---|
| PT Adaro | 24.3 | 16.5 |
| PT Kaltim Prima | 21.3 | 20.7 |
| PT Kideco Jaya Agung | 16.9 | 11.0 |
| PT Arutmin | 15.0 | 13.9 |
| PT Berau Coal (KKS) | 9.1 | 6.2 |
| PT Indomico Mandiri | 7.9 | 7.9 |
| Total | 94.5 | 76.2 |
| % of Total output, Indonesia | 70.0 135.0 | 73.0 105.0 |

with production conducted under its own management. The other approach – adopted, e.g., by BHP-Billiton/Arutmin – provides for investment only in the mine's infrastructure, e.g., road access, power supply, crushing and screening plant and loading equipment, whereas actual extraction, incl waste removal and restoration of the terrain as well as coal transportation (by road

or inland waterway) is outsourced to companies with their own personnel subject to a firm price per tonne of coal or cubic metre of waste. Coal is almost entirely extracted in opencast operations and in mine sizes of 2-15 mill. t annually. However, there are also numerous smaller mines and cooperatives with an annual output of 0.5-1.0 mill. t which supply the big producers or exporters. Waste removal and coal extraction are mainly handled by truck and shovel.

Mining costs for Indonesian coal are in a bandwidth of USD 14-26/t, free mine. Whereas inland transportation costing USD 2.0-7.0/t is much cheaper than in South Africa, port handling charges, viz. USD 2.0 – 4.5/t, are rather higher. The low extraction costs are due not least to the specific investment in the export capacities developed during the last decade. These are USD 20-25/t of annual output, so that they are among the lowest in the world and only half as high as in South Africa, for example.

There are no official productivity figures, although estimates can be made using the data of several leading producers. Most of the extraction is in efficient opencast mines, and productivity per man-year is likely to be in a bandwidth of 6,000-12,000 t.

**Infrastructure**

Along with mining, an efficient infrastructure, too, has been developed. The investment required for this was provided by the coal producers and involves the geographical development of the terrain, i.e. the construction of approach roads and settlements, river terminals and seaports as well as loading equipment. Thanks to the pits' proximity to the coast and the existence of navigable inland waterways, it has been possible to do without the construction of railroads so far. On East Kalimantan, Indonesia at present has six major deep-water ports with an annual handling capacity of 73 mill. t, which allow the loading of 60,000-180,000 dwt freighters. In addition, there are ten further coal terminals nation-wide (inter alia, Samarinda and Palikpapan) with a total annual capacity of 40 mill. t and a depth that is usually suitable for panamax sizes.

Extending Indonesia's infrastructure has met with no problems so far and has kept in step with its export volumes.

**Export and port capacities in Indonesia, 2004**

| | mill. t |
|---|---|
| Adang Bay | 12 |
| Benjamasin | 10 |
| Kotabaru | 10 |
| Pulan Laut | 10 |
| Tanjung Bara | 17 |
| Tarahan | 14 |
| Total | 73 |
| 10 further coal-loadings ports | 40 |
| Capacity, total | 113 |

**Exports**

Exports have developed as dynamically as output. Indonesia has become the world's second-largest exporter, posting 105 mill. t, after Australia. The focus of sales is on Asia. However, growing amounts of Indonesian coal are being delivered to Europe where it is used as an admixture to highly sulphurous lignite (Balkan states/ Spain), but also as normal steam coal. Small amounts (approx. 2 mill. t) of Indonesian coal are marketed as PCI coal.

The export rate has risen continuously in recent years, although domestic demand will increase again in the next few years, mainly due to the commissioning of new power plants.

**Outlook**

After the breakneck pace of development in output and exports during recent years, the signs continue to point toward further expansion. All

larger companies have expansion plans, and Indonesia in 2005 is likely to overtake Australia as an exporter of steam coals and become the biggest steam coal exporter with a 20 % share in the world market. However, a slackening of investment in Indonesia's hard coal mining operations has been noted in recent years, so that, in the face of growing domestic demand after 2006, it is becoming questionable whether the

**Export developments, Indonesia, 2002 - 2004**

| | 2002 mill. t | 2003 mill. t | 2004 mill. t |
|---|---|---|---|
| Hard coal output | 107.0 | 109.0 | 135.0 |
| Steam coal exports | 76.0 | 89.0 | 105.0 |
| Export rate, in % | 71.0 | 75.0 | 78.0 |
| Chief import countries/regions | | | |
| EU-15/after 2004: EU-25 | 9.0 | 10.4 | 11.9 |
| Japan | 18.0 | 20.5 | 22.5 |
| South Korea | 7.0 | 7.9 | 11.6 |
| Taiwan | 14.5 | 15.8 | 17.7 |
| India | 5.0 | 7.8 | 10.6 |
| Hong Konk | 4.6 | 6.8 | 7.4 |

rate of growth in exports can be maintained in the medium term, although the country's low production costs make Indonesia one of the most competitive exporters on the world market.

## China


### General

In the years 2003/2004, the "China factor" definitely made itself felt on the world markets for raw materials, energy and transport services. Against a backdrop of high demand in China and GDP growth averaging 9 %, crude-steel production of 127 mill. t in 2000 rose to 272 mill. t in 2004, while iron-ore imports were up from 70 mill. t to 210 mill. t in the same period. With increasing electrification and with power needs growing at a rate of 10-15 % per year, the demand for coal and copper, too, was up. This demand clashed with scarce capacities on the world market and led to rising energy and commodity prices on a wide front.

Primary energy consumption reached a good 2 bn tce in 2004, with a good 70 % or 1.4 bn tce being accounted for by coal.

Power plant capacity rose to 450 GW in 2004, with 80 %, or most of it, being accounted for by coal-fired plants. By 2020, capacity is set to double to 900 GW. The 1.3 bn Chinese currently

consume 1,400 kWh per inhabitant; in Germany, the figure is 6,400 kWh per inhabitant. China's coal activities are coordinated by the "Bureau of Energy" which reports to the National Development and Reform Commission.

**Reserves/output**

China's coal resources are practically immeasurable and vary considerably in type and quality. "Resources defined" by geological mapping, exploration and mining are currently (2004) put at 1,018 bn t. The BGR has established definitely measured and minable reserves of 96 bn t. Most of this (60 %) dates from the Jurassic or Carboniferous (25 %) periods, i.e. they sedimented 140-250 and 290-360 million years ago and have been subject to several phases of rock formation since then. This being so, deposits close to the surface, too, are marked by strong seam inclines, so that the reserves minable in opencast pits are relatively low, and most of the mining is pursued in underground mines. The bandwidth of coal qualities ranges from anthracite, via low-volatile, all the way to highly volatile hard coals. Only 12 % of the hard coal resources are medium to highly volatile coking coals, while most of the rest (63 %) is accounted for by highly volatile steam coal. Geographically, the coal resources are concentrated on North China, with all of 48 % being located in the provinces of Hebei, Shanxi and Inner Mongolia.

In 2004, too, China continued expanding its coal production. It reached nearly 2 bn t, having risen by over 200 mill. t since the previous year. Most of it was untreated raw coal. Of this, lignite production accounted for some 45 mill. t. Shanxi province mined 493 mill. t, Inner Mongolia 200 mill. t and Hunan province 154 mill. t, to name just the most important regions.

China by now extracts nearly twice the amount of coal mined in the US and produces 43 % of the world's hard coal. Most of China's production is in underground operations; a mere 10 % comes from opencast mines. 2004 production was as follows:

| | |
|---|---|
| State-owned mines | 922 mill. t |
| Provincial mines | 315 mill. t |
| Small operators | 719 mill. t |
| Total | 1,956 mill. t |

Power generation on a coal basis in China, with some 1,800 TWh, accounts for about 80 % of China's electricity production. Steel making took 272 mill. t and cement production 970 mill. t. Accordingly, coal was used as follows:

| | |
|---|---|
| approx. 920 mill. t | Power plants |
| approx. 300 mill. t | Steel industry |
| approx. 650 mill. t | Industry/domestic |
| approx. 80 mill. t | Exports |
| approx. 1,950 mill. t | Total |

The Chinese government's aim is to set up 8-10 big mining companies that each produce 50-100 mill. t or more. Shenhua with over 100 mill. t, Datong with over 50 mill. t and Yanzhou with over 40 mill. t are on the road there. Hardly any mine, however, produces more than 3 mill. t/a, i.e. output is much below that of export mines in other countries. The interest shown by foreign firms in participating in China's mining operations is growing. For example, Anglo American's intention to invest USD 150 mill. was recently announced on the occasion of Shenhua going public.

The number of employees in China's mining operations is not exactly known, but is put at some 5 mill. miners. Average productivity per man-year is very low, viz. 350 t (2003 figures, China Coal), although much more effi-

**China's biggest hard coal producers**

| Company | Output, 2004 mill. t |
|---|---|
| Shenhua | 120 |
| Datang | 54 |
| Yanzhou | 45 |
| China Coal | 48 |
| Xishan | 31 |
| Yangquan | 29 |
| Jincheng | 24 |
| Total | 351 |
| % of Total output, China | 18 1,956 |

**Handling capacities of China's ports, 2003**

| Coal loading ports | Capacity (nominal) mill. t | Handling, 2003 within China mill. t | Exports mill. t |
|---|---|---|---|
| Quinhuangdao | 105 | 64 | 47 |
| Tianjin | 60* | 39 | 17 |
| Huanghua | 30 | 29 | 2 |
| Rizhao | 24 | 10 | 13 |
| Lianyungang | 17 | 9 | 5 |
| Qingdao | 17 | 6 | 2 |
| Other | 40* | 30 | 6 |
| Total | 293 | 187 | 92 |

*Estimate

cient mines are now operating; they are geared toward exports. These mines are likely to have productivity per man-year that ranges between 500 t and 600 t. The fob costs for Chinese coal are likely to be in a bandwidth of USD 37-48/t. They can be broken down into USD 29-36/t mining costs, USD 6-9/t inland freight (the average transportation distance being 560 km) and USD 2-3/t port handling charges.

**Infrastructure**

China's coal industry can now rely on an infrastructure that has recently been purposefully extended and become more efficient. To start with, this includes the railways, which transported a total of some 1 bn t across an average distance of 550 km in 2004.

China's coal seaports handle both domestic supplies, via coastal shipping, and coal exports. In 2003, for example, some 279 mill. t of coal was handled, with 187 mill. t being accounted for by domestic traffic and 92 mill. t by exports. To this must be added numerous river ports whose handling quantities are not known. Handling capacities and their utilization in 2003 is shown in the following Table:

**Exports**

Both the rationalization measures taken in the coal industry and the systematic extensions to the infrastructure in recent years have led to a rapid expansion of coal exports, which reached a total volume of 87 mill. t in 2004.

Compared with 2003, coal exports dipped 7 mill. t, the fall mainly concerning coking coal. In the process, China lost its second rank as exporting nation to Indonesia. China needs most of its coking coal itself and is increasingly compelled to supplement its domestic supplies with imports. On balance, the result is that other world market producers of coking coals had to make available an additional amount of almost 8-10 mill. t at relatively short notice in 2004. In southern China, steam coals for power plants and steel mills located close to the coast are also imported on a continuous basis from Vietnam, Indonesia and Australia. In northern China, quantities have been imported recently from North Korea as well. Imports from Russia are being negotiated.

China is also an important coke exporter. Exporting 15 mill. t, China, with a 50 % share, tops the list of supplier countries in a world market that reached some 30 mill. t in 2004.

**Export developments, China, 2002 - 2004**

| | 2002 mill. t | 2003 mill. t | 2004 mill. t |
|---|---|---|---|
| Hard coal output | 1,409.0 | 1,727.0 | 1,956.0 |
| Hard coal exports | 84.0 | 94.0 | 87.0 |
| Steam coal | 71.0 | 81.0 | 81.0 |
| incl. anthracite | | 5.0 | 6.0 |
| Coking coal | 13.0 | 13.0 | 6.0 |
| Coke exports | 14.0 | 15.0 | 15.0 |
| Export rate, in % | 7.0 | 5.0 | 4.0 |
| Chief import countries/regions | | | |
| EU-15/after 2004: EU-25 | 2.5 | 1.9 | 1.5 |
| Japan | 27.7 | 31.3 | 28.5 |
| South Korea | 25.4 | 29.7 | 24.8 |
| Taiwan | 14.2 | 16.0 | 19.9 |
| India | 2.3 | 2.4 | 3.1 |
| Hong Konk | 3.0 | 2.1 | 1.1 |
| Philippines | 2.9 | 2.9 | 2.9 |

Coal exports are the exclusive preserve of 4 state-licensed exporters, incl 3 trading companies and one producer. Exports are handled by the following companies:

| Exporters | mill. t in 2004 |
|---|---|
| Chinese National Coal Industry Import and Export Corp. (CNCIEC) | 39 |
| Shenhua Group Corp. Ltd. | 25 |
| Shanxi Province Coal Import-Export Group Corp. | 11 |
| China National Minerals and Metals Import & Export Group (MINMETALS) | 3 |
| Total | 78 |

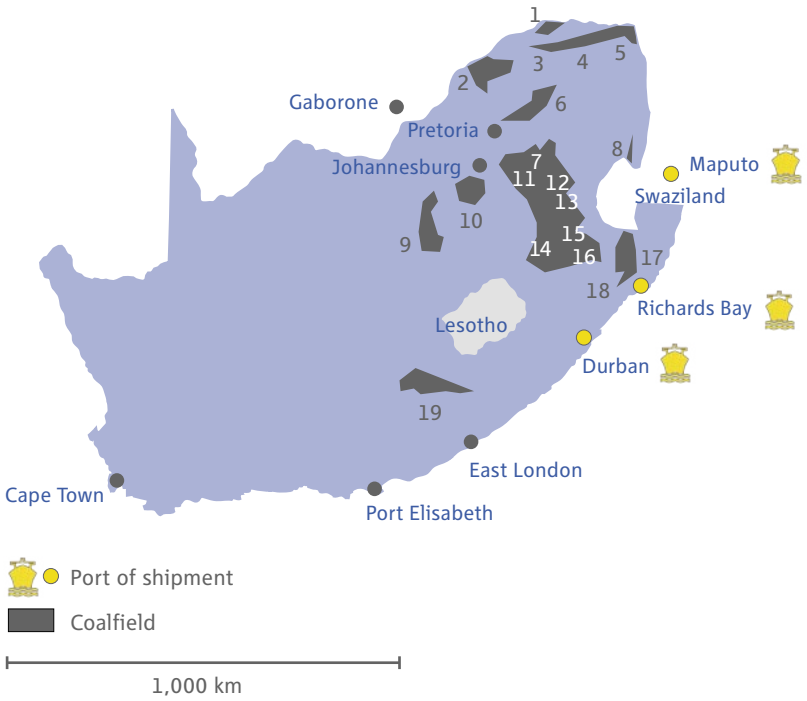
**Outlook**

Medium-term prospects in China's coal industry are determined by the current five-year-plan that runs until 2005. Important targets are the creation of 8 major producers with an annual output of 50-100 mill. t each, the closure of further small operations and an increase in the raw-coal processing rate. The country's accession to the World Trade Organization (WTO) has accelerated the restructuring and rationalization of the coal sector. At the same time, the provisions on foreign trade in coal are likely to be liberalized step by step, as are regulations governing participations in mines by foreign investors.

Thanks to massive extensions to transport capacity – infrastructure for rail and ports – and a considerable number of new coking plants, China will remain an efficient world market supplier. Faster and better transport in China is likely to ensure flexible supplies in the future as well. Still, due to its cost structure, above all to its low productivity, China needs a higher price level than Australia and Indonesia if it is to hold its market position.

## South Africa

1 Limpopo
2 Waterberg
3 Western Soutpansberg
4 Central Soutpansberg
5 Eastern Soutpansberg
6 Springbok Flats
7 Springs – Witbank
8 Kangwane
9 O.F.S. – Vierfontein
10 Vereeniging – Sasolburg
11 South Rand
12 Highveld
13 Mpumalanga
14 Klip River
15 Utrecht
16 Vryheid
17 Nongoma
18 Somkele
19 Molteno – Indwe




### General

South Africa's economy continues to do well and is benefiting from good demand for raw materials worldwide. Nevertheless, there are still huge structural problems like unemployment and a housing shortage. The disease AIDS, too, is problematic. Its currency has stabilized and appreciated against the dollar, though the flipside is less income from its raw-material exports in domestic currency. However, since most commodity prices have risen even more strongly than the increase in the currency value, the margins for raw-material and coal producers have improved.

Until recently, the extraction of natural resources in South Africa has been by landowner mining, i.e. mining rights have lain with the owners of the land. State control merely took the form of a statutory approval procedure and mining supervision, so that no royalty had to be paid to the state. Wide areas of land were owned by big mining companies, and this is also true of the country's coal deposits. In 2002, the government and the mining companies agreed on a new mining law, whereby all of the country's natural resources are transferred to state ownership. Present and future mining companies must re-apply for their mining rights, the issue of which is to be associated with statutory stipulations; deposits which are not exploited at present or whose short-term exploitation has not been applied for by the landowner can now be granted to other interested parties. The idea is to remove the often decade-old blockage of unused natural resources on the part of landowners, and to give mining and employment fresh impetus by encouraging small- and medium-sized businesses.

### Reserves/output

According to more recent (2003) studies, South Africa's hard coal reserves are estimated at 34 bn t. Other studies put South African reserves at 50 - 60 bn t. The difference lies mainly in the estimate of the Waterberg reserves. If extraction goes on rising beyond the current level, some of the best-

quality deposits, like the Witbank, Highveld, Ermelo and KwaZulu/Natal mining areas, will be depleted in a few decades.

There are 11 coalfields in all, extending from the border with Botswana in the Northern Province, via the provinces of Gauteng, Mpumalanga, and Freestate, to KwaZulu/Natal in the southeast, with 83 % of the reserves concentrated in the mining areas of Witbank, Highveld, Vereeneging/Sasolburg, Ermelo and Waterberg. While the first four mining areas are relatively close to the coast of the Indian Ocean, viz. just under 600 km by rail, the distance from the Waterberg area, located at the Botswana border, doubles to 1,120 km.

South Africa's hard coal is classified as so-called Gondwana coal, dating from the Permian period in the earth's evolution, so that it is comparatively rich in ash and must be treated, at least for exporting. This coal has only limited – if any – coking properties and, to that extent, is low- to medium-volatile (16-29 %); it is relatively (< 1 %) low-sulphur steam coal.

In 2004, South Africa's mining sector produced 243 mill. t, incl 175 mill. t going to domestic consumption with 68 mill. t being exported. Power producers bought 109 mill. t, coal upgrading facilities at Sasol (liquid fuels from coal) 40 mill. t, industry and households 20 mill. t, and the steel industry 6 mill. t. Eskom is planning, from 2010 onwards, to build 1,200 - 1,500 MW new capacity per year, which will require a substantial increase in production capacity.

Among the chief mining regions are Witbank, Highveld, Vereeneging/Sasolburg, Ermelo and Waterberg – areas with a current 98 % share in total output. The coal is mined both in underground and opencast operations. The opencast pits reach depths of 60 m, with max. 5 seams, though only 2-3 are usually suitable for dragline operations, which account for two thirds of opencast pit output. Truck and shovel mining, by contrast, is mainly used in the multi-seam mining area of Waterberg. Sections of the deposit where opencast mining is uneconomical are often exploited in underground mines. The flat seams lend themselves to extraction at depths of hardly more than 200 m. The mining technique deployed here is board and pillar, which accounts for over 90 % of underground mine production, with longwalling being used only in exceptional cases due to the prevalence of dolerite intrusions and geological faults. In board and pillar operations, coal extraction is dominated by the continuous miner, but mechanized drilling and blasting, too, are still used occasionally. The opencast share amounts to some 65 %, the underground mining share 35 %.

In 2004, the coal industry had a total workforce of some 50,000 blue- and white-collar employees. Relative to total output of 243 mill. t, this is equivalent to average productivity of approx. 5,000 t/man-year.

**South Africa's biggest hard coal producers**

| Company | Output, 2004 mill. t | Exports, 2004 mill. t |
|---|---|---|
| Anglo Coal | 54.5 | 20.0 |
| BHP-Billiton Plc. | 55.3 | 21.0 |
| SASOL (7/03-6/04) | 50.4 | 3.0 |
| Xstrata Plc. | 19.2 | 13.0 |
| Total | 179.4 | 57.0 |
| % of Total output, South Africa | 74.0 243.0 | 84.0 68.0 |

The mining costs of South African hard coal have been calculated at about USD 16-24/t, free mine, so that South Africa is among the low-cost countries in world hard coal mining. Internal transportation costs from the mines to the Richards Bay coal terminal are put at USD 6-10/t, depending on distance, while handling at the terminal costs USD 1.50-2.00/t.

Consolidation trends in world hard coal mining have also affected South Africa. Here, we find four largely global players dominating the extraction and export of hard coal, namely

- BHP-Billiton,
- SASOL,
- Anglo Coal, and
- Xstrata Plc.

In 2004, they operated 39 of South Africa's 59 mines, controlling 74 % of the country's total output and 84 % of its total exports. Anglo Coal is originally a South African company which has now extended its commitments and participations to include Australia, Colombia, Venezuela and China. BHP-Billiton, by contrast, is the result of a merger in 2000 between BHP, Australia, and INGWE, South Africa, and, besides Australia, also operates in Colombia. Duiker, South Africa, in its turn, was taken over in 2000 by GLENCORE, a raw materials trader with global reach, and at the start of 2002 brought into XSTRATA Plc, which is listed on the London stock exchange. To be mentioned is Black Economic Empowerment (BEE). The BEE target is a 26 % share of production by joint ventures between incumbent suppliers and startup BEEs, e.g. Eyesizwe Coal.

**Infrastructure**

Some two thirds of coal output, most of it untreated, is used in nearby power stations or liquefaction plants in mine-mouth operations, so that no infrastructure need be provided – not, at least, as far as transportation is concerned – although this is not true of coal exports: driven by the insight that South Africa has coal reserves capable of covering more than just domestic demand for decades to come, the government and mining companies decided in the 1970s to embrace long-term development of coal exports and build up a modern infrastructure.

As a result, three railway corridors exist today to the export ports located on the Indian Ocean at Richards Bay, Durban and Maputo (Mozambique). The most important link is the 600-km long state-run COALlink line from the Witbank mining area to Richards Bay, which already transported 1.2 bn t of coal between its commissioning in 1976 and year's end 2004. The electrified railway has a current capacity of 72 mill. t p.a., with 12 unit trains a day having a loading capacity of up to 16,800 t. Of minor importance, by contrast, are the rail links to Durban and Maputo. While mainly standardized steam coal is transported to Richards Bay in large quantities, the other two lines are used to haul smaller quantities of special types, like anthracite or screened lumps for use in industry and households. The government is planning medium-term privatization of rail traffic.

The coal ports have always been operated by the private sector. They have a total handling capacity of 78 mill. t p.a. The most important is the Richards Bay Coal Terminal with a handling capacity of 72 mill. t p.a. Owner and operator is a joint venture of the 7 largest South African coal producers.

Present planning calls for extensions to Richards Bay from 72 mill. t/a to 86 mill. t/a, although

**Shares of producers in Richards Bay Coal Terminal after extensions**

| | mill. t p.a. |
|---|---|
| RBCT = Richards Bay Coal Terminal | 74.50 |
| Ingwe | 26.58 |
| Anglo Coal | 19.50 |
| Duiker | 16.93 |
| Tesa | 4.60 |
| Sasol | 4.05 |
| Kangra | 1.86 |
| Eyesizwe | 0.98 |
| SDCT = South Dunes Coal Terminal | 6.50 |
| Golang | 3.25 |
| Kumba Coal | 2.15 |
| Eskom Enterprises | 1.10 |
| Common Users = small mines within the scope of Black Economic Empowerment (BEE) | 5.00 |
| Total | 86.00 |

only about 65 mill. t/a (90 %) of the terminal is being used owing to serious deficits in rail transport. In addition to the previous partners, the partners in the South Dunes "Coal Terminal" project are to participate in the terminal, plus the so-called common users who want coal exports within the scope of the "Black Economic Empowerment" efforts. This concerns 14 smaller companies.

**Exports**

Exports in 2004 were down 3 mill. t compared with 2003 and amounted to 68 mill. t, incl 65 mill. t steam coal, 2 mill. t metallurgical coal (PCI coal) and 1 mill. t anthracite. South Africa has lost its export position in the Asian area almost completely to China and Indonesia. Sales focus is on the EU (25) with 53 mill. t and on the Mediterranean area with 10 mill. t.

**Export developments, South Africa, 2002 - 2004**

| | 2002 mill. t | 2003 mill. t | 2004 mill. t |
|---|---|---|---|
| Hard coal output | 219 | 238 | 243 |
| Hard coal exports | 69 | 71 | 68 |
| Steam coal | 67 | 70 | 66 |
| Coking coal | 2 | 1 | 2 |
| Export rate, in % | 32 | 30 | 28 |
| Chief import countries/regions | | | |
| EU-15/after 2004: EU-25 | 49.2 | 54.3 | 52.6 |
| Israel | 5.4 | 5.2 | 6.9 |
| Morocco | 3.3 | 2.1 | 1.8 |
| Turkey | 1.0 | 1.6 | 1.6 |
| Taiwan | 1.7 | 1.6 | 1.4 |

**Outlook**

South Africa's importance in the steam coal market has declined in recent years. China and Indonesia have overtaken South Africa, while Colombia and Russia have the potential to close the gap with it. South Africa does have the reserves for further expansion, but the big opencast pits/ underground mines in the Witbank and Highveld coalfields will be depleted in the medium to long term, and must be replaced with new mines. The Waterberg mining area is much farther away from the coast (over 1,000 km) and is only available for exports at higher costs. Nonetheless, South Africa ought to be able to increase its volume from currently 68 mill. t/a again. Since the major producers in South Africa also pursue sizeable activities in Colombia, expansion is pursued in the country where the outlook for the bottom line happens to be more favourable.

## Russia


### General

Russia's coal mining sector has undergone profound structural change. In the period from 1993 to 2001, capacities of 173 mill. t were shut down, while new capacities of 57 mill. t were developed. The number of employees fell in this period from a good 800,000 to today's 200,000 or so workers in mining. This process was flanked by a USD 1 bn restructuring loan from the World Bank. After a significant drop in output, Russia's mining sector is back on a growth track, with 95 % being privatized.

### Reserves/output

The World Energy Council puts Russia's economically minable reserves at 147 bn t, as things stand today. The resources are distributed across a total of six hard coal regions, viz. Pechora/North, Donetsk, Kuznetsk, Kansk Achinsk, the Far East and the northeast. Their raw coals have average calorific values of 4,900-5,700 kcal/kg (as received), an ash content of 17-25 % and a sulphur content of 0.9-1.1 %. No details are available on the state of the deposits, seam thicknesses or extraction conditions in the coalfields.

Developed reserves amount to 18.4 bn t, incl 3.9 bn t coking coal. In 2004, Russia produced 283 mill. t. Output can be broken down as follows:

- Coking coals 75 mill. t
- Steam coals 208 mill. t
  - Highly volatile coal 86 mill. t
  - Low volatile coal 47 mill. t
  - Anthracite 8 mill. t
  - Lignite 67 mill. t

Of the output, 181 mill. t (64 %) is extracted in opencast operations and 102 mill. t (36 %) by underground mining. There are 241 coal mining operations, incl 104 underground pits and 137 opencast mines. The most important mining area is Kuznetsk with some 144 mill. t, so that it has the biggest share in coking coal production and exports.

As in the case of all other raw materials, coal reserves are publicly owned. A "committee for the coal mining industry", which reports to the Fuel and Energy Ministry, acts as supervisory and steering body for the coal mining industry. The aimed-at privatization of the industrial sector is largely completed.

Average extraction depth in underground mines is between 500-550 m. The chief mining method there – back in 1980 already – was longwalling, accounting for 85 %. The rest involved block caving and hydromechanical extraction. Lignite mining is by bucket wheel excavator and hard coal mining by shovel and truck. Owing to the high degree of mechanization, the raw hard coal is highly diluted and must be treated, so that roughly two thirds of the raw output is prepared in processing plants. This concerns all coking coals and most of the steam coals. Preparation is largely by jig (50 %), followed by the heavy media process (30 %). The resulting products, which are suitable for exporting, have the following quality features: Steam coals have medium to high 27-34 % volatility, 11-15 % ash and 8-15 % moisture. Their calorific value is 6,000-6,200 kcal/kg (as received); the 0.3-0.6 % sulphur content is favourable, as is the grinding hardness of 55-67 HGI. Coking coals, by contrast, with 19-42 % volatile components have a high bandwidth. Their ash content ranges between 8 and 11 %, with 6-10 % moisture and 0.5-0.8 % sulphur. Their coking properties of 7-9 FSI are good.

The 200,000 employees have an average productivity of 900 t/man-year. However, these are average figures. There are now efficient opencast mines in Russia as well that are likely to reach higher productivity rates. According to information from Rosinformugol, productivity per man-year was 1,600 t, with underground mining operations averaging 1,200 t/man-year and opencast mines 2,400 t/man-year. The bandwidth in productivity extends from 7,600 t/man-year to 600 t/man-year. These rates only refer to the number of employees in mining, which is believed to be some 112,000 miners. The competitiveness of Russian coal is based on low wages (€ 3,600/man-year).

Mining costs are said to average USD 15-16/t. Opencast mines have costs of about USD 13/t, and underground mines some USD 18/t. Favourable costs of USD 10/t are reported by the Kuznetsk opencast mine, and high costs by Workuta, viz. USD 28/t. Transportation costs are in the order of USD 10-20/t, depending on mining area. To this must be added – depending on loading port – transit fees (USD 4-5/t), post-treatment costs (USD 2-3/t) in the ports and handling outlays (USD 2-3/t)

**Russia's biggest hard coal producers**

| Company | Output, 2004 mill. t |
|---|---|
| OAO SUEK „SIBENERGO" | 90 |
| UGMK | 41 |
| Steel group „Metschel" | 20 |
| Severstal | 14 |
| Russkji Ugol | 14 |
| EWRAS Holding | 3 |
| Total | 182 |
| % of Total output, Russia | 64<br>283 |

**Infrastructure**

The infrastructure that serves coal mining is relatively well developed and dependable. Still, the industry is marked by, and bears the burdens of,

long rail distances to the consumer centres in Western Russia or to the exporting ports. These distances are between 2,000 and 2,400 km (Pechora) and 3,500/4,500 km (Kuznetsk) to the Baltic/Atlantic/Black Sea ports or 3,000 km to the Pacific ports. After the dissolution of the Soviet Union, Russia lost its traditional coal exporting ports in the Baltic and the Black Sea to the Baltic states and Ukraine, so that exports are increasingly having to be redirected to other ports. In the Atlantic area, the changes can be seen in the extensions to Murmansk (6 mill. t p.a.) to enable that port to handle coal exports as well, and the new port Ust Luga near St. Petersburg, still unfinished, with an annual coal handling capacity of 8 mill. t and handling options for panamax freighters. In the Far East, too, the handling capacity of the capesize port of Vostochny is planned to be extended from currently 16 mill. t to 25 mill. t while, in the northern Sea of Japan, 2001 saw the start of construction on the coal port Vanino with scheduled handling capacity of 10 mill. t p.a.

At present, both the Baltic ports and the Russian ports are planning a series of extension measures to keep pace with growing exports. Increasingly, producers or their trading houses (e.g. Krutrade) are getting involved in investment projects for the ports.

**Handling capacities of Russian, Baltic and Ukrainian ports**

| | 2004<br>mill. t p.a. |
|---|---|
| **Baltic Sea/Northern Russia** | |
| Murmansk | 8.9 |
| Vysotsk | 3.1 |
| Riga | 9.4 |
| Ventspils | 3.9 |
| Tallinn | 2.3 |
| St. Petersburg | 2.5 |
| Other | 1.6 |
| Ust Gluga (commissioned in 2005) | |
| Total | 31.7 |
| **Southern Russia/Ukraine** | |
| Mariupol | 2.5 |
| Kerch | 0.9 |
| Izmail | 1.2 |
| Yuzhny | 5.0 |
| Tuapse | 3.2 |
| Other | 0.7 |
| Total | 13.5 |
| **Russia/Far East** | |
| Vostochny | 14.4 |
| Vanino | 0.8 |
| Total | 15.2 |
| Grand Total | 60.4 |

Source: McCloskey

**Exports**

Exports of Russian coal has increased strongly in recent years to reach 76 mill. t in 2004. They can be broken down as follows:

- Exports to countries outside the CIS 66.0 mill. t
  - sea-bound 61.5 mill. t
  - on land 4.5 mill. t
- Exports to CIS states 10.0 mill. t
- Total 76.0 mill. t

The strongest sales region was Europe with 32.0 mill. t. Its take has doubled in recent years, although the Far Eastern market, too, is growing. For example, some 15 mill. t was sold to Japan and South Korea. Russia is the only country with loading ports for steam coal and coking coal on both the Atlantic and the Pacific markets.

The quality of Russia's exports has continuously improved in recent years thanks to the installation of magnetic separators in some of the conveyor belt systems at the loading ports. The wagon fleet of Russia's railways, too, is tending to get better.

**Export developments, Russia, 2002 - 2004**

| | 2002 mill. t | 2003 mill. t | 2004 mill. t |
|---|---|---|---|
| Coal output | 253.0 | 279.0 | 283.0 |
| Hard coal exports* | 40.0 | 49.0 | 66.0 |
| Steam coal | 33.0 | 38.0 | 53.0 |
| Coking coal | 7.0 | 11.0 | 13.0 |
| Export rate, in % (only sea-bound) | 16.0 | 18.0 | 22.0 |

*in countries outside the former USSR, only sea-bound

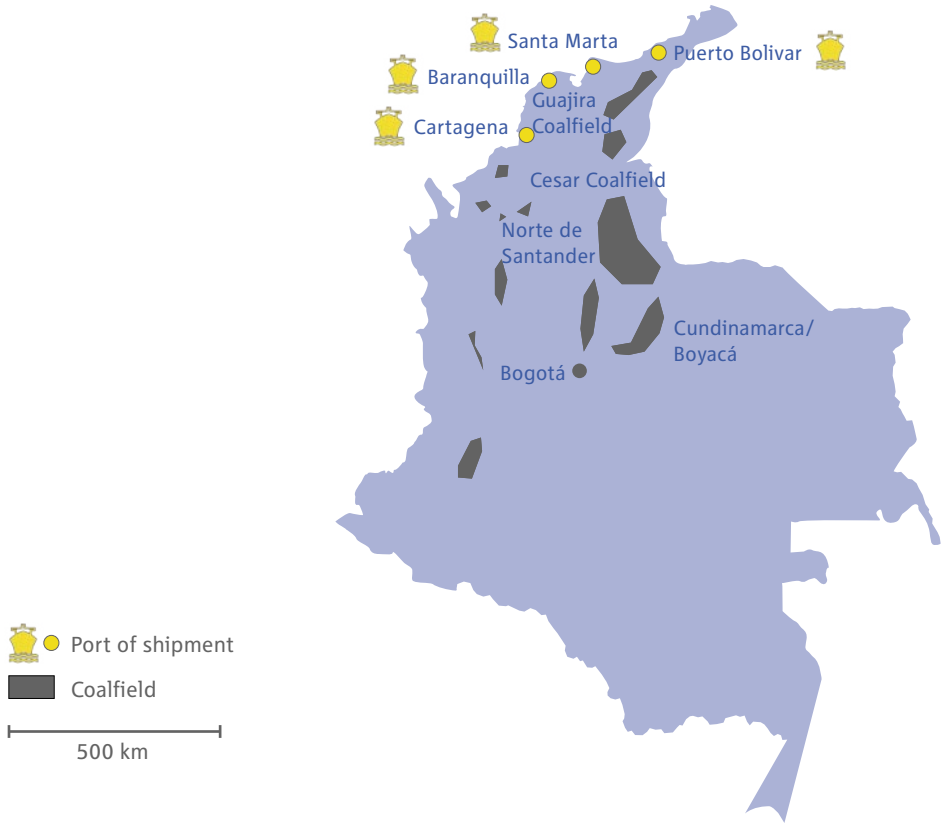
| Chief import countries/regions | | | |
|---|---|---|---|
| EU-15/after 2004: EU-25 | 14.0 | 21.1 | 32.0 |
| Turkey | 4.0 | 5.0 | 6.5 |
| Romania | 1.5 | 1.7 | 2.5 |
| Japan | 6.3 | 7.6 | 9.3 |
| South Korea | 3.0 | 3.5 | 5.1 |

## Outlook

Russia's coal output has risen again recently and is to be increased by 2010 from approx. 280 mill. t today to 310 mill. t and, by 2020, to 375 mill. t. The by-now privatized coal sector is developing a not inconsiderable, organized dynamism.

The export share in output has likewise grown continuously as of late. On the basis of low mining costs in the export opencast pits, Russia's coal is currently on an expansion course in view of the high world market prices. Given the long on-land transport routes of 2,000-4,500 km, it is decisive how Russia's railways will adjust their tariff policy to fluctuations in the world market prices.

## Colombia




### General

Colombia is one of the richest Latin American countries in raw material terms. Its hard coal reserves are the largest on the half-continent. Still, the country has only recently joined the group of exporters to the world coal market. Although its coal deposits have been known for decades and are located near the coast, they long remained undeveloped because of the sub-optimal infrastructure. Development was started at last in the wake of the second oil crisis of 1979/1980, which caused a shortage of steam coals on world markets. The American mineral oil group EXXON and the Colombian state-owned company CARBOCOL then resolved to jointly develop the El Cerrejón North deposit on the Guajira peninsula where, by the standards of the time, a mega export project with a planned annual output of 15 mill. t started extracting coal in 1985. This example was followed by several new developments, so that Colombia has grown to be the second biggest steam coal supplier to the Atlantic market after South Africa.

Raw materials in Colombia are in public ownership, and the state decides on their exploitation. Supervision of the coal industry has lain with ECOCARBON, which reports to the Ministry of Mining and Energy. It explores the country's coal resources to check their development potential, draws up initial development plans and, in an international bidding process, offers deposits for tendering by private companies. It issues 30-year extraction licences. A 5 % royalty is levied on the proceeds from all extracted coal.

**Reserves/output**

The country's coal resources are put at some 12 bn t, of which, according to Barlow Jonker (2004), 7.1 bn t are deemed definitely measured and minable. Geologically, these are young coal formations dating from the more recent Cretaceous and early Tertiary periods (approx. 70 mill. years). They are located in seven coal basins in all, the Guajira and Cesar coalfields being closest to the coast and most interesting in commercial terms.

The quality of Colombian hard coals varies, extending from the highly volatile range all the way to anthracite. The coals located in the Cordillera Occidental (Cesar) and its foothills (Guajira) are of low rank and, hence, highly volatile (30-39 %) or rich in moisture (7-16 %). By contrast, ash (4-10 %) and sulphur content (0.4-1.0 %) are low, so that high net calorific values of 6,500-7,000 kcal/kg are reached. This being so, the coal needs no preparation except crushing and screening and is excellently suitable as steam coal and, in some cases, even as PCI coal. The drawbacks include a proneness to self-ignition, but also a relatively high grinding hardness of 40-45 HGI. The seams of the deposits located in the Cordillera Central (e.g. Cundinamarca/Boyacá, Santander, Norte de Santander) are usually of a higher rank and also bear coking coals.

In 2004, coal output totalled 52 mill. t, i.e. 15 % above the previous year's level. At some 46 mill. t (88 %), most of the output is handled by the two large-scale opencast mines Cerrejón Norte and Mina Pribbenow. Here, Prodeco, with approx. 4 mill. t (8 %), is the only medium-sized producer. The remainder of the output is distributed across six smaller pits.

Almost all of the output destined for export came from opencast mines. Seam formations are usually level (0-15°) and reach thicknesses of up to 150 m; they comprise up to 27 workable seams with thicknesses of 1-15 m. Extraction is normally by truck and shovel with occasional support from draglines to remove the overlying strata. Just one – as far as is known – export pit is engaged in underground mining; its operations are only partly mechanized using the board and pillar method with drilling and blasting. Much more widespread, by contrast, are underground operations in small and very small mines, which produce for the local market and are not included in the statistics.

Productivity of Colombia's output is thanks to large-scale opencast mines. Cerrejón, with approx. 5,000 employees and 25 mill. t/a, reaches productivity of 5,000 t/man-year, the Mina Pribbenow pit, with 3,000 employees, 7,000-8,000 t/man-year. The smaller pits have low productivity, but also low infrastructure costs in pit operations. In places, they are dependent on transportation by truck.

Mining costs for export coals in large-scale opencast mines are currently put at USD 22-24/t, free mine. To this must be added USD 2-3/t for rail transport and USD 3-5/t in port handling charges, so that overall costs, fob, are USD 27-32/t. These are the costs of the highly mechanized and capital-intensive major operations. Although the free-mine costs of the mid-sized mines with a low degree of mechanization in the Cordilleras are lower, these mines have costs of some USD 12-14/t for transportation by truck to the ports, so that their competitiveness relative to the big producers is at best marginal.

**Colombia's biggest hard coal producers**

| Company | Exports, 2004 mill. t |
|---|---|
| Cerrejon | 24.9 |
| Drummond Ltda. | 20.9 |
| Prodeco/Caribe | 4.2 |
| Other | 1.0 |
| Total | 51.0 |
| % of Total output, Colombia | 98.0<br>52.0 |

The coal industry experienced another wave of consolidation in recent years. The owner consortium of Carbones del Cerrejón (BHP-Billiton, Anglo Coal, Glencore each holding 1/3) has now been renamed Cerrejón Coal Co.; it also owns 100 % of the Cerrejón Zona Norte pit.

Some 50 % of Colombia's output is marketed by the consortium, therefore. In addition, Glencore, with the Prodeco/Caribe pit, has secured further shares in output. The output of Cerrejón Coal Co. is marketed via CMC in Dublin, and is organizationally separate from the distribution of BHP/Amcoal/Glencore.

**Infrastructure**

Colombian ports can currently handle approx. 63 mill. t/a. Capacities are said to be as follows:

**Port capacities, Colombia, 2004**

| | mill. t |
|---|---|
| Puerto Bolivar | 31.0 |
| Cienaga (Drummond) | 25.0 |
| Prodeco Port | 5.0 |
| Carbosam | 1.6 |
| Barranquilla | 0.3 |
| Total | 62.9 |

Colombia's two main ports are linked to the pits by rail. The haul from El Cerrejón to Puerto Bolivar is 145 km, and that from Mina Pribbenow to Cienaga 210 km. They handled 46 mill. t in 2004. The smaller pits transport their coal to the ports in trucks. Any further expansion in coal output requires extensions to the railway system.

The Colombian government has included USD 320 mill. for infrastructure measures in its budget. Public and private efforts will probably be bundled to extend the railway lines and ports in order to allow further expansion of Colombia's coal industry.

**Exports**

In 2004, 98 % of the output was exported. With 31 mill. t, sales focused on Europe and with 20 mill. t on North, Central and South America. Most of the coal is used as steam coal, but in smaller amounts also as PCI coal.

The biggest buyer is the US with 13 mill. t, but the Central and South American countries are taking growing amounts. Noteworthy buyers in Europe are Germany, the Netherlands, France and Israel.

**Export developments, Colombia, 2002 - 2004**

| | 2002 mill. t | 2003 mill. t | 2004 mill. t |
|---|---|---|---|
| Hard coal output | 41.0 | 45.0 | 52.0 |
| Hard coal exports | 35.0 | 44.0 | 51.0 |
| Export rate, in % | 85.0 | 97.0 | 98.0 |
| Chief import countries/regions | | | |
| EU-15/after 2004: EU-25 | 20.0 | 21.2 | 25.6 |
| Other Europ. countries* | 3.4 | 5.5 | 5.7 |
| US | 6.8 | 12.0 | 13.3 |
| Canada | 2.0 | 1.5 | 1.7 |

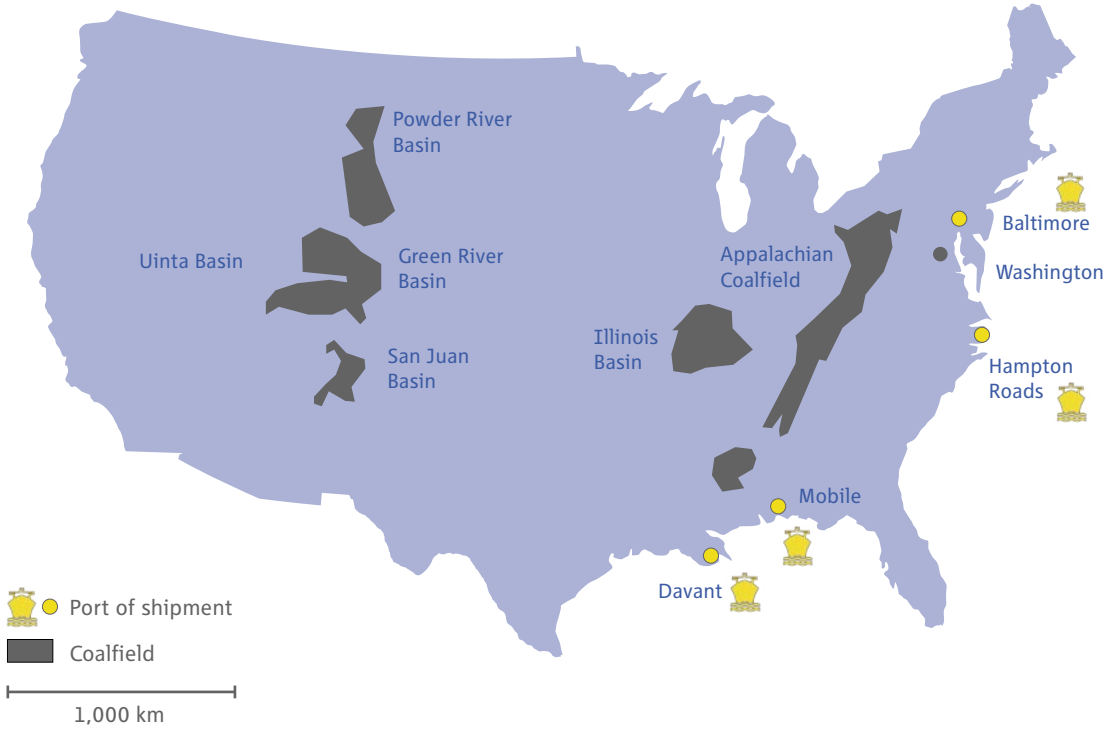
*incl. riparian Mediterranean countries

**Outlook**

The outlook for Colombia's hard coal mining sector has improved in recent years. Demand in North, Central and South America is growing steadily. South Africa cannot boost its exports at present, since its railway problems go unsolved, so that Colombia is well on track to become the biggest supplier of steam coal to the Atlantic market.

All the major companies have announced sizable expansion plans and, as regards their deposit potential, the preconditions for further growth are indeed in place. However, the infrastructure must grow alongside and considerable efforts must be made in the next two years if the logistics side is not to become an export bottleneck.

## US




**General**

In future, too, the US will be backing coal as an important energy source to cover its energy needs. Accounting for 24 % of the country's total energy consumption and 51 % of its power generation, coal will remain an indispensable primary energy source for some time to come. Against this background, the government is making efforts to simplify the approval procedure for the development and exploitation of coal deposits. Also, the US is not a signatory to the Kyoto climate-protection protocol for the reduction of GHG emissions and is rather trying to make a contribution toward protecting the climate by improving the coal-combustion technology.

The American President again confirmed this stance at the most recent G8 summit in the UK in July 2005. The US is massively backing technology programmes to reduce $CO_2$ emissions and, after 2012, will be seeking to include the newly industrialized countries in the emission-control efforts.

Coal has a good competitive position in the US, since gas prices have steadily risen of late, and gas-based power plants, too, have recently been commissioned, so that gas demand is set to rise.

Against the background of a robust economic cycle, coal-based power generation was nearly 2,000 TWh in 2004 and made a 51 % contribution toward electricity supplies. A further rise in this share is foreseeable.

**Reserves/output**

Unlike its reserve situation in oil and gas, the country's coal deposits are virtually inexhaustible. The US has some 25 % of the world's definitely measured and minable coal reserves and 32 % of the hard coal reserves. The latter are put at some 250 bn t. The deposits are located in the Appalachian coalfield near the coast in the country's East. It has hard coal (and anthracite) and is followed by the Illinois basin east of the Mississippi, which has bituminous hard coal high in

sulphur. In the West, there are sub-bituminous coals, likewise low in sulphur, of the Powder River, Green River, Uinta and San Juan basins. Extensive lignite reserves can be found in the southern Gulf region and in the northern lignite basin on the Canadian border.

In the Western United States, approximately 60 percent of the coal reserve base is owned by the Federal government. In order to mine coal on Federal Lands, companies must obtain a Federal coal lease, generelly set at 12.5 % of the minemouth value of coal for coal mined by surface methods and 8 % mined by underground methods. Indian tribes also own a considerable amount of Western coal reserves. In the country's East, by contrast, landowner mining still applies, i.e. at one time, only the owners of the land had control of any natural resources located under it. In the meantime, however, mining rights have sometimes been separated from land ownership and can be assigned to mining companies in return for payment of a royalty (4-7 % of proceeds per t) to be freely negotiated with the owners.

US coal mining is entirely a private-sector activity. In 2004, some 1,300 mines were operational, incl 54 % opencast pits and 46 % underground mines, the number of operations having fallen by 1,000 within a decade. Output stagnated in the same period. In the wake of this consolidation process, ten producers now (2004) account for 68 % of total US coal output.

Coal mining is highly mechanized, and some 67 % takes place in opencast mines with depths of approx. 60 m. This extraction method is particularly widespread in the Western coalfields. There, one or two seams, mostly over 18 m thick, are freed of waste using draglines to permit subsequent coal extraction by truck and shovel. In the Appalachian coalfield, by contrast, draglines are used only rarely, i.e. wherever there are huge amounts of waste above the coal seams (mountain top removal). The coal seams, which are mostly thinner there, and the interburden are then removed by truck and shovel. Underground mining, accounting for 33 % of output takes over from opencast mining in the Appalachians, but also in the Western coalfields as soon as a coal/waste ratio of 8 cbm/t coal is clearly exceeded. Then, operations mainly involve driving tunnels in board and pillar work using continuous miners and shuttle cars and, increasingly, longwall operations as well.

**Biggest US hard coal producers**

| Company | Output, 2004 mill. t | Exports, 2004 mill. t |
|---|---|---|
| Peabody Energy Corp. | 176 | 14 |
| Arch Coal Inc. | 135 | |
| Kennecott Energy Co. | 118 | |
| Consol Energy, Inc. | 61 | 10 |
| Foundation Coal Corp. | 56 | |
| Massey Energy Co. | 38 | 6 |
| The North American Coal Corp. | 31 | |
| Kiewit Mining Group, Inc | 28 | |
| Westmoreland Coal C. | 26 | |
| Total | 669 | 30 |
| % of Total output, US | 72<br>933 | 43 |

The coals have a wide quality spectrum. Whereas the sub-bituminous coals in the Western coalfields require no further preparation, so that the raw coal need only be crushed and screened, the raw coals in the Eastern coalfields generally have to be treated. This is particularly true of coking coal. The sub-bituminous coals in the Western coalfields have a high moisture (26 %) and volatile matter (> 30 %) content with a high grinding hardness (< 50 HGI), while their ash (5 %) and sulphur (0.3 %) content is low, as are the calorific values of 4,800-5,050 kcal/kg (as received). Such coals are used exclusively in power generation. By contrast, the hard coals of the Appalachians have less moisture (5-12 %) and volatile matter (17-39 %), but higher ash values (5-15 %), calorific values (6,000-7,200 kcal/kg as received) and good grindability (50-90 HGI). The sulphur content (0.5-3.0 %), too, is much higher in

places. These coals are used both in power generation and as coking coal. In the latter case, however, only coals with a low ash (6-8 %), moisture (8 %), sulphur (0.7-0.9 %) and volatile matter (18-33 %) content are suitable. Among Asian consumers, the US coking coals are classified as hard coking coal and were once very popular as additives in view of their reactivity and fluidity.

Coal output in 2004 totalled 1,008 mill. t (+3.8 % compared with the previous year), of which 933 mill. t was hard coal (incl sub-bituminous coals) and 75 mill. t lignite. Of the total, 569 mill. t came from the coalfields west of the Mississippi and 439 mill. t from the east of the river. The trend noted for some years now toward a rise in output west of the Mississippi relative to the eastern mining areas continued. While low sulphur content was once the dominant reason for western coal's rising market share in the domestic market, the low cost of western coal has increasingly become the primary reason for its expanded use in recent years. Enactment of the Clean Air Act Amendments of 1990, which entered into force in 1995, placed a long-term cap on electricity sector $CO_2$ emissions of 8.11 mill. t per year. During the mid-1990's, the need to reduce $SO_2$ emissions at U.S. coal-fired power plants led to increased demand for the low sulphur coals produced in the western regions of the Powder River basin – in spite of higher transport costs – at the expense of coals with a higher sulphur content mainly from the Illinois Basin and partly from the Appalachian coalfield.

Coal consumption in 2004 totalled 1,001 mill. t, incl 920 mill. t (92 %) for power generation and 57 mill. t (6 %) for the heat market. Only 24 mill. t (2 %) was shipped to coking plants.

In 2004, the US hard coal mining industry employed a workforce of 71,000. With an output of 1,008 mill. t, this translates into average productivity of 14,200 t/man-year. Here, high productivity ratios of 22,000 t/man-year are reported in opencast pits, above all in the large operations of the Powder River basin while underground mines, located mainly in the Appalachian coalfield, only manage 8,300 t/man-year.

Mining costs have continued to rise in recent years, partially due to government stipulations which compelled companies to form higher provisions for social commitments, as well as environmental stipulations. The US features huge differences in mining costs. In the Appalachian coalfield, costs have the following spread:

| | |
|---|---|
| Steam coal | USD 21 – 37/t |
| Coking coal | USD 30 – 48/t |

As regards coking coal, it must be borne in mind that it has to be better processed and, frequently, that it is extracted from thinner seams involving higher costs.

In the Powder River basin with its large-scale opencast mines and thick seams, by contrast, costs are in a bandwidth of USD 4-6/t.

Rail transportation to the exporting ports costs USD 15-26/t for Appalachian coal, with some USD 2-3/t for port handling.

**Infrastructure**

US coal mining has a well developed and efficient infrastructure which gets more than 969 mill. t of coal p.a. to domestic consumers or to the exporting ports. This involves both the railroad network and inland shipping, which transport 66 % and 7 % resp. Following several mergers of railroad companies in the last three years, coal transportation from the Western coalfields of over 400 mill. t p.a. is now concentrated on Burlington Northern and Union Pacific, while CSX and Norfolk Southern mainly serve the Appalachian coalfield, handling a good 200 mill. t p.a. between them. Inland shipping uses the Mississippi/Missouri rivers and the Great Lakes to transport more than 140 mill. t p.a. Some 124 mill. t is transported by truck. Using conveyor belts or shuttle vehicles, 97 mill. t is transported to consumers directly. For export coals from the Appalachian

coalfield to the seaports, the rail distances range between 600 and 1,000 km and, for inland shipping (Gulf ports), between 700 and 2,500 km. There are no capacity bottlenecks in coal transportation.

At present, the US has some 19 coal ports with more than 20 terminals and an annual handling capacity of 269 t. The chief of these are Baltimore and Hampton Roads on the East coast, followed by Davant and Mobile on the Gulf coast with 13 %. As steam coal imports grow, the Gulf ports in particular are gaining in importance as import ports, and are increasingly being re-equipped.

**Exports**

Following years of steady falls, US exports have recovered somewhat recently. They have gone up, in particular against a backdrop of higher world market prices. The American mining sector has a certain flexibility and is able, thanks to better processing technology, to convert steam coals into higher-volatile coking coal, thus boosting its potential. Its 2004 export volume can be broken down as follows:

| | Coking coal in mill. t | Steam coal in mill. t | Total in mill. t |
|---|---|---|---|
| Maritime trade | 23 | 3 | 26 |
| Land trade | 1 | 16 | 17 |
| Total | 24 | 19 | 43 |

The focus of maritime coal exports is on Europe and South America, but Asia, too, took 6.7 mill. t of US coal in 2004.

In almost constant decline, US coal exports to Asia fell from a recent historical high of 20.7 mill. t in 1988 to a low of 0.2 mill. t in 2003. US hard coal imports have risen in recent years. In 2004, they totalled 25 mill. t, with 3 mill. t coming from Canada and 22 mill. t from the world market. The imports were mainly steam coals to supply power stations located close to the coast.

**Export developments, US, 2002 - 2004**

| | 2002 mill. t | 2003 mill. t | 2004 mill. t |
|---|---|---|---|
| Hard coal output | 918 | 900 | 933 |
| Hard coal exports | 35 | 38 | 43 |
| Steam coal | 16 | 18 | 19 |
| Coking coal | 19 | 20 | 24 |
| Export rate, in % | 4 | 4 | 5 |
| Hard coal imports | 15 | 22 | 25 |
| Chief import countries/regions | | | |
| EU-15/after 2004: EU-25 | 13.2 | 12.7 | 12.1 |
| Other Europe | 1.8 | 2.4 | 1.7 |
| Canada | 14.4 | 18.2 | 15.7 |
| Latin America | 4.1 | 4.5 | 5.1 |
| Japan | 1.1 | 0.0 | 4.0 |

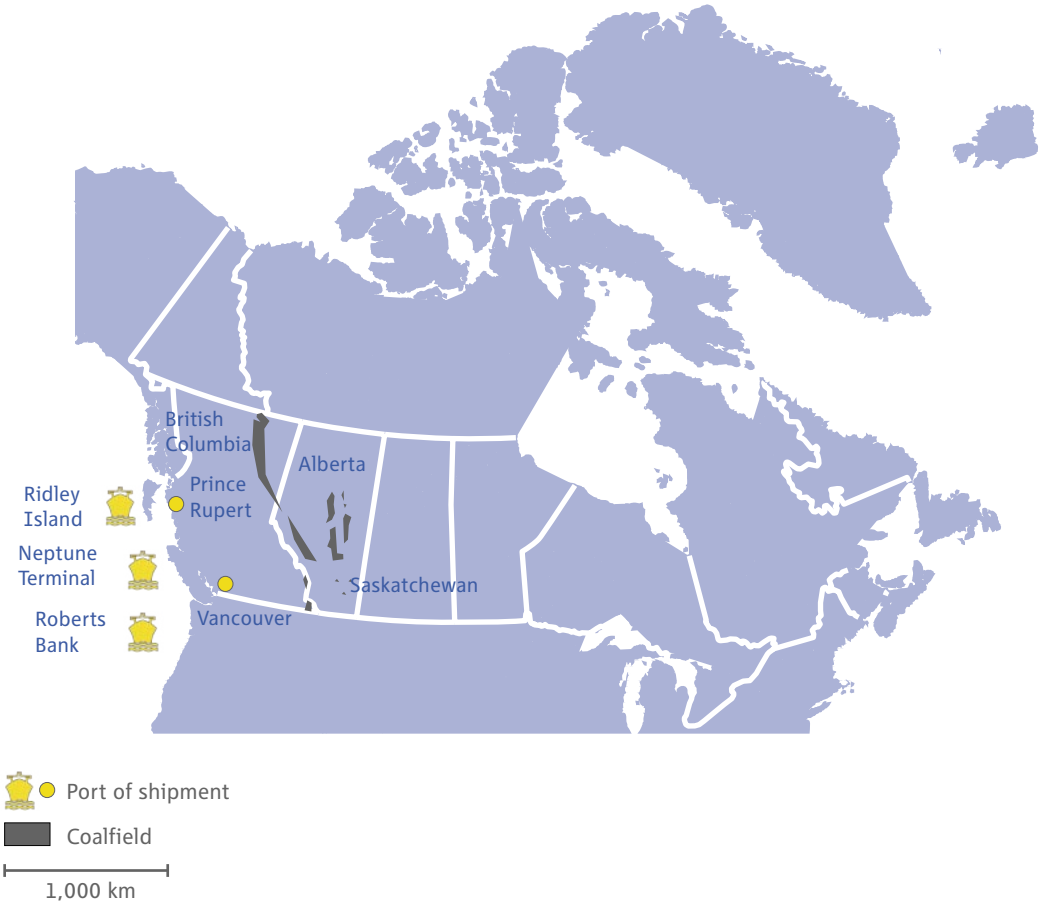
**Outlook**

The prospects for US coal mining are still very good. Due to increasing oil and gas prices in the US, the share of coal in power generation will go on rising. The trend toward higher world market prices provides a flank to a certain revival in exports, above all of coking coal.

In 2004, imports and exports from and to the world market were virtually in balance. The Appalachian coalfield, which is important for exports, is said to be rather on the decline in its production volume. However, with a higher price level, more difficult deposit sections, too, can be mined. Imports from the world market may continue gaining in significance, especially on the East coast.

A role as coking coal swing supplier will be played by the US on a modest scale in the foreseeable future.

## Canada




### General

Canada had its coal-exporting début in the early 1970s; until then, the country's coal industry had almost entirely served the domestic market. The move into the world coal market was only triggered by the growing coking coal requirements of the Japanese and, later, of the Korean steel industries in the second half of the last century. Their strategic aim was the development of assured supplies as a second string to their Australian bow in the Pacific and in addition to the quantities bought from the US at that time. Canada then developed three coal deposits, complete with infrastructure, within two decades to serve the export market, so that exports surged from zero in 1969 to 36.5 mill. t in 1997. Since then, however, the export-oriented hard coal mining industry is an also-ran in terms of competitiveness. The reasons for this are the changing quality requirements to be met by coking coals and the relatively high mining and transportation costs to the coast, but also long-stagnating demand on the world coking coal market.

### Reserves/output

Canada's measured and minable coal resources are put by the World Energy Council at 8.6 bn t, incl 4.5 bn t hard coal, 1.3 bn t sub-bituminous coal and 2.8 bn t lignite. Approx. 91 % of all deposits are located in the Western provinces of Saskatchewan, Alberta and British Columbia. While the lignite basins are confined to Saskatchewan, the sub-bituminous coals are located in a belt starting in the United States, extending to Alberta and reaching into the northwest via the

foothills of the Rocky Mountains. Parallel to this, a further hard coal belt in the West starts in the foothills of the Rocky Mountains already and also extends to British Columbia.

While the sub-bituminous coalfields located in the foothills are in largely undisturbed and flat layers, the hard coal deposits in the foothills are often inclined and impacted by fault tectonics. The coal-bearing layers are up to some 650 m thick with up to 60 seams of a workable thickness.

The country commercially exploits both lignites/sub-bituminous coals and hard coals. The former are used exclusively at mine-mouth power plants to generate electricity, whereas nearly all of the hard coal – incl 90 % coking coal – is exported.

The coking coals have the following typical quality features: generally low volatility of 21-25 % (also medium volatility in places: 26-29 %), 8-9.5 % ash, 1 % (inherent) moisture and 0.5 % sulphur with a swelling index of 6-8. The coking coals are classified by Asian consumers as hard to semi-soft. Exported steam coals have calorific values of 5,800-7,100 kcal/kg (as received) with 19-32 % volatile matter, 10-15 % ash, 7-9 % moisture and 0.3-1.0 % sulphur, and have a good grinding hardness of 60-70 HGI. The sub-bituminous coals of the Rocky Mountains' foothills are largely equivalent in quality terms to those of the US Powder River basin.

Coal mining in the Western provinces is confined to opencast pits. As in the Powder River basin/US, the waste is removed by dragline and the sub-bituminous coals and lignite extracted by truck and shovel. Once crushed, the coal goes directly via belt conveyor to the nearby power plant without further preparation. Hard coal mining, by contrast, involves numerous 1-10 m thick seams, usually with a 20-40° incline, requiring selective mining using bulldozer/frontend loader/shovel and heavy-duty truck. The life span of the opencast hard coal pits located in the Eastern foothills of the Rocky Mountains is seriously limited owing to the rapid rise in the coal/waste ratio to values of over 8 cbm/t coal. However, the deposits located close to the surface are usually still sufficient for operations to continue for some time to come. In 2004, seven companies were mining hard coal in British Columbia, and nine coal in Alberta (incl four hard coal mines, four sub-bituminous coal pits and one lignite mine) and two lignite in Saskatchewan.

Canada's coal output totalled 65 mill. t in 2004, incl 29 mill. t of hard coals and 36 mill. t of sub-bituminous coals or lignites. Nearly all of the hard coals are destined for export as prepared products. A large share of 24 mill. t is coking coal and 2 mill. t steam coal. The latter are a by-product of extraction and preparation, e.g. oxidized coking coals located close to the surface which have lost their coking properties due to decay, but retain their net calorific value. There are also ash-rich middlings from the preparation process which are unsuitable as coking coal.

While the entire output of lignite and sub-bituminous coal was used as steaming coal in the country, nearly 100 % of hard coal output or 26 mill. t was exported in 2004.

The start of 2003 saw the completion of the consolidation process in Canada's hard coal mining sector which had been ongoing for years due to the financial problems of the Canadian pits. The setting up of the Fording Canadian Coal Trust (FCCT) and the Canadian Coal Partnership (CCP) has enabled all Canadian hard coal interests to be bundled, giving birth to the world's second largest coking coal exporter. The new company goes by the name of Elk Valley Coal Corporation (EVCC) and exports some 24 mill. t of coking coal. The steam coal activities are amalgamated in the much smaller Luscar Coal.

Against a background of an improved earnings situation, EVCC is planning to develop the "Cheviot Coking Coal" project with potential output of 2.8 mill. t, while the mining company Pine Valey Mine Corporation launched the Wil-

low Creek project, which produces PCI coal for export.

Productivity in Canada's mining sector is seen in a bandwidth of 8,000-11,000 t/man-year, while mining costs range between USD 26 and 36/t. Transportation costs are between USD 20 and 22/t, port handling costs between USD 3-5/t.

**Infrastructure**

The infrastructure available to the Canadian coal industry is excellently developed, reliable and efficient, but nonetheless remains the sector's weak point on account of the transport distances involved. All exporting mines have rail links either to Canadian National (CN), Canadian Pacific (CP) or BC Rail Ltd., with transport distances of over 1,000 km to the exporting ports on the Pacific coast. Even more serious is the distance of 2,400 km to the densely populated industrial centres on the North American lakes. Compared with other exporting countries like Australia, Indonesia, South Africa and even China, which serve the Pacific market, this is a definite drag on the industry's cost situation and competitiveness. The coal is exported via the Pacific ports of Roberts Bank (Westshore Terminal) and Neptune Terminal (both Vancouver), Texada on Vancouver Island and Ridley Island (Prince Rupert), with a handling capacity of 51.5 mill. t annually.

At present, the Westshore Terminal, with about 25 mill. t, is the most used loading port. The terminal is now being modernized and has expansion potential. The Neptune Terminal has a capacity of 8 mill. t, only half of which is currently being used. Its capacity can be expanded to 10 mill. t/a at relatively short notice. The Ridley Terminal has a capacity of 12 mill. t, although a mere 1 mill. t was shipped in 2004. New projects by the Western Canadian Coal Company could revive the terminal. The two leading rail operators – CN and CP – have announced massive investment. CP wants to invest CD 160 mill. in 25 projects, and CN as much as CD 474 mill. The investments have a 5-year time span.

**Exports**

Exports stabilized in 2004 in view of rising world coking coal prices. Most of Canada's coking coal output is now being marketed on a one-stop shopping basis, which is likely to make a contribution toward price stabilization. Sales focus is on Europe with about 30 %, and South East Asia with 50 %. Also for reasons of diversification, Canada's coal has attracted interest again relative to over-mighty Australia.

**Export developments, Canada, 2002 - 2004**

| | 2002 mill. t | 2003 mill. t | 2004 mill. t |
|---|---|---|---|
| Hard coal output | 30.0 | 27.0 | 29.0 |
| Hard coal exports | 25.0 | 25.0 | 26.0 |
| Steam coal | 2.0 | 1.0 | 2.0 |
| Coking coal | 23.0 | 24.0 | 24.0 |
| Export rate, in % | 83.0 | 92.0 | 90.0 |
| Chief import countries/regions | | | |
| EU-15/after 2004: EU-25 | 4.9 | 6.0 | 6.2 |
| Other Europ. countries* | 1.3 | 0.7 | 1.7 |
| Japan | 9.4 | 7.8 | 5.4 |
| South Korea | 4.4 | 3.7 | 0.0 |
| US | 1.8 | 1.8 | 2.5 |
| Latin America | 1.8 | 2.5 | 3.2 |

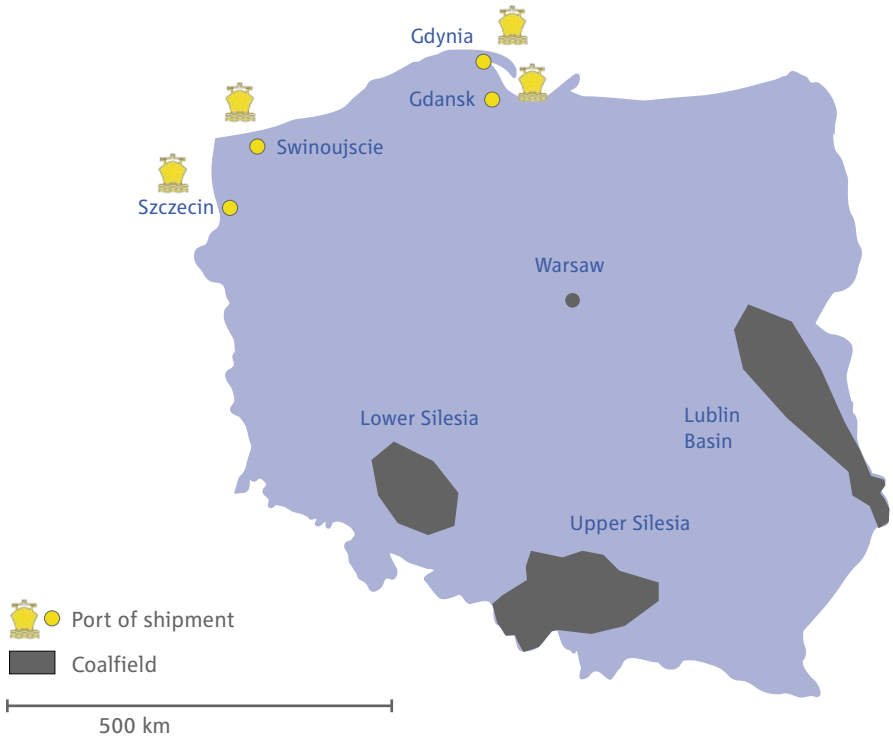
*incl. riparian Mediterranean countries

**Outlook**

Due to long transportation routes, West Canada's hard coal mining has a considerable cost disadvantage compared with Australian and US coking coal pits. Nonetheless, the outlook for Canada's coking coal exports are vastly improving thanks to higher world market prices and a tightening of the supply range due to China's withdrawal from exporting coking coal, since many consumers prefer not to cover their needs with Australian coal only. Hence, Canada's exports are on the up again at present. The market leader Elk Valley Coal is planning the development of the Cheviot pit, while the smaller

companies Grand Cache Coal, Pine Valley and Western Canadian Coal, too, have new developments in the pipeline which, in their final stage, could add an extra 10-12 mill. t in the way of export quantities.

## Poland




### General

Poland is not only one of Europe's traditional hard coal producers; it was once one of the main suppliers to the world hard coal market. The country assumed the leading role among European mining countries in 1972 with an output of 150.7 mill. t and, until 1979, was the world's second largest coal exporter after the US, selling 41.4 mill. t that year. Although its role as an exporting country was already fading in the 1980s, output was maintained at a significant level (1988: 193 mill. t) compared with other European countries. It was not until the political turnaround in eastern bloc countries associated with a growing market-economy orientation that Poland, too, experienced in the early 1990s the process of contraction in hard coal mining that had already begun in Western Europe 20 years previously. Thus, output amounted to a mere 99 mill. t in 2004 and has stabilized in recent years. Poland's coal is currently in a better competitive situation than in the past thanks to high world market prices. 93 % of the country's power generation is based on hard coals and lignite.

### Reserves/output

The country's economically minable coal reserves, according to the World Energy Council, amount to 14.3 bn t, incl 12.1 bn t hard coals. They are distributed between the Upper and Lower Silesian and the Lublin basins, with the Upper Silesian coalfield accounting for 93 % of the total. The coal formation there contains some 400 coal seams, about half of which are of economic interest with a thickness of 0.8-3.0 m. About two thirds of the seams are at an incline of less than 10°, and the rest max. 35°. Some 56 % of the minable coal reserves consist of steam coal, and 44 % of coking coal. All of the country's natural resources, including coal, are state-owned.

Owing to the improved overall situation for Poland's mining sector thanks to restructuring successes – flanked by higher world market prices for fossil energies – the Polish government resolved a privatization programme. According to the scheme, the first company, Katowicka Grupa Kapitalowa (Katowice Coal Holding), is to be privatized by end-2005, with the coking coal producer, Jastrzebka Spolka Weglowa SA, following in 2006, and Kopania Weglowa in 2007. The domestic distribution company (Weglobzyt) and the exporting firm (Weglokoks), too, are to be sold. For four mines – Budryk, Bogdanka, Janina and Sobieski Jaworzno – individual solutions must be found.

For further structural adjustments, two lines of thinking are being pursued: one base scenario which provides for a cutback of output to 84-86 mill. t in the coming years, and an alternative line planning a reduction in output only to 95 mill. t by 2007 – high world market prices provided.

**Poland's biggest hard coal producers**

| Company | No. of mines | Output, 2004 mill. t | Exports, 2004 mill. t |
|---|---|---|---|
| Kompania Weglowa SA | 18.0 | 53.8 | 14.9 |
| Katowicka Group Kapitalowa | 7.0 | 18.4 | 3.3 |
| Jastrzebska Spolka Weglowa SA | 5.0 | 13.7 | 2.1 |
| Independent mines | 4.0 | 13.3 | 0.5 |
| Total | 34.0 | 99.2 | 20.8 |

2004 output of 99 mill. t can roughly be broken down into 17 mill. t coking coal and 82 mill. t steam coal. Domestic consumption is some 78 mill. t, incl coking plants' needs; 21 mill. t. is exported.

All mining is in underground operations at an average working depth of some 600 m. Extraction is fully mechanized with the coal being mined by longwalling methods (114 longwalls).

The raw coal from underground operations is diluted by secondary rock and requires preparation. In the past, this produced "western" quality standards only for coking coal. The extension of existing, and the commissioning of new, preparation plants in recent years has led to a qualitative approximation to world market requirements at least for exported steam coal. This quality is marked by 25-31 % volatile matter, 8-16 % ash, 7-11 % moisture, 0.6-1.0 % sulphur content, and has a calorific value of > 6,000 kcal/kg (as received), though the grinding hardness of 45-50 HGI is usually less favourable. The coking coals are of medium to high volatility (23-33 %) with an ash and sulphur content of 7-9 % and 0.6-1.0 % resp. Their coking properties with a swelling index of 6-9 are excellent.

At present, the Polish hard coal mining sector has a workforce of some 127,000. This is equivalent to productivity of just under 800 t/man-year. Major improvements can hardly be expected with working depths of 500-600 m. Polish mining costs are estimated at USD 45-50. If we include freight and handling, Poland's mining sector requires export prices of at least USD 60-65/t. The labour cost share is over 50 %. Together with the US, this makes Poland a marginal seller to the Atlantic steam coal market.

The zloty has recently firmed against the USD, and this is having an adverse effect on income for Poland, as in the case of South Africa and Australia.

**Infrastructure**

The coal mining industry and exporters have an efficient infrastructure at their disposal based on cross-border rail links to neighbouring countries and to those Baltic Sea ports that are suitable for exporting coal and currently have an annual handling capacity of 22.6 mill. t in all. The ports are Gdansk, Swinoujscie, Szczecin and Gdynia,

with only Gdansk being able to load capesize freighters. Swinoujscie and Gdynia, by contrast, are only accessible for panamax ships, while only handysize vessels can access Szczecin. The rail distance from Upper Silesia to the exporting ports is some 1,100 km. Poland's inland shipping, on the other hand, is hardly developed and is only used for deliveries to domestic river-side power plants.

**Exports**

Thanks to high world market prices, exports of Poland's coal industry have stabilized. Together with coke (converted into coal terms), 25 % of output is exported, the focus of sales being on the EU-25; the main buyer is Germany with 7 mill. t steam coal and 1.7 mill. t coke. Due to high mining costs, exports are dependent on the present price level of more than USD 50/t fob. The high price is currently permitting Poland to continue exporting at cost-covering prices, thus extending the supply range for Europe's power plants.

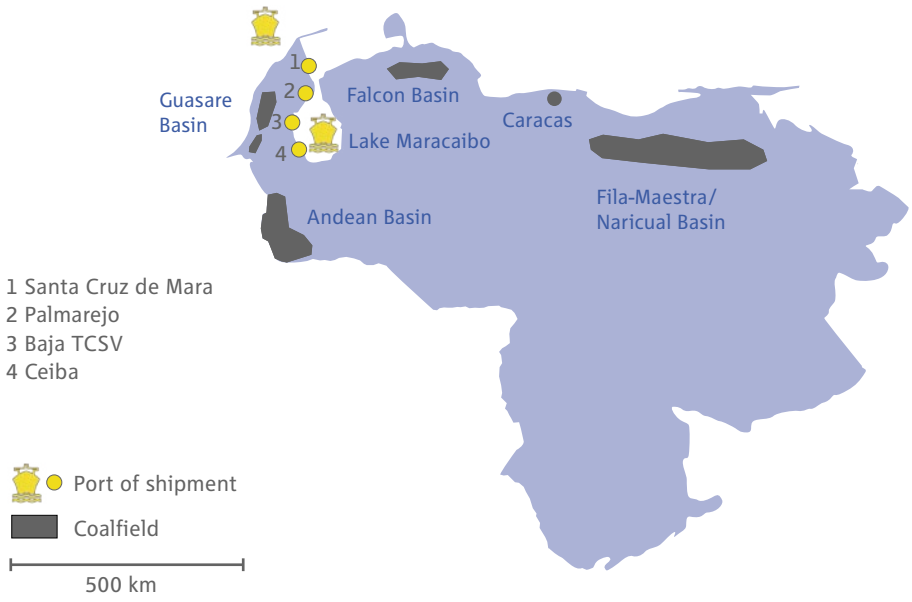
**Export developments, Poland, 2002 - 2004**

| | 2002 mill. t | 2003 mill. t | 2004 mill. t |
|---|---|---|---|
| Hard coal output | 102.0 | 100.0 | 99.0 |
| Hard coal exports | 23.0 | 21.0 | 21.0 |
| Steam coal | 20.0 | 19.0 | 18.0 |
| Coking coal | 3.0 | 2.0 | 3.0 |
| Coke exports | 2.0 | 3.0 | 3.0 |
| Export rate, in % | 25.0 | 25.0 | 25.0 |
| Chief import countries/regions | | | |
| EU-15/after 2004: EU-25 | 18.1 | 15.2 | 17.4 |

**Outlook**

Poland's hard coal mining sector has been able to stabilize somewhat thanks to high world market prices and can export on a cost-covering basis. To that extent, exports can be expected in the medium term as well. Still, due to difficult geological conditions and rising labour costs, Poland's mining industry remains subject to cost pressures. If energy prices settle at the current level in the long term, this will make structural adjustments for the Polish mining sector easier.

## Venezuela




### General

One potential major contributor to the world hard coal market is Venezuela. This country made its first big impression in 1991 with exports of 1.9 mill. t and now (2004) serves the world market with a volume of some 8 mill. t, equivalent to a share of 1.0 %. Although Venezuela will never be a big player on an international level, its development potential is nevertheless substantial and of growing interest to European and North American consumers in particular. One obstacle to the speedy development of coal exporting is the infrastructure, which has been inadequate for years now: there has been a lack of efficient rail links from the exporting mines to the deep-water ports and of facilities for handling capesize freighters.

As in all of South America, raw materials are in state ownership. Mining rights are granted by the mining ministry (Ministerio de Minas), which issues licences for prospection, exploration and extraction. Coal mining, too, is subject to these arrangements. The royalty levied on the coal mined is 10 % of the sales proceeds, free mine. As in the mineral oil sector, state influence on the coal mining industry, which has been unimportant as regards exports and foreign currency, is considerable, since the state has substantial holdings in the big coal companies. The envisaged expansion of the coal mining industry is being hindered by state intervention in the private sector's development plans for the infrastructure. To this must be added uncertainty among foreign investors about the security of investment and about the future taxation of profits and their transfer abroad.

### Reserves/output

The country's coal resources of some 4.5 bn t are relatively modest by world standards. This is true in particular of the definitely measured and minable 1.4 bn t (Venezuelan energy ministry). Most of these resources can be mined in opencast operations and are distributed across five coal basins, i.e. the Fila Maestra and Naricual basins located on the East coast; the Falcon basin, likewise near the coast; the Andine basin situated southwest of Lake Maracaibo; and, finally, the Guasare basin in the extreme northwest of the country which, with more than 90 % of total

reserves, is the most important by far. A coal formation located there dates back to the more recent Cretaceous or the late Tertiary (approx. 70 mill. years). It is 130 m thick with up to 23 seams having a max. thickness of 13 m. With a moderate incline, the deposits are hardly disturbed. The Guasare basin is a continuation of the neighbouring Colombian Guajira coalfield.

The quality of the Guasare coals is largely identical with Colombian Guajira coal. The highly volatile (35 %) coal contains a mere 6-7 % ash and 7 % moisture, so that a calorific value of 6,900 kcal/kg (as received) is reached. This being so, it makes excellent steam coal, especially since it contains only 0.5 % sulphur. What is more, it also has slight coking properties, so that it is increasingly being used as PCI coal, and some can also be employed as semi-soft coking coal.

Most of the coal is mined in opencast pits using truck and shovel in view of the large number of seams. Since the seams are not seriously diluted, even the raw coal is of very high quality and needs no further costly preparation apart from crushing and screening. Only one mid-sized mining operation (Mina Norte: 1.5 mill. t p.a.) extracts from an opencast pit by board and pillar. The remaining underground mines are confined to small companies with low degrees of mechanization. Coal mining is currently concentrated on the Guasare region, which accounts for some 90 % of total output, while mining by the small operators in the east of the country (Fila Maestra/Falcon) has been dormant for some years now.

The biggest producers currently (2004) are CARBONES DEL GUASARE and CARBONES DEL GUAJIRA, with the mines located in the Falcon and Fila Maestra/Naricual basins not producing at the moment. Altogether, Venezuela's hard coal mining sector has a mining capacity of just under 9 mill. t p.a. In 2004, RAG Coal International sold its share in Paso Diablo (25.5 %) to Peabody Energy. The other shares are held by Anglo American (24.9 %) and Carbozulia (49.6 %).

2004 output was 8 mill. t, i.e. at the previous year's level and was almost entirely exported. Failing official statistics, no figures are available at present on the workforce levels in the coal mining sector and on productivity. We may assume, however, that this is high in fully mechanized opencast pits (Paso Diablo mine). A contractor has been operating the pit for some years now.

**Venezuela's biggest hard coal producers**

| Company | Exports, 2004 mill. t |
|---|---|
| Carbones del Guasare S.A. | 6.4 |
| Carbones de la Guajiara S.A. | 0.8 |
| Interamerican Coal | 0.6 |
| Xcoal | 0.2 |
| Other (Colombian coal) | 0.5 |
| Total | 8.5 |
| % of Total output, Venezuela | 100.0<br>8.0 |

Mining costs in modern large opencast operations (operating costs) are currently put at USD 16-20/t. Transportation by truck to the port adds a further USD 5-6/t with port handling charges of USD 3-5/t, since the coal has to be shipped on inland waterways to an offshore loading terminal. This being so, the coal finally ends up onboard with fob costs of USD 24-31/t.

**Infrastructure**

The infrastructure of the Guasare coalfield is poor. There is no rail link from the mines to the ports of shipment, so that the entire amount of several million tonnes a year has to be transported by truck over a distance of 85 km on public roads. All ports, like Santa Cruz de Mara, Palmarejo, Baja TCSV and Ceiba, are located on Lake Maracaibo. They have a present handling capacity of just under 10 mill. t annually, but are only directly accessible for handysize ships

with a low draught. Panamax ships, by contrast, can only be handled far from the coast either by barge and pontoon crane or by tanker converted into a floating interim store. Although now technically optimized, this is still a costly procedure.

According to most recent information, Sandwell Energy is said to have been awarded a planning contract for a USD 400 mill. project which comprises a deep-water port for coal and a rail link-up. Phase 1 is to have a capacity of 12 mill. t, and phase 2 24 mill. t. With this in place, the Socuy project could be tackled.

**Exports**

Coal exports were at an unchanged 8.5 mill. t in 2004, of which 8 mill. t demonstrably came from Venezuelan production; the 0.5 mill. t difference being classified as Colombian coal (Cucuta, Caipá), which is transported by truck and shipped via the Venezuelan ports of Palmarejo and La Ceiba. Most of the exports go to the US and Europe. The focus of exports has shifted from Europe to the US in recent years. Increasingly, the coal is also imported by South American steel companies as PCI coal.

**Export developments, Venezuela, 2002 - 2004**

| | 2002 mill. t | 2003 mill. t | 2004 mill. t |
|---|---|---|---|
| Hard coal output | 8.0 | 8.0 | 8.0 |
| Hard coal exports | 8.0 | 8.0 | 8.0 |
| Export rate, in % | 100.0 | 100.0 | 100.0 |
| Chief import countries/regions | | | |
| EU-15/after 2004: EU-25 | 3.0 | 2.8 | 2.4 |
| US | 3.9 | 4.3 | 4.4 |

**Outlook**

The prospects for an efficient and export-oriented coal mining sector are uncertain, being dependent on the development of a major operation with an annual mining capacity of some 15 mill. t that includes the Paso Diablo mine – which is already producing – plus the adjacent Sucui deposit. The project includes the construction of an 80-km rail link to the Gulf of Venezuela, and a deep-water port located there which is set to handle capesize ships as well. Besides this, two further smaller projects with an annual mining capacity of some 2 mill. t each (Cosila, Cachirí) are awaiting implementation. In the next three years, a slight increase in Venezuela's coal exports can be expected. If the port gets built, exports could reach 18-20 mill. t in the long term.

## Vietnam


### General

Vietnam is making efforts to boost its economy and has lost no time in recent years in expanding its coal mining activities.

### Reserves/output

Vietnam has important reserves of lignite and anthracite, which are not yet fully explored. The deposits are mainly located in northern Vietnam, with smaller deposits of anthracite, hard coal and lignite in the centre and north of the country. The most noteworthy reserves can be found in the Quang-Ninh basin, these being divided into

the three coalfields Hongai, Compha and Hong Bi and containing 6.6 bn t measured, incl 3.1 bn t minable, anthracite reserves.

Besides the anthracite reserves, there are also large lignite reserves, which are estimated at 20 bn t. Production is both in underground mines and opencast operations. The share of opencast mines is on the decline, since the deposits are approaching depths of 350 m, so that they are no longer accessible for opencast mining. 95 % of the output is anthracite. In 2004, the total reached 25 mill. t. Domestic consumption amounted to 14 mill. t, exports to 11 mill. t. Internal sales of 5 mill. t went to power plants, 2 mill. t to cement works and 7 mill. t to other sectors.

The opencast mines use the truck and shovel technique, while underground mines use board and pillar and longwalling. Productivity of 500-600 t/man-year is very low. Since deposits in opencast mines are limited, Vietnam must develop modern underground operations and is having recourse to foreign assistance in this respect.

95 % of mining is controlled by VINACOAL (Vietnam National Coal Corporation). The qualities are low in sulphur (0.6 %) and can reach calorific values of over 7,000 kcal/kg, depending on treatment.

Data on employees and costs are not yet available. Since Vietnam is exporting on a growing scale, it may be assumed that this must be lucrative for the Vietnamese economy. In 2005, Vietnam was able to push through much higher export prices.

**Infrastructure**

The Quang-Ninh basin has a long production history. To that extent, transportation by rail and truck is efficient. In places, there are conveyor belts to the coal-preparation plants.

Exporting ports exist in Hongai and Compha. Export capacity is currently being expanded. Campha can load ships up to 7,000 dwt, Hongai up to 10,000 dwt, but also ship sizes up to 30,000 dwt when at anchor.

**Exports**

Exports reached some 11 mill. t in 2004. The biggest buyers are southern Chinese power plants and cement works, taking 6 mill. t, while 1 mill. t was shipped as PCI coal to Japan and China. Thanks to its outstanding quality, Vietnam coal is supplied to the global metallurgical industry and markets that need a high carbon content.

**Export developments, Vietnam, 2002 - 2004**

| | 2002 mill. t | 2003 mill. t | 2004 mill. t |
|---|---|---|---|
| Hard coal output | 15.0 | 19.0 | 25.0 |
| Hard coal exports | 5.6 | 6.6 | 10.5 |
| Export rate, in % | 37.0 | 35.0 | 42.0 |
| Chief import countries/regions | | | |
| China | 2.3 | 4.0 | 6.0 |

**Outlook**

Vietnam proposes to expand its production to 35-40 mill. t by 2010 and increase its exports correspondingly. To do so, the existing pits must be modernized and new mines built. Vietnam receives strong support from Japan and Poland.

# Coal geology and mining techniques

**Deposits**

Coal, which is a product of organic, i.e. plant, sedimentation, occurs in seam-shaped deposits. Since this process was not continuous, the sediment is often interspersed with clayey-sandy sediments, so that we usually encounter coal in multi-seam deposits. Growing pressure from more recent rock sediments triggered a carbonization process which, with increasing dewatering of the organic substances and carbon enrichment, ended in the formation of coal. The rock formations that followed then frequently deformed what had originally been horizontal seams with a series of folds and faults.

Most of the hard coal resources in the northern hemisphere date back to the Carboniferous period, i.e. their sedimentation occurred 250-300 mill. years ago. The deposits in North America include the hard coal mining areas of the Appalachians and Canada's eastern provinces, in Europe those of Western, Central and Eastern Europe, while in Asia they can be found in Siberia and above all in China. In North America, they are supplemented by hard coals from the Mesozoic era, i.e. the Jurassic and the Cretaceous periods (130-70 mill. years). They are located in the mining areas of the Rocky Mountains in the US and Canada and in their eastern foothills.

The hard coal deposits of the southern hemisphere, by contrast, formed in the Palaeozoic era or the Permian period, i.e. 210 mill. years ago already. They are found only sporadically in southern Brazil (Santa Catarina), but above all in South Africa and in the east Australian coalfields of New South Wales and Queensland. India's hard coals, too, (from the time when India still formed part of South Africa in earth's evolution) belong to the Permian, and only the hard coals of South America's northern Andes, i.e. Colombia and Venezuela, are assigned to earth's late Mesozoic era, i.e. the Cretaceous period.

**Mining techniques**

Coal deposits can extend to depths of several thousand metres in complex conditions, but can also be flat deposits close to the surface, so that extraction conditions, too, vary, and the coal must be extracted selectively from the surrounding strata. Depending on the depth of the coal seams and their overlying layers (waste), the coal is extracted either in opencast pits or underground mines.

The profitability threshold worldwide in the opencast mining of hard coal is currently an average waste/coal ratio of some 6 bank cubic metres (bcm) to 1 t of raw coal for the entire opencast pit content and its life. The mining technology employed in opencast pit operations depends on the number and thickness of the seams and on their inclination. Minimum thicknesses of 0.5 to 1.0 m are considered workable. Where the seams worked are flat, the waste is crushed or loosened by drilling and blasting and removed by dragline. The seam exposed in dragline operations is likewise drilled and blasted and then loaded by shovel or frontend loader onto heavy-duty trucks for transportation. In this work, rope shovels are generally deployed, but increasing use has been made of hydraulic shovels recently. By contrast, the extraction of several, and more inclined (upward of 15°) seams is by truck and shovel, with the entire group of seams and waste layers being worked in horizontal slices (levels). The group of seams is first drilled and blasted and then worked from top to bottom, separately for waste and seams, the material being loaded onto heavy trucks. Rope and smaller hydraulic shovels as well as frontend

loaders are deployed, occasionally supported by bulldozers.

A technique hardly ever used in hard coal mining, by contrast, is the extraction method usual in lignite mining involving bucket wheel excavator, since its deployment requires relatively soft coal and surrounding strata.

Deposits where the above waste/coal ratio of 6 bcm/t is exceeded are worked in underground mines. Where deposit depth allows, this is done from the surface by tunnelling using gently sloping tunnels fitted with conveyor belts. Coal deposits at greater depths, by contrast, are developed by shafts, through which the coal is conveyed. In underground mining, it is now rare for seams of less than 1.5 m thickness to be worked. Extraction involves either board and pillar or longwall mining. In the former case, a continuous miner is used to drive haulage roads crossing at right angles into the coal seam, with pillars being left standing between them to bear the cover. Transportation of the raw coal to the belt conveyors is often by shuttle cars. One variant of the board and pillar method involves conventional drilling and blasting using frontend loaders to load the coal onto the belts. In longwalling, by contrast, continuous miners are used to drive horizontal roads into the seams to be mined and then longwall equipment is installed, frequently several hundreds of metres long. This system consists of walking roof support, face conveyor and extraction machine, i.e. shearer. This face moves as mining advances uphill, leaving a worked-out space without pillars, which causes the cover to collapse behind the advancing operations.

**Preparation**

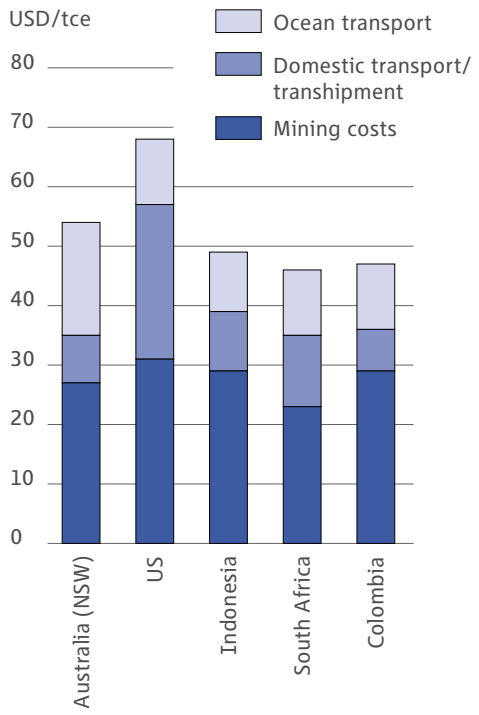
Since raw coal is often seriously diluted owing to the high degree of mechanization in mining operations, it must be subjected to a cleaning process, i.e. preparation, to meet customer requirements. This is true, above all, if the hard coal has to be transported over longer distances as is usually the case in export coal. No preparation is required, by contrast, if the hard coal is to be used in the immediate vicinity of its mining area, e.g., in power plants.

For preparation, the run-of-mine coal is first crushed while still moist and then separated by grain size, i.e. as coarse, fine and very fine. In the subsequent sorting of coal and tailings, the crucial features are specific weight in the case of coarse and fine grain, and surface properties in the case of very fine grain. The separating medium in the former case is either water or heavy media (sink/float process), with the separation taking place in sink-float vessels (for coarse grain) or washers (jigs), or in water cyclones or heavy media cyclones (for medium grain). The very fine grain, by contrast, is cleaned by froth flotation. The crucial economic factor in preparation is the share of clean coal obtained from the raw coal. This is some 80 % for steam coal and 65 - 70 % for coking coal. As quality requirements rise, the share of clean products in the raw coal falls. While the hard coal types from the Carboniferous period, which are widely distributed in the northern hemisphere, prove to be relatively easy to prepare, the situation is much more difficult in the case of the "Gondwana" coals of the southern continents from the Permian period owing to the intimate intergrowth of coal with inorganic sedimentary substances.

# Transportation and handling of hard coal

The transportation costs for hard coal – especially where purchases are made overseas – have a crucial share in the end-consumer price, which can account for more than half the total costs depending on the supplier country.

**Cost structure of various export countries for steam coal cif ARA, 2004**




Source: Association of Coal Importers (Verein der Kohlenimporteure)

In view of the impact of transportation costs on prices, the efficiency of the coal chain is being continuously improved. The chain from mining location to end consumer consists of the following links:

- Transportation in the exporting country to the coast
- Storage in the exporting port
- Port handling and, in places, additional transportation to an offshore loading facility
- Marine transportation,
- Discharge at the port of destination
- Storage in the importing port
- Transportation to the consumer.

Transportation of hard coal to the port of shipment is generally by rail. The feasible distances for economic transportation are limited by cost considerations, i.e. the export mines are located relatively near the coast. For example, rail distances for export coal from the following countries are

| | |
|---|---|
| Colombia | 45-210 km |
| Indonesia | 50-200 km |
| Australia | |
| New South Wales | 80-280 km |
| Queensland | 132-380 km |
| South Africa | 420-590 km |
| US | |
| Appalachians | 480-1,425 km |
| Powder River Basin | 1,690-3,650 km |
| China | 550-650 km |

but have their absolute limits in:

| | |
|---|---|
| Canada | 1,100 km |
| Russia | |
| on average | 4,000 km |
| Kuznetsk/Baltic ports | 4,500 km |

The railroad is often double-track with standard, but also wide (Russia) gauges and low inclinations, and is designed for high axle loads (> 25 t). The unit trains of up to 2.5 km in length

(200 wagons and 4-6 engines) are powered by diesel or electric engines and have a capacity between 10,000-16,000 t. Where rail links to the coast are non-existent, the coal can also be taken to the port by truck (Colombia 300 km, Venezuela 80 km). Another option is shipping by inland waterway, e.g. to the US Gulf ports (600-2,900 km) or, in Indonesia, to the deep-water ports/loading points.

In the port of shipment, the coal is discharged by tippler and moved by belt conveyor and stacker to stockyards that can take a total volume of up to 6 mill. t with up to 50 different varieties. Recovery is by bucket wheel reclaimer or subsurface extractor onto conveyor belts, which take the coal to the shiploader and, finally, to the ship. For each ship to be loaded, there are one or two shiploaders available with loading capacities of up to 6,000 t/h, so that loading a large freighter hardly ever takes more than a day. Altogether, there were some 50 ports of shipment worldwide in 2004 with an annual handling capacity of about 1,100 mill. t of coal.

Marine transport of coal is by bulk freighter. The entire bulk volume on the world market amounted to approx. 2,400 mill. t in 2004. It can be broken down as follows:

| | | |
|---|---|---|
| Coal | 685 mill. t | 28.5% |
| Steam coal | 505 mill. t | |
| Coking coal | 180 mill. t | |
| Iron ore | 590 mill. t | 24.5% |
| Cereals | 270 mill. t | 11.0% |
| Bauxite | 70 mill. t | 3.0% |
| Phosphate | 30 mill. t | 1.0% |
| Other | 755 mill. t | 32.0% |
| Total | 2,400 mill. t | 100.0% |

For traffic in dry bulk commodities, a freight hold of 327 mill. dwt in 5,900 ships was available in 2004. Coal travelled some 3,400 bn tonne-miles, equivalent to an average transport distance per tonne of approx. 5,000 nautical miles. At end-2004, about 900 bulk carriers had been ordered, scheduled for delivery in the next three years. Depending on cargo size, distance to the port of discharge and permissible draught in the ports, three ship sizes are deployed to transport the coal, viz.

10,000 to 50,000 dwt = handysize,
50,000 to 60,000 dwt = panamax and
80,000 to 150,000 dwt = capesize

Handysize ships are mainly used for small quantities (e.g. anthracite, lump coal), short distances, coastal shipping and ports of shipment/destination with only little draught. However, most coal transportation is ocean-wide or between oceans, using panamax and capesize freighters. The first can pass through the Panama Canal, while the second have to round Cape Horn or the Cape of Good Hope; in the latter case, this is not entirely true, since the Suez Canal can now be used by smaller capesize ships as well. In coal shipments, 44 % are accounted for by capesize ships, 31 % by panamax units and 24 % by handysize freighters.

In the receiving countries, some 220 ports of discharge were available in 2004 with a total annual handling capacity of 1,200-1,300 mill. t, although this does have to be shared with other dry bulk commodities. Some of these have dedicated coal terminals, however, e.g. in the ARA ports (Amsterdam-Rotterdam-Antwerp). Coal discharge is usually by grab unloader onto belt conveyors, which move the coal to stockyards, though the discharge process, with some 15,000-20,000 t/d, takes much longer than loading.

Subsequent inland transportation is from the stockyards, where the coal is loaded onto trains or river boats and shipped to consumers. The train sizes deployed are much smaller, however, than in the exporting countries and rarely reach 2,000 t. In some places, e.g. in the ARA ports, the coal can be loaded directly or via stockyards

onto river ships. The standard barge size takes 2,000-2,500 t and is able, depending on water levels, to travel the Central Rhine in tows of four barges and on parts of the German waterway network in single barges.

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