Coal

Although coal use is expected to be displaced by natural gas in some parts of the world, only a slight drop in its share of total energy consumption is projected by 2020. Coal continues to dominate many national fuel markets in developing Asia.

World coal consumption has been in a period of generally slow growth since the late 1980s, a trend that is expected to continue. Although 1999 world consumption, at 4.7 billion short tons,[9] was 15 percent higher than coal use in 1980, it was lower than in any year since 1984 (Figure 51). The *International Energy Outlook 2001* (*IEO2001*) reference case projects some growth in coal use between 1999 and 2020, at an average annual rate of 1.5 percent, but with considerable variation among regions.

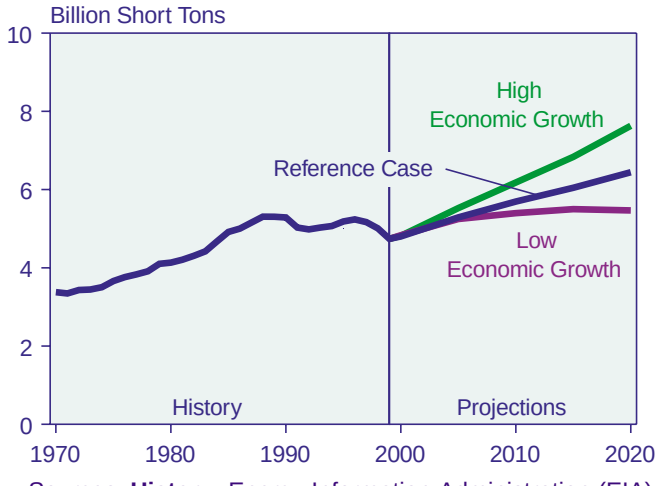
Coal use is expected to decline in Western Europe, Eastern Europe, and the former Soviet Union (FSU). Increases are expected in the United States, Japan, and developing Asia. In Western Europe, coal consumption declined by 42 percent between 1985 and 1999, displaced in large part by the growing use of natural gas and, in France, nuclear power. Even sharper declines occurred in the countries of Eastern Europe and the former Soviet Union (EE/FSU), where coal use fell by 44 percent between 1985 and 1999 as a result of the economic collapse that followed the breakup of the Soviet Union, as well as some fuel switching.

The projected slow growth in world coal use suggests that coal will account for a shrinking share of global primary energy consumption. In 1999, coal provided 22 percent of world primary energy consumption, down from 27 percent in 1985. In the *IEO2001* reference case, the coal share of total energy consumption is projected to fall to 19 percent by 2020 (Figure 52).

The expected decline in coal's share of energy use would be even greater were it not for large increases in energy use projected for developing Asia, where coal continues to dominate many fuel markets, especially in China and India. As very large countries in terms of both population and land mass, China and India are projected to account for 29 percent of the world's total increase in energy consumption over the forecast period. The expected increases in coal use in China and India from 1999 to 2020 account for 92 percent of the total expected increase in coal use worldwide (on a Btu basis). Still, coal's share of energy use in developing Asia is projected to decline (Figure 53).

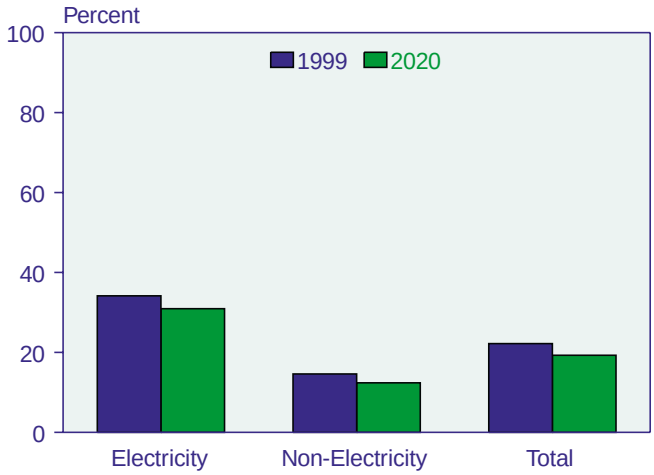
Coal consumption is heavily concentrated in the electricity generation sector, and significant amounts are also

Figure 51. World Coal Consumption, 1970-2020



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

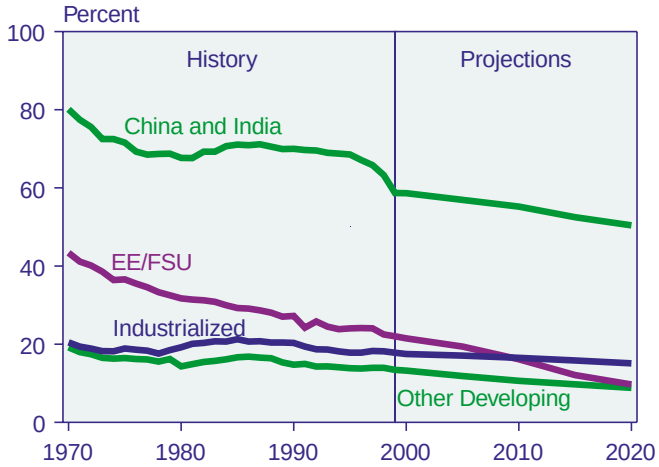
Figure 52. Coal Share of World Energy Consumption by Sector, 1999 and 2020



Sources: **1999**: Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **2020:** EIA, World Energy Projection System (2001).

[9]Throughout this chapter, tons refers to short tons (2,000 pounds).

Figure 53. Coal Share of Regional Energy Consumption, 1970-2020



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

used for steel production. More than 55 percent of the coal consumed worldwide is used for electricity generation. Power generation accounts for virtually all the projected growth in coal consumption worldwide. Where coal is used in the industrial, residential, and commercial sectors, other energy sources—primarily natural gas—are expected to gain market share. One exception is China, where coal continues to be the main fuel in a rapidly growing industrial sector, reflecting the country's abundant coal reserves and limited access to alternative sources of energy. Consumption of coking coal is projected to decline slightly in most regions of the world as a result of technological advances in steelmaking, increasing output from electric arc furnaces, and continuing replacement of steel by other materials in end-use applications.

The *IEO2001* projections are based on current laws and regulations and do not reflect the possible future ratification of proposed policies to address environmental concerns. In particular, the forecast does not assume compliance with the Kyoto Protocol, which currently is not a legally binding agreement. The implementation of plans and policies to reduce emissions of greenhouse gases could have a significant effect on coal consumption. For example, in an earlier study, the Energy Information Administration (EIA) projected that the United States could not meet its Kyoto emissions target without reducing annual coal consumption by somewhere between 18 percent and 77 percent (on a Btu basis) by 2010, depending on a number of other assumptions [***1***].

Developments in international coal markets are also important to the coal outlook. International prices for steam coal (used in power generation) declined sharply in 1999 amid strong competition among exporters, with increasing exports from Australia and Indonesia and decreasing exports from the United States and Canada. In 2000, international coal markets were affected by sharp increases in ocean shipping rates, a recovery in coal export prices during the second half of the year, and a substantial increase in overall coal trade. In Asia, some price increases reflected a tighter market, caused in part by coal miner strikes in Indonesia and Australia and China's failure to meet export commitments.

Highlights of the *IEO2001* projections for coal are as follows:

- World coal consumption is projected to increase by 1.7 billion tons, from 4.7 billion tons in 1999 to 6.4 billion tons in 2020. Alternative assumptions about economic growth rates lead to forecasts of world coal consumption in 2020 ranging from 5.5 to 7.6 billion tons (Figure 51).
- Coal use in developing Asia alone is projected to increase by 1.7 billion tons. China and India together are projected to account for 29 percent of the total increase in energy consumption worldwide between 1999 and 2020 and 92 percent of the world's total projected increase in coal use, on a Btu basis.
- The share of coal in world total primary energy consumption is expected to decline from 22 percent in 1999 to 19 percent in 2020. The coal share of energy consumed worldwide for electricity generation is also projected to decline, from 34 percent in 1999 to 31 percent in 2020.
- World coal trade is projected to increase from 548 million tons in 1999 to 729 million tons in 2020, accounting for between 11 and 12 percent of total world coal consumption over the period. Steam coal (including coal for pulverized coal injection at blast furnaces) accounts for most of the projected increase in world trade.

Environmental Issues

Like other fossil fuels, coal has played an important role in fueling the advancement of civilization, but its use also raises environmental issues. Coal mining has a direct impact on the environment, affecting land and causing subsidence, as well as producing mine waste that must be managed. Coal combustion produces several types of emissions that adversely affect the environment, particularly ground-level air quality. Concern for the environment has in the past and will in the future contribute to policies that affect the consumption of coal and other fossil fuels. The main emissions from coal combustion are sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulates, and carbon dioxide (CO_2) [***2***]. Recent studies on the health effects of mercury have also brought to the forefront concerns about emissions of mercury from coal-fired power plants.

Sulfur dioxide emissions have been linked to acid rain, and many of the industrialized countries have instituted policies or regulations to limit sulfur dioxide emissions. Developing countries are also increasingly adopting and enforcing limits on sulfur dioxide emissions. Such policies typically require electricity producers to switch to lower sulfur fuels or invest in technologies—primarily flue gas desulfurization (FGD) equipment—that reduce the amounts of sulfur dioxide emitted with coal combustion.

Environmental regulation influences interfuel competition (i.e., how coal competes with other fuels, such as oil and gas), particularly in the power sector, where the competition is greatest. For example, compliance with increasingly stringent restrictions on emissions could be increasingly costly and could lead to reduced demand for coal. On the other hand, improved technologies may provide cost-effective ways to reduce emissions from coal-fired power plants. Integrated gasification combined-cycle (IGCC) technology, which may soon be commercially competitive, can increase generating efficiencies by 20 to 30 percent and also reduce emission levels (especially of carbon dioxide and sulfur oxides) more effectively than existing pollution control technologies [***3***].

In 1998, about 230 gigawatts of coal-fired capacity around the world—about 44 percent of it in the United States—used FGD technologies [***4***]. In the developing countries of Asia, only minor amounts of existing coal-fired capacity currently are equipped with desulfurization equipment. For example, in China, the world's largest emitter of sulfur dioxide, data for 1995 indicated that only about 3 percent of coal-fired generating capacity (at that time, less than 4 gigawatts out of a total of 140 gigawatts) had FGD equipment in place [***5***].

In addition to sulfur dioxide, increased restrictions on emissions of nitrogen oxides, particulates, and carbon dioxide are now appearing and are likely to increase. Although the potential magnitudes and costs of additional environmental restrictions for coal are uncertain, it seems likely that coal-fired generation worldwide will face steeper environmental cost penalties than will new gas-fired generating plants. Yet the future is also unclear for nuclear and hydropower, which compete with coal for baseload power generation. Some countries have proposals or plans to restrict and even eliminate nuclear power, which is frequently a target of public protest and opposition. Large-scale hydropower is also increasingly unpopular, and in some places the available resources have already been heavily exploited. Limited prospects for nuclear and/or hydropower capacity in some areas could potentially increase coal use for power generation.

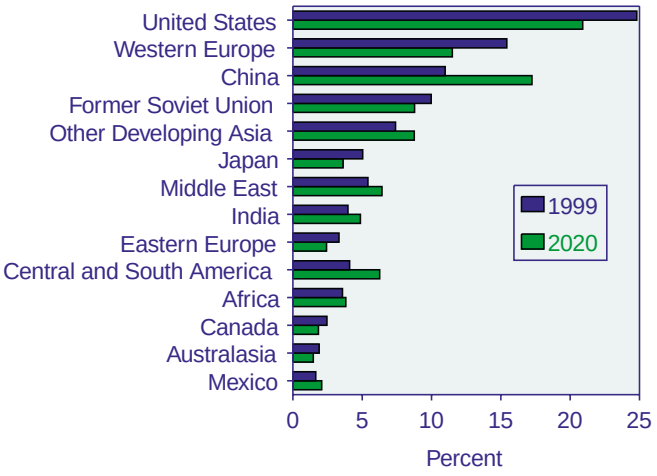
By far the most significant emerging issue for coal is the potential for a binding international agreement to reduce emissions of carbon dioxide and other greenhouse gases. On a Btu basis, the combustion of coal produces more carbon dioxide than the combustion of natural gas or of most petroleum products. Carbon dioxide emissions per unit of energy obtained from coal are nearly 80 percent higher than those from natural gas and approximately 20 percent higher than those from residual fuel oil, which is the petroleum product most widely used for electricity generation.

In 1999, the United States and China were the world's dominant coal consumers and also the two top emitters of carbon dioxide, accounting for 25 percent and 11 percent, respectively, of the world's total emissions. Different economic growth rates and shifting fuel mixes explain in part why the U.S. share of world carbon emissions is projected in the *IEO2001* forecast to decline to 21 percent by 2020, while China's share is projected to increase to 17 percent (Figure 54). Worldwide, coal is projected to continue as the second largest source of carbon dioxide emissions (after petroleum), accounting for roughly 30 percent of the world total in 2020.

Reserves

Coal is the most abundant of the fossil fuels, and its reserves are also the most widely distributed. Estimates of the world's total recoverable reserves of coal in 1999, as reported by EIA, are essentially unchanged from 1998, at about 1,089 billion tons.[10] The resulting ratio of coal reserves to production exceeds 220 years, meaning

Figure 54. Regional Shares of World Carbon Emissions, 1999 and 2020



Sources: **1999:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **2020:** EIA, World Energy Projection System (2001).

[10]Recoverable reserves are those quantities of coal which geological and engineering information indicates with reasonable certainty can be extracted in the future under existing economic and operating conditions.

that at current rates of production (and no change in reserves), coal reserves could last for another two centuries. The distribution of coal reserves around the world varies notably from that of oil and gas, in that significant reserves are found in the United States and the FSU (Figure 55) but not in the Middle East. The United States and the FSU each have roughly 25 percent of global coal reserves. China, Australia, India, Germany, and South Africa each have between 6 and 12 percent of world reserves [***6***].

Quality and geological characteristics of coal deposits are other important parameters for coal reserves. Coal is a much more heterogeneous source of energy than is oil or natural gas, and its quality varies significantly from one region to the next and even within an individual coal seam. For example, Australia, the United States, and Canada are endowed with substantial reserves of premium coals that can be used to manufacture coke. Together these three countries have supplied approximately 85 percent of globally traded coking coal during recent years (see below, Table 17).

At the other end of the spectrum are reserves of low-Btu lignite or "brown coal." Coal of this type is not heavily traded because of its relatively low heat content and other problems relating to transport and storage. In 1999, lignite accounted for 19 percent of total world coal production (on a tonnage basis), and the top three producers accounted for 41 percent of world lignite production: Germany (178 million tons), Russia (99 million tons), and the United States (84 million tons). On a Btu basis, lignite deposits show considerable variation. Estimates by the International Energy Agency for 1998 show that the average heat content of lignite produced in member countries of the Organization for Economic Cooperation and Development (OECD) varied from a low of 4.8 million Btu per ton in Greece to a high of 12.3 million Btu per ton in Canada [***7***].

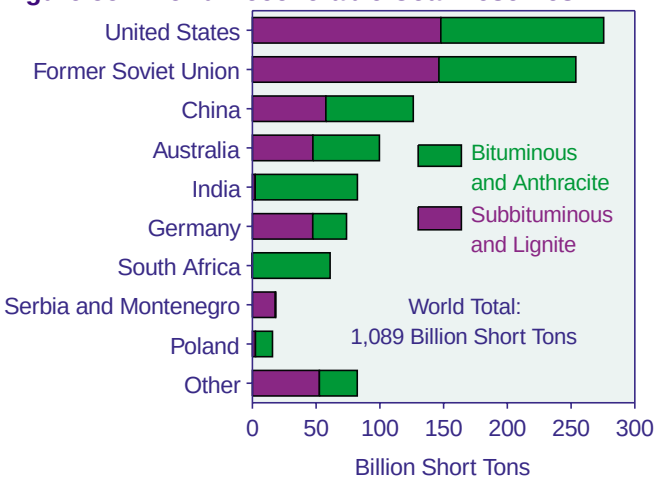
Regional Consumption

Developing Asia

As a region, Asia accounted for 36 percent of the world's coal consumption in 1999. China, the world's largest consumer of coal, accounted for almost 23 percent of global coal consumption in 1999. Large increases in coal consumption are projected for China and for India (Figure 56), which also has sizable coal reserves, based on an outlook of strong economic growth for both countries and the expectation that much of their increased demand for energy will be met by coal, particularly in the industrial and electricity sectors. The *IEO2001* forecast assumes no changes in environmental policies in the two countries. It also assumes that necessary investments in the countries' mines, transportation infrastructure, industrial facilities, and power plants will be made.

The electricity sector accounted for roughly 30 percent of China's coal consumption in 1999 on a Btu basis. By 2020, coal use for electricity generation in China is expected to rise to 17.0 quadrillion Btu from 5.9 quadrillion Btu in 1999. However, 59 percent of the total increase in coal consumption by 2020 is projected to occur in the non-electricity sectors, including industrial applications and the manufacture of coal coke for use in making steel and pig iron. In 1998, China was the world's leading producer of both steel and pig iron [***8***].

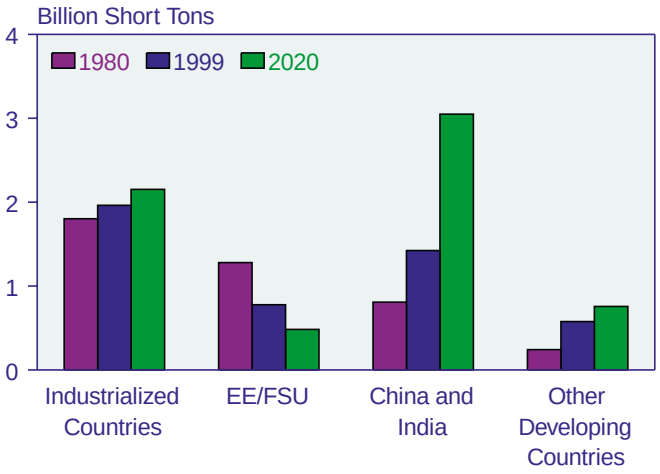
Figure 55. World Recoverable Coal Reserves



Note: Data represent recoverable coal reserves as of January 1, 1999.

Source: Energy Information Administration, *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001), Table 8.2.

Figure 56. World Coal Consumption by Region, 1980, 1999, 2020



Sources: **1980 and 1999:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **2020:** EIA, World Energy Projection System (2001).

(Pig iron offers a more direct link to overall coal use, as its production requires the use of coal coke and coal. Overall steel production includes steel manufactured by electric arc furnaces, which bypass the use of coal.) According to these forecasts, China would account for 40 percent of world coal use in 2020.

Energy consumption in India is also dominated by coal, and more than two-thirds of the coal consumed is used in the power sector, where most growth in coal demand is projected to occur. Coal use for electricity generation in India is projected to rise by 2.1 percent per year, from 4.5 quadrillion Btu in 1999 to 6.9 quadrillion Btu in 2020. A single company, Coal India Limited, has dominated domestic production in India, and now the government is seeking to deregulate coal distribution and some coal prices, which could affect consumption when the policies are implemented.

The rest of developing Asia is a huge and diverse area, accounting for more than 15 percent of the world's current population and 11 percent of the increase in primary energy use projected in the *IEO2001* reference case. Outside China and India, however, coal is expected to play a less prominent role in the energy mix. Coal use in other developing Asia is projected to increase by 2.0 quadrillion Btu between 1999 and 2020, as compared with a projected increase of 32.3 quadrillion Btu for the world. For other developing countries in Asia, as in India, coal is used predominantly for electricity generation. The coal share of energy used for power generation in other developing Asia (excluding South Korea) rose from 28 percent in 1995 to 29 percent in 1999 and is projected to continue growing to 31 percent in 2020.

South Korea is a significant coal user in both the power and steel industries, although electricity generation there is also based on nuclear power and natural gas. South Korean Pohang Iron & Steel (POSCO) is the world's largest steel producing company, buying coal on both long-term and one-year contracts [***9***]. Coal consumption in South Korea is expected to increase from 1.4 quadrillion Btu in 1999 to 1.9 quadrillion Btu in 2020, accounting for more than 25 percent of the projected increase in developing Asia outside China and India.

Taiwan is the next largest coal user in other developing Asia. Its electricity industry is similar to Korea's in that coal plays an important role together with nuclear power and imported natural gas. Taiwan's state power generating company, Taipower, purchases three-quarters of its coal needs through long-term contracts (primarily with Australia) to supply several very large coal-fired power plants. These include Taichung, with a capacity of 4,400 megawatts and annual coal use of around 13 million tons, and Hsinta, with a capacity of 2,100 megawatts and annual coal use of around 6 million tons [***10***].

Indonesia is the third largest coal producer in Asia (after China and India), but with its smaller economy and power needs, it consumes less than half as much coal as Taiwan. Political and economic instability could affect coal production and consumption in Indonesia, although the first part of 2000 was a good year in terms of production, sales, and increased domestic demand. During the summer of 2000, worker strikes for higher wages at the country's largest coal producer, Kaltim Prima (jointly owned by Rio Tinto and BP Amoco), caused the company to declare *force majeure* on export contracts and contributed to a tightened Asian market [***11***].

Elsewhere in developing Asia, Thailand uses about as much coal as Indonesia, and with a brighter economic outlook, is expecting steady growth in coal consumption. Malaysia uses far less coal, generating more power from domestically produced natural gas, although it is building and commissioning several large coal-fired power plants that will lead to rising coal use [***12***].

Industrialized Asia

Among the Asian industrialized countries—Australia, New Zealand, and Japan—Australia is the world's largest coal exporter and Japan is a major importer. Australian coal exports grew steadily in the 1990s, facilitated by aggressive pricing policies on the part of marketers. More than half of Australia's coal production is exported, with nearly one-half of it bound for Japan. Australia is also the fourth largest coal consumer in the Asian region, using coal to fuel the bulk of its power generation.

Japan, which is the third largest coal user in Asia and the fifth largest globally, imports basically all the coal it consumes, much of it from Australia. Some coal is used for the country's steel production (Japan is the world's third largest steel producer and second leading producer of pig iron), which experienced strong growth during the first part of 2000. Coal is also used heavily in the Japanese power sector, accounting for about 16 percent of the energy used for electricity generation and 45 percent of the coal used in the country. More than 3 gigawatts of coal-fired power generating capacity was reportedly added by Japanese utilities during 2000, with several new generating units ranging in size from 700 to 1,000 megawatts [***13***].

Western Europe

Coal consumption in Western Europe has declined by almost 40 percent over the past 9 years, from 894 million tons in 1990 to 546 million tons in 1999. The decrease was smaller on a Btu basis, as much of it resulted from reduced consumption of low-Btu lignite in Germany. Coal consumption is also expected to decline over the forecast period, but at a slower rate. One reason for the

decline is that environmental concerns in Western Europe are particularly strong, affecting the competition among coal, natural gas, and nuclear power in the electricity sector. On the other hand, consumption could be positively affected by the planned phaseout of nuclear power in some countries [***14***]. A sustained increase in natural gas prices (which were higher during 2000) would also increase the competitiveness of coal, particularly in the power sector.

The consumption of hard coal, in particular, has been declining in Western Europe along with regional production.[11] Following the closure of the last remaining coal mines in Belgium and Portugal in the early 1990s, only four countries in the European Union—the United Kingdom, Germany, Spain, and France—continue to produce hard coal, now at declining rates [***15***]. In Germany, Spain, and France, agreements on future coal production subsidies that involve the governments, mining companies, and labor unions suggest that further production declines are forthcoming.

A pattern of declining domestic coal production and consumption is evident in the United Kingdom, the second largest coal user in Western Europe (and for many years, the largest producer). However, this trend was affected by the privatization of British Coal at the end of 1994 as well as one of Europe's most advanced deregulation programs in the gas and power industries. Production of bituminous coal in the United Kingdom declined between 1991 and 1999 by 62 million tons, and coal consumption fell by 53 million tons (45 percent) during the same period. The country's coal imports have risen steadily over the past few years and are increasingly favored for their lower prices and lower sulfur content. During 2000, AES (from the original name of Applied Energy Services) announced a switch to imported coal for its Drax power plant, and British Energy announced that it would use imported coal at the Eggborough power plant taken over from National Power [***16***].

Coal production subsidies in the United Kingdom were phased out and discontinued for several years, but during 2000 the government announced that it would resume subsidies. An aid package approved by the European Commission is designed to help UK coal mines (those that may be viable in the long run) survive the current period of low coal prices and decreased restrictions on the use of natural gas for electricity [***17***]. The subsidy package involves $167 million made available through July 2002.

In comparison to the United Kingdom, a German plan for subsidies to its coal industry was scrutinized by the European Union (EU), which had concerns that too much aid was planned for the industry's operational costs and not enough for shutting down unprofitable mines. Germany adjusted its plan by allocating more of the planned funds to mines due for closure [***18***]. As the largest consumer of coal in Western Europe, Germany accounted for 47 percent of regional consumption in 1999. Most of Germany's coal use is for power generation and district heat. Consumption declined steadily in the 1990s, as did domestic coal production (a trend similar to that in the United Kingdom). Between 1991 and 1999, German lignite production declined by 130 million tons reflecting in large part the closure of unprofitable mines [***19***]. In the *IEO2001* reference case, Germany's coal consumption is projected to continue falling, although not as dramatically as in recent years. By 2020, coal use in Germany is expected to fall to 219 million tons from the 1999 level of 258 million tons, a drop of 39 million tons over a 21-year period.

France is not a large producer or consumer of coal, accounting for less than 5 percent of Western Europe's coal consumption in 1999. A plan is already well under way there to modernize, rationalize, and restructure the coal industry, with a goal of closing all mines in France by 2005. The trend in reducing production capacity partly reflects unfavorable geological conditions. French coal production has been in the decline since the 1960s [***20***], and about 22,000 jobs were lost to mine closures and industry restructuring between 1986 and 1999. Coal accounts for about 6 percent of electricity supply in France, which is predominantly from nuclear power. After the floods of early 2000, however, repair and maintenance outages at nuclear power plants led to a burst of coal imports. As a result, imports for the year are likely to be much higher than originally anticipated (in the range of 8 million tons, instead of 3 million tons) [***21***].

Spain produces and consumes more coal than France but still far less than the United Kingdom. Production of hard coal is in decline, and Spain also has a plan to restructure the industry and reduce subsidies. The process could involve a number of challenges, because Spanish coal fields generally are located in small, geographically isolated areas that are heavily dependent on coal mining [***22***]. Lower than average rainfall in Spain and Portugal during part of 2000 depleted hydropower reserves and contributed to higher than expected coal imports [***23***].

Coal use in other major coal-consuming countries in Western Europe is projected either to decline or to remain close to current levels. In the Scandinavian countries (Denmark, Finland, Norway, and Sweden), environmental concerns and competition from natural gas

[11] Internationally, the term "hard coal" is used to describe anthracite and bituminous coal. In data published by the International Energy Agency, coal of subbituminous rank is classified as hard coal for some countries and as brown coal (with lignite) for others. In data series published by EIA, subbituminous coal production is included in the bituminous category.

are expected to reduce coal use over the forecast period. Coal consumption in Italy is projected to remain relatively flat in the *IEO2001* forecast. Partially offsetting the expected declines in coal consumption elsewhere in Europe is a projected increase in consumption of indigenous lignite for power generation in Greece. Under an agreement reached by the countries of the European Union in June 1998, Greece committed to capping its emissions of greenhouse gases by 2010 at 25 percent above their 1990 level—a target that is much less severe than the emissions target for the European Union as a whole, which caps emissions at 8 percent below 1990 levels by 2010.

Eastern Europe and the Former Soviet Union

In the EE/FSU countries, the process of economic reform continues as the transition to a market-oriented economy replaces centrally planned economic systems. The dislocations associated with institutional changes in the region have contributed substantially to declines in both coal production and consumption. Coal consumption in the EE/FSU region has fallen by 674 million tons since 1988, to 778 million tons in 1999. In the future, total energy consumption in the EE/FSU is expected to rise, primarily as the result of increasing production and consumption of natural gas. In the *IEO2001* reference case, coal's share of total EE/FSU energy consumption is projected to decline from 22 percent in 1999 to 10 percent in 2020, and the natural gas share is projected to increase from 45 percent in 1999 to 53 percent in 2020.

The three main coal-producing countries of the FSU—Russia, Ukraine, and Kazakhstan—are facing similar problems. The three countries have developed national programs for restructuring and privatizing their coal industries, but they have been struggling with related technical and social problems. Of the three, Kazakhstan has shown the most rapid progress. Many of Kazakhstan's high-cost underground coal mines have been closed, and its more competitive surface mines have been purchased and are now operated by international energy companies [***24***].

In Russia and Ukraine, efforts have been aimed primarily at shutting down inefficient mines and transferring associated support activities—such as housing, kindergartens, and health facilities—to local municipalities. The closure of inefficient mines in both countries has been slow, however, leading to delays in the scheduled disbursement of loan money from the World Bank. In addition, Ukraine lost access to funding from the International Monetary Fund (IMF) for a period of time after it provided incorrect information to IMF about its monetary reserves. In both countries, coal-mining regions continue to wield considerable political clout, putting pressure on the leadership through strikes and their ability to influence election results. In the fourth quarter of 2000, the World Bank released the final $70 million of a $300 million coal sector adjustment loan initially approved in December 1996 [***25***]. The two final segments ($150 million) of $1,300 million in coal sector adjustment loans to Russia are scheduled to be disbursed by the World Bank during the first quarter of 2001 [***26***].

In Eastern Europe, Poland is the largest producer and consumer of coal; in fact, it is the largest coal producer in Europe and second only to Germany in consumption. In 1999, coal consumption in Poland totaled 164 million tons and was dominated by hard coal use. Coal consumption in other Eastern European countries is dominated by the use of low-Btu subbituminous coal and lignite produced from local reserves.

At present, Poland's hard coal industry is operating at a loss [***27***]. Over the past several years, a number of coal industry restructuring plans have been put forth for the purpose of transforming Poland's hard coal industry to a position of positive earnings, eliminating the need for government subsidies. The World Bank has approved loans to support restructuring of the coal industries in both Poland and the Czech Republic, which are continuing to close unprofitable mines.

North America

Coal use in North America is dominated by U.S. consumption. In 1999, the United States consumed 1,045 million tons, accounting for 93 percent of the regional total. By 2020 U.S. consumption is projected to rise to 1,297 million tons. The United States has substantial supplies of coal reserves and has come to rely heavily on coal for electricity generation, a trend that continues in the forecast. Coal provided 51 percent of total U.S. electricity generation in 1999 and is projected to provide 44 percent in 2020 [***28***]. The forecast reflects projected declines (in real terms) in both minemouth coal prices and coal transportation rates, as well as heavy use of existing coal-fired power generating capacity to help meet expected growth in electricity demand.

In Canada and Mexico, coal consumption is projected to rise from 77 million tons in 1999 to 93 million tons in 2020. In the near term, Canadian cement producers faced with high natural gas prices during 2000 (in western Canada) are looking at converting to coal use [***29***]. After reaching an historical peak in 1997, Canadian coal production declined for a second consecutive year in 1999, accompanied by several mine closures and a slight drop in exports, reflecting expanded international competition (particularly from exporters in Australia, Indonesia, and China) [***30***].

Mexico consumed 13 million tons of coal in 1999. Two coal-fired generating plants operated by the state-owned utility Comision Federal de Electricidad (CFE) consume approximately 10 million tons of coal annually,

most of which originates from domestic mines [***31***]. Domestic production is located predominantly in the northern state of Coahuila and includes a high proportion of low-quality brown coals (used for power generation) [***32***]. On Mexico's Pacific coast, a newly completed import facility with a throughput capacity of 10 million tons per year will supply CFE's Petacalco power plant and a nearby integrated steel mill [***33***]. Despite this activity, natural gas is expected to be the fuel of choice for most new generating capacity in Mexico.

Africa

African coal production and consumption are concentrated heavily in South Africa. In 1999, South Africa produced 248 million tons of coal, 70 percent of which went to domestic markets and the remainder to exports [***34***]. Ranked third in the world in coal exports since the mid-1980s (behind Australia and the United States), South Africa became the second largest coal exporter in 1999 when its exports exceeded those from the United States. South Africa is also the world's largest producer of coal-based synthetic liquid fuels. In 1998, about 15 percent of the coal consumed in South Africa (on a Btu basis) was used to produce coal-based synthetic oil, which in turn accounted for more than a quarter of all liquid fuels consumed in South Africa [***35***].

For Africa as a whole, coal consumption is projected to increase by 39 million tons between 1999 and 2020, primarily to meet increased demand for electricity (this forecast assumes 4.1-percent average annual economic growth for the region). Some of the increase in coal consumption is expected outside South Africa, particularly as other countries in the region seek to develop and use domestic resources and more varied, less expensive sources of energy.

In Nigeria, for example, the Ministry of Solid Minerals Development approved a coal development plan in 2000, including the reentry of Nigeria into international coal trade and increased domestic use [***36***]. The Ministry of Energy in Kenya has begun prospecting for coal in promising basins in the hope of diversifying the fuels available to its power sector. A large portion of the country's electricity is supplied by hydropower, which has led to shortages during recent times of drought [***37***]. Tanzania also has begun promoting plans for coal resource development (the Mchuchuma-Katewaka mine) and a new 400-megawatt coal-fired power plant to improve power supply and attract foreign investment [***38***].

Central and South America

Coal has not been an important source of energy in Central and South America, accounting for less than 5 percent of the region's total energy consumption in 1999. In the electricity sector, hydroelectric power has met much of the region's electricity demand, and new power plants are now being built to use natural gas produced in the region. Natural gas is expected to fuel much of the projected increase in electricity generation over the forecast period.

Brazil, with the eighth largest steel industry worldwide in 1999, accounted for more than 66 percent of the region's coal demand, with Colombia, Chile, Argentina, and to a lesser extent Peru accounting for much of the remaining portion. The steel industry in Brazil accounts for more than half the country's total coal consumption, relying on imports of coking coal to produce coke for use in blast furnaces [***39***]. Although Brazil's steel production was fairly flat in the late 1990s, strong growth during the first part of 2000 was part of a broader industry trend.

In the forecast, increased use of coal for making steel (both coking coal and coal for pulverized coal injection) makes up a large portion of the projected increase in Brazil's coal consumption. The expected completion of several coal-fired power plants in Brazil, fueled primarily by domestic coal, accounts for much of the remaining growth in coal consumption projected for South America. In Colombia, weakening government authority during 2000 at the hands of paramilitary and guerilla groups slowed foreign investment and domestic coal production.

In Puerto Rico, AES plans to build a 450-megawatt coal-fired plant despite the recent commissioning of a gas-fired power plant fueled by liquefied natural gas from Trinidad and Tobago. This suggests that coal could be competitive for power generation in those parts of Central America where pipeline natural gas and hydropower are not available.

Middle East

The Middle East, including Turkey, accounted for about 2 percent of global coal use in 1999. As a whole, the region relies heavily on oil and gas for its primary sources of energy. Still, coal use is expected to grow in the region. In the *IEO2001* reference case, coal consumption in the Middle East is projected to increase from 96 million tons in 1999 to 120 million tons in 2020, representing an average annual growth rate of 1.1 percent.

Turkey accounts for most of the coal that is used in the Middle East. In 1999, a total of 84 million tons of coal was consumed in Turkey, most of it low-Btu, locally produced lignite [***40***]. Over the forecast period, coal consumption in Turkey (both lignite and hard coal) is expected to increase by 17 million tons, primarily to fuel additional coal-fired power generation.

Israel and Iran accounted for most of the remaining 12 million tons of coal consumed in the Middle East in 1999. In Israel, all the coal consumed is used for power

generation and district heating, and coal accounts for roughly 75 percent of the country's total electricity generation [***41***]. The startup of two new coal-fired generating units at Israel Electric Corporation's Rutenberg plant in 1999 and 2000 is expected to add approximately 3 million tons to Israel's total annual coal consumption [***42***]. Israel is now pursuing a natural gas development plan in order to diversify its fuel mix. In Iran, approximately 1 million tons of coal consumption has been met historically by indigenous suppliers [***43***].

Trade

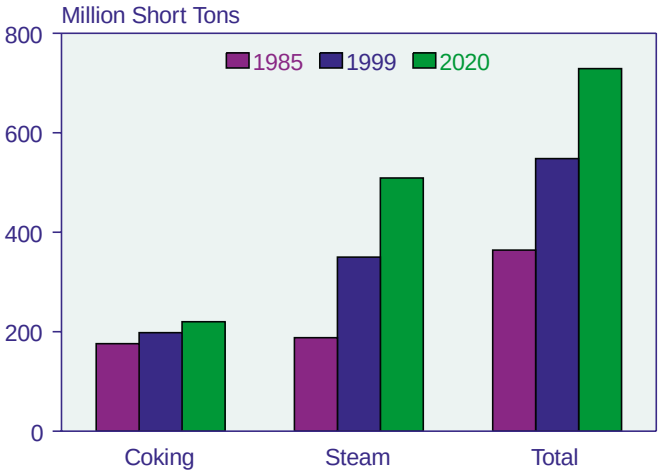
Overview

The amount of coal traded in international markets is small in comparison with total world consumption. In 1999, world imports of coal amounted to 548 million tons (Table 17 and Figure 57), representing 12 percent of total consumption. By 2020, coal imports are projected to rise to 729 million tons, accounting for an 11-percent share of world coal consumption. Although coal trade has made up a relatively constant share of world coal consumption over time and should continue to do so in future years, the geographical composition of trade is shifting.

In recent years, international coal trade has been characterized by relatively stable demand for coal imports in Western Europe and expanding demand in Asia (Figure 58). Rising production costs in the indigenous coal industries in Western Europe, combined with continuing pressure to reduce industry subsidies, have led to substantial declines in production there, creating the potential for significant increases in coal imports; however, slow economic growth in recent years, environmental concerns, and increased electricity generation from natural gas, nuclear, and hydropower have curtailed the growth in coal imports. Conversely, growth in coal demand in Japan, South Korea, and Taiwan in recent years has contributed to a substantial rise in Asia's coal imports.

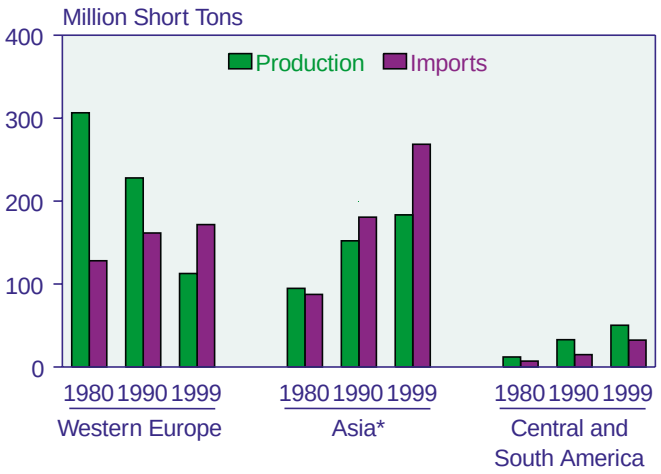
Most recently, in 1999 and 2000, international coal markets have undergone some significant changes, particularly on the supply side (coal export capacity and ocean transportation). In 1999, fierce price competition prevailed in world coal markets, substantially affecting trade patterns and the revenues obtained from exports. Australia and Indonesia saw major increases in their coal exports in 1999, while the United States saw a major reduction in its exports for the year, dropping to the lowest level since the mid-1970s [***44***]. Because of the reduction in U.S. coal exports, South Africa was able to displace the United States as the world's second largest coal-exporting country, a position that the United States had held since 1984.

Figure 57. World Coal Trade, 1985, 1999, and 2020



Sources: **1985:** Energy Information Administration (EIA), *Annual Prospects for World Coal Trade 1987*, DOE/EIA-0363(87) (Washington, DC, May 1987). **1999:** International Energy Agency, *Coal Information 1999* (Paris, France, August 2000); Energy Information Administration, *Quarterly Coal Report, October-December 1999*, DOE/EIA-0121(99/4Q) (Washington, DC, April 2000). **2020:** Energy Information Administration, *Annual Energy Outlook 2001*, DOE/EIA-0383(2001) (Washington, DC, December 2000), National Energy Modeling System run AEO2001.D101600A.

Figure 58. Production and Imports of Hard Coal by Region, 1980, 1990, and 1999



*Data for Asia exclude China, India, and Australasia.

Note: Production and imports include data for anthracite, bituminous, and subbituminous coal.

Sources: Energy Information Administration, Office of Energy Markets and End Use, International Statistics Database.

Although both South African and Canadian producers priced their coal exports at very competitive prices in 1999, they did not see substantial increases in shipments over 1998. On the spot market, South African exporters consistently priced their cape size cargos of steam coal at or below $18 per ton (FOB port of exit in 1999 dollars) but still were having a difficult time competing with

Table 17. World Coal Flows by Importing and Exporting Regions, Reference Case, 1999, 2010, and 2020
(Million Short Tons)

Exporters	Importers											
	Steam[a]				Coking				Total			
	Europe[b]	Asia	America	Total[c]	Europe[b]	Asia[d]	America	Total[c]	Europe[b]	Asia	America	Total[c]
	1999											
Australia	12.3	76.2	1.3	**87.4**	23.3	69.7	6.7	**102.0**	35.6	145.8	8.0	**189.4**
United States	4.9	4.5	17.1	**26.5**	19.4	4.1	8.7	**32.2**	24.3	8.6	25.8	**58.6**
South Africa	49.3	19.0	1.7	**70.2**	0.9	0.8	0.8	**2.9**	50.2	19.7	2.4	**73.1**
Former Soviet Union	12.1	4.9	0.0	**17.0**	2.6	2.9	0.0	**5.5**	14.7	7.7	0.0	**22.5**
Poland	14.0	0.0	0.0	**14.0**	3.3	0.0	0.7	**3.9**	17.3	0.0	0.7	**18.0**
Canada	0.1	4.5	0.7	**5.4**	6.9	20.1	2.8	**31.9**	7.1	24.6	3.4	**37.3**
China	3.4	31.5	0.4	**33.7**	0.2	6.9	0.0	**7.2**	3.6	38.4	0.4	**40.9**
South America[e]	25.8	0.0	9.3	**38.7**	0.6	0.0	1.4	**1.8**	26.3	0.0	10.7	**40.5**
Indonesia[f]	10.7	40.3	3.2	**57.2**	1.3	8.6	0.4	**11.1**	12.0	48.9	3.6	**68.3**
Total	**132.6**	**180.9**	**33.6**	**350.1**	**58.5**	**113.0**	**21.5**	**198.3**	**191.1**	**293.8**	**55.1**	**548.4**
	2010											
Australia	10.2	121.5	0.8	**132.4**	31.8	82.0	8.0	**121.7**	42.0	203.4	8.8	**254.2**
United States	5.0	7.7	9.7	**22.4**	18.9	1.3	15.0	**35.2**	23.8	9.1	24.7	**57.6**
South Africa	49.6	28.9	4.6	**83.0**	1.0	6.1	0.0	**7.1**	50.5	35.0	4.6	**90.1**
Former Soviet Union	12.1	2.8	0.0	**14.9**	1.5	0.0	0.0	**1.5**	13.7	2.8	0.0	**16.4**
Poland	8.0	0.0	0.0	**8.0**	3.6	0.0	0.0	**3.6**	11.7	0.0	0.0	**11.7**
Canada	5.1	3.3	0.0	**8.4**	4.6	20.1	2.8	**27.4**	9.6	23.4	2.8	**35.7**
China	1.2	65.1	0.0	**66.4**	0.0	8.3	0.0	**8.3**	1.2	73.4	0.0	**74.6**
South America[e]	36.5	0.0	34.7	**71.2**	0.0	0.0	0.0	**0.0**	36.5	0.0	34.7	**71.2**
Indonesia[f]	9.0	64.5	0.0	**73.5**	0.9	4.0	0.0	**5.0**	9.9	68.6	0.0	**78.5**
Total	**136.7**	**293.8**	**49.7**	**480.2**	**62.3**	**121.7**	**25.8**	**209.8**	**198.9**	**415.5**	**75.5**	**690.0**
	2020											
Australia	6.6	129.3	0.9	**136.8**	35.8	86.3	12.2	**134.3**	42.4	215.6	13.1	**271.1**
United States	2.9	8.6	10.2	**21.7**	15.2	1.5	17.7	**34.4**	18.1	10.1	28.0	**56.1**
South Africa	46.7	38.1	4.2	**89.0**	0.0	6.6	0.0	**6.6**	46.7	44.7	4.2	**95.6**
Former Soviet Union	12.1	3.9	0.0	**16.0**	1.5	0.0	0.0	**1.5**	13.7	3.9	0.0	**17.5**
Poland	5.5	0.0	0.0	**5.5**	3.4	0.0	0.0	**3.4**	8.9	0.0	0.0	**8.9**
Canada	5.1	1.6	0.0	**6.6**	4.3	19.9	1.5	**25.7**	9.3	21.5	1.5	**32.3**
China	3.4	70.7	0.0	**74.1**	0.0	8.8	0.0	**8.8**	3.4	79.5	0.0	**82.9**
South America[e]	38.8	0.0	36.9	**75.7**	0.0	0.0	0.0	**0.0**	38.8	0.0	36.9	**75.7**
Indonesia[f]	6.8	77.0	0.0	**83.8**	0.9	4.1	0.0	**5.0**	7.7	81.1	0.0	**88.8**
Total	**127.8**	**329.1**	**52.2**	**509.1**	**61.0**	**127.3**	**31.5**	**219.8**	**188.9**	**456.4**	**83.7**	**729.0**

[a]Reported data for 1999 are consistent with data published by the International Energy Agency (IEA). The standard IEA definition for "steam coal" includes coal used for pulverized coal injection (PCI) at steel mills; however, some PCI coal is reported by the IEA as "coking coal."

[b]Coal flows to Europe include shipments to the Middle East and Africa.

[c]In 1999, total world coal flows include a balancing item used by the International Energy Agency to reconcile discrepancies between reported exports and imports. The 1999 balancing items by coal type were 3.0 million tons (steam coal), 5.4 million tons (coking coal), and 8.4 million tons (total).

[d]Includes 9.7 million tons of coal for pulverized coal injection at blast furnaces shipped to Japanese steelmakers in 1999.

[e]Coal exports from South America are projected to originate from mines in Colombia and Venezuela.

[f]In 1999, coal exports from Indonesia include shipments from other countries not modeled for the forecast period. The 1999 non-Indonesian exports by coal type were 7.2 million tons (steam coal), 1.4 million tons (coking coal), and 8.6 million tons (total).

Notes: Data exclude non-seaborne shipments of coal to Europe and Asia. Totals may not equal sum of components due to independent rounding. The sum of the columns may not equal the total, because the total includes a balancing item between importers' and exporters' data.

Sources: **1999:** International Energy Agency, *Coal Information 2000* (Paris, France, August 2000); Energy Information Administration, *Quarterly Coal Report, October-December 1999*, DOE/EIA-0121(99/4Q) (Washington, DC, April 2000). **Projections:** Energy Information Administration, *Annual Energy Outlook 2001*, DOE/EIA-0383(2001) (Washington, DC, December 2000), National Energy Modeling System run AEO2001.D101600A.

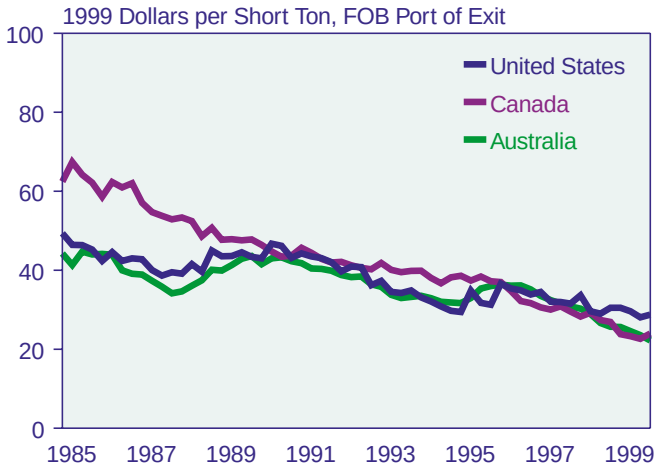
shipments of Russian and Polish coal to Europe [***45***]. Russian exporters, benefiting from a sharp decline in the ruble, were able to offer coal at a considerable discount from previous years. Canada, which relies heavily on exports of coking coal to Asian steel producers, faced a slight reduction in world coking coal demand in 1999 and strong competition from Australian producers.

A number of factors led to the 1999 drop in world coal prices, including favorable exchange rates for key exporters [***46***];[12] productivity improvements; substantial increases in coal export capacity combined with limited growth in coal imports (world coal trade increased by less than 1 percent between 1998 and 1999); aggressive price negotiations on the part of coal importers; and the acceptance of a wider range of coals (in terms of coking quality parameters) for the manufacture of coke for steelmaking. Figures 59 and 60 show FOB port-of-exit prices for steam and coking coal by quarter, as published by the International Energy Agency, in constant 1999 dollars. The figures illustrate a significant divergence in U.S. coal export prices from those of Australia and Canada since about the first quarter of 1998. Discouraged by low export prices, some U.S. coal producers idled export capacity in 1999, while others diverted some of their potential exports (both steam and coking coals) to the domestic steam coal market.

In 2000, international coal markets were affected by several factors including higher ocean freight rates, strong growth in coal import demands, a recovery in coal export prices (FOB port of exit), and a substantial increase in coal exports from China. On the transport side, ocean freight rates rose substantially in 2000, with rates for much of the year typically double those seen in 1999. The primary impacts of the higher rates were a shift in world coal trade patterns to shorter shipping routes for the year (for example, South Korea increased its take of coal from China in 2000, reducing its imports from more distant sources, such as Australia and South Africa [***47***]) and a higher delivered cost of coal imports. The short-term outlook is for shipping rates to decline to more normal levels as early as spring 2001, as a substantial amount of new shipping capacity is expected to enter the market [***48***].

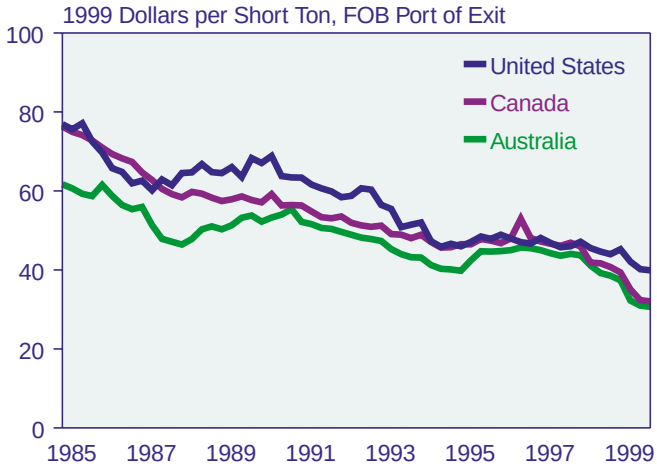
Coal export prices (FOB port of exit), the other important component of the delivered price of coal imports, leveled out in early 2000 and then increased substantially during the second half of the year. Strong growth in coal import demand and limited supplies of coal exports available to meet the additional import requirements were the key factors underlying the price recovery. For the most part, the significant growth in coal import

Figure 59. Steam Coal Export Prices by Quarter, 1985-1999



Sources: **Nominal Prices in U.S. Dollars:** International Energy Agency. **GDP Deflators:** U.S. Department of Commerce, Bureau of Economic Analysis.

Figure 60. Coking Coal Export Prices by Quarter, 1985-1999



Sources: **Nominal Prices in U.S. Dollars:** International Energy Agency. **GDP Deflators:** U.S. Department of Commerce, Bureau of Economic Analysis.

demand in 2000 was based on the commissioning of a number of new coal-fired generating units in Asia in 1999 and 2000. An additional factor contributing to coal import growth was higher oil prices, which led to substitution of coal-fired generation for oil-fired generation in some coal-importing countries.

Also noteworthy was a sharp increase in coal exports from China, from 41 million tons in 1999 to more than 50 million tons in 2000. This had been a stated goal of China's Coal Industry Ministry since the mid-1990s, but

[12]The exchange rate for the Australian dollar was US$0.64 in December 1999, 20 percent below its recent historical peak of US$0.80 in May 1996. The exchange rate for the South African Rand was US$0.16 in December 1999, 41 percent below its recent historical peak of US$0.27 in January 1996. Between August 1998 and December 1999, the Russian ruble lost 75 percent of its value compared with the U.S. dollar.

one that many industry experts did not expect to be met by 2000 [***49***]. Recent actions by the Chinese government to encourage coal exports included an increase in coal export rebates and a reduction in the export handling fees charged by China's four official coal export agencies [***50***]. Australia and South Africa also were able to increase their exports of coal substantially in 2000.

Asia

Despite setbacks that resulted from the region's financial crisis in 1998, Asia's demand for imported coal remains poised for additional increases over the forecast period, based on strong growth in electricity demand in the region. Continuing the recent historical trend, Japan, South Korea, and Taiwan are projected to account for much of the regional growth in coal imports over the forecast period.

Japan continues to be the world's leading importer of coal and is projected to account for 24 percent of total world imports in 2020 [***51***], slightly less than its 1999 share of 27 percent [***52***]. In 1999, Japan produced 4 million tons of coal for domestic consumption and imported 147 million tons. The closure of Japan's Miike mine in March 1997 left the country with two remaining underground coal mines and several small surface mines. Production at the two underground mines is expected to end when the government eliminates industry subsidies in 2001, leaving virtually all of Japan's coal requirements to be met by imports [***53***].

As the leading importer of coal, Japan has been influential in the international coal market. Historically, contract negotiations between Japan's steel mills and coking coal suppliers in Australia and Canada established a benchmark price for coal that was used later in the year as the basis for setting contract prices for steam coal used at Japanese utilities [***54***]. Other Asian markets also tended to follow the Japanese price in settling contracts.

Japan's influence has declined somewhat over the past several years, however, and the benchmark pricing system that was so influential in setting contract prices for Japan's steel mills was revised substantially in 1996. The revisions reflected a move away from a system which, in effect, averaged coal prices (with minor adjustments for quality) to a regime with a broad spectrum of prices, where high-quality coking coals received a substantial premium relative to lower quality coals [***55***].

Similar changes have occurred in the annual negotiation process between Japanese electric utilities and Australian steam coal suppliers, with a tiered pricing structure replacing a single benchmark price. To date the new pricing system has been characterized by a relatively small portion of Australia's coal shipments to Japanese utilities being priced at or slightly below a negotiated "reference" price, with the remaining tonnage priced considerably lower [***56***].[13] Liberalization of the Japanese electricity market is placing increased cost-cutting pressure on utilities, making them less concerned about long-term supply and much more focused on prices.

What seems to be occurring in the Asian coal markets is a shift away from contract purchases to the spot market. The shift to more competitive coal markets in Asia implies that coal producers in Australia and other exporting countries will be under increased pressure to reduce mining costs in order to maintain current rates of return. It also means that less competitive suppliers, such as the United States, will find it difficult to increase or maintain coal export sales to the region.

China and India, which import relatively small quantities of coal at present, are expected to account for a significant portion of the remaining increase in Asian imports. Imports by China and India have the potential to be even higher than the projected amount, but it is assumed in the forecast that domestic coal will be given first priority in meeting the large projected increase (1.6 billion tons) in coal demand. In addition, coal imports by Malaysia, the Philippines, and Thailand are also projected to rise substantially over the forecast period, primarily to satisfy demand at new coal-fired power plants. Additions to coal-fired generating capacity in these countries in 1999 and 2000 included 1,000 megawatts of new coal-fired generating capacity in Malaysia (Port Klang No. 3) and 2,040 megawatts of new coal-fired capacity in the Philippines (Sual I and II, Masinloc II, and Mauban) [***57***].

During the 1980s, Australia became the leading coal exporter in the world, primarily by meeting increased demand for steam coal in Asia. Some growth in exports of coking coal also occurred, however, as countries such as Japan began using some of Australia's semi-soft or weak coking coals in their coke oven blends. As a result, imports of hard coking coals from other countries, including the United States, were displaced. Australia's share of total world coal trade, which increased from 17 percent in 1980 to 35 percent in 1999, is projected to reach 37 percent in 2020 [***58***]. Australia should continue as the major exporter to Asia, continuing to meet approximately one-half of the region's total coal import demand.

Europe, Middle East, and Africa

Coal imports to Europe, the Middle East, and Africa taken as a whole are projected to remain relatively

[13]During Japan's fiscal year 1999 (April 1, 1999, through March 31, 2000), Australian steam coal suppliers received an average of $25.81 per ton (FOB port of exit in 1999 U.S. dollars) for coal delivered to Japan's electric utilities, 5 percent below the negotiated reference price of $27.17 per ton.

constant over the forecast period. Projected declines in overall imports to the countries of Western Europe are offset by small increases projected for Turkey, Romania, Morocco, and Israel.

In Western Europe, strong environmental lobbies and competition from natural gas are expected gradually to reduce the reliance on steam coal for electricity generation, and further improvements in the steelmaking process will continue to reduce the amount of coal required for steel production. Strict environmental standards are expected to result in the closure of some of Western Europe's older coke batteries, increasing import requirements for coal coke but reducing imports of coking coal.

Projected reductions in indigenous coal production in the United Kingdom, Germany, Spain, and France are not expected to be replaced by equivalent volumes of coal imports. Rather, increased use of natural gas, renewable energy, and nuclear power (primarily in France) is expected to fill much of the gap in energy supply left by the continuing declines in the region's indigenous coal production.

In 1999, the leading suppliers of imported coal to Europe were South Africa (26 percent), Australia (19 percent), South America (14 percent), and the United States (13 percent). Over the forecast period, low-cost coal from South America is projected to meet an increasing share of European coal import demand, displacing some coal from such higher cost suppliers as the United States and Poland.

The Americas

Compared with European and Asian coal markets, imports of coal to North and South America are relatively small, amounting to only 55 million tons in 1999 (Table 17). Canada imported 32 percent of the 1999 total, followed by Brazil (26 percent) and the United States (17 percent) [***59***]. Most (86 percent) of the imports to Brazil were coking coal [***60***], and a majority of the remaining import tonnage was steam coal used for pulverized coal injection at steel mills [***61***].

Over the *IEO2001* forecast period, coal imports to the Americas are projected to increase by 29 million tons, with most of the additional tonnage going to the United States, Mexico, and Brazil. Coal imports to the United States are projected to increase from 9 million tons in 1999 to 20 million tons by 2020 [***62***]. Coal-fired power plants in the southeastern part of the country are expected to take most of the additional import tonnage projected over the forecast period, primarily as a substitute for higher priced coal from domestic producers. Coal imports to the Brazilian steel industry are projected to rise substantially as the result of strong growth in domestic steel demand and a continuing switch from charcoal to coal coke. Mexico is projected to import additional quantities of coal for both electricity generation and steelmaking. Additional imports of coal to the Americas are projected to be met primarily by producers in Colombia and Venezuela.

Coking Coal

Historically, coking coal has dominated world coal trade, but its share has steadily declined, from 55 percent in 1980 to 36 percent in 1999 [***63***]. In the forecast, its share of world coal trade continues to shrink, to 30 percent by 2020. In absolute terms, despite a projected decline in imports by the industrialized countries, the total world trade in coking coal is projected to increase slightly over the forecast period as the result of increased demand for steel in the developing countries. Increased imports of coking coal are projected for South Korea, Taiwan, India, Brazil, and Mexico, where expansions in blast-furnace-based steel production are expected.

Factors that contribute to the decline in coking coal imports in the industrialized countries are continuing increases in steel production from electric arc furnaces (which do not use coal coke as an input) and technological improvements at blast furnaces, including greater use of pulverized coal injection equipment and higher average injection rates per ton of hot metal produced. Each ton of pulverized coal (categorized as steam coal) used in steel production displaces approximately one ton of coking coal [***64***].[14] In 1998, the direct use of pulverized coal at blast furnaces accounted for 15 and 13 percent of the coal consumed for steelmaking in the European Union and Japan, respectively [***65***].

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[14] Approximately 1.4 tons of coking coal are required to produce 1 ton of coal coke. However, according to information provided by the World Coal Institute, each ton of coal injected to the blast furnace through pulverized coal injection (PCI) equipment displaces only about 0.6 to 0.7 tons of coal coke. As a result, each ton of PCI coal displaces approximately 1 ton of coking coal. Steel companies are able to reduce their operating costs, however, because coal used for pulverized coal injection is typically less expensive than the higher quality coals required for the manufacture of coal coke.

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