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.

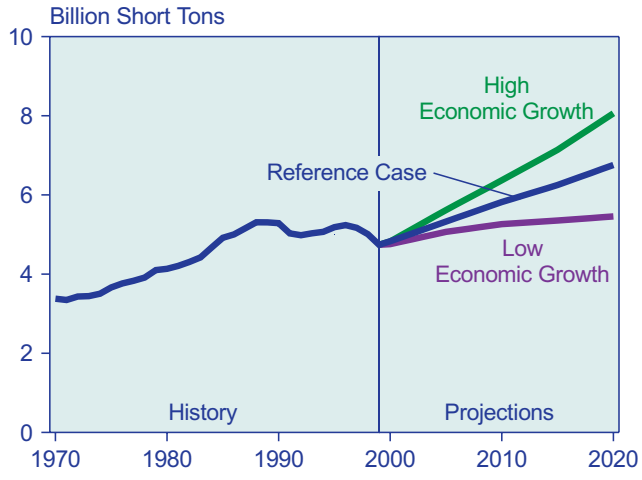
World coal consumption has been in a period of generally slow growth since the late 1980s, a trend that is expected to continue. Although 1999 world consumption, at 4.7 billion short tons,[7] was 15 percent higher than coal use in 1980, it was lower than in any year since 1984 (Figure 53). The *International Energy Outlook 2002* (*IEO2002*) reference case projects some growth in coal use between 1999 and 2020, at an average annual rate of 1.7 percent (on a tonnage basis), 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 35 percent between 1985 and 1999 (on a Btu basis), 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 48 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 *IEO2002* reference case, the coal share of total energy consumption is projected to fall to 20 percent by 2020 (Figure 54).

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 83 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 55).

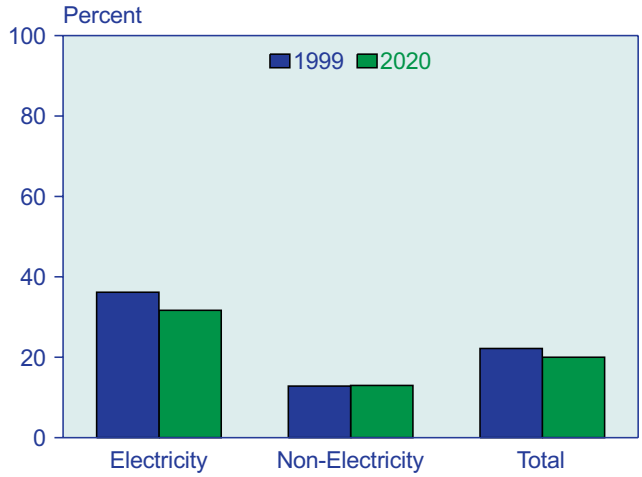
Coal consumption is heavily concentrated in the electricity generation sector, and significant amounts are also used for steel production. Almost 65 percent of the coal

Figure 53. 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, February 2001). **Projections:** EIA, World Energy Projection System (2002).

Figure 54. 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, February 2001). **2020:** EIA, World Energy Projection System (2002).

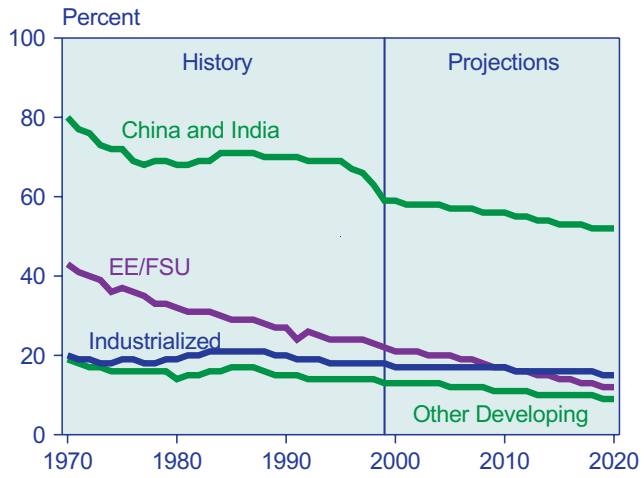
[7]Throughout this chapter, tons refers to short tons (2,000 pounds).

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 other 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 *IEO2002* 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. World coal trade grew by 55 million tons between 1999 and 2000, increasing to 604 million tons. In 2001, international coal markets were affected by a recovery in ocean shipping rates, higher coal export prices than in 1999 and 2000, and a surge in Chinese coal exports to 95 million tons, representing an increase of nearly 35 million tons over its exports in 2000.

Figure 55. 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, February 2001). **Projections:** EIA, World Energy Projection System (2002).

Highlights of the *IEO2002* projections for coal are as follows:

- World coal consumption is projected to increase by 2.0 billion tons, from 4.7 billion tons in 1999 to 6.8 billion tons in 2020. Alternative assumptions about economic growth rates lead to forecasts of world coal consumption in 2020 ranging from 5.5 to 8.1 billion tons (Figure 53).
- Coal use in developing Asia alone is projected to increase by 1.8 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 83 percent of the world's total projected increase in coal use, on a Btu basis.
- China is projected to add an estimated 100 gigawatts of new coal-fired generating capacity (333 plants of 300 megawatts each) by 2020 and India approximately 65 gigawatts (217 plants of 300 megawatts each).
- The share of coal in world total primary energy consumption is expected to decline from 22 percent in 1999 to 20 percent in 2020. The coal share of energy consumed worldwide for electricity generation is also projected to decline, from 36 percent in 1999 to 32 percent in 2020.
- World coal trade is projected to increase from 604 million tons in 1999 to 776 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). Recent studies on the health effects of mercury (Hg) 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 [***2***].

At the end of 1999, more than 280 gigawatts of coal-fired capacity around the world—approximately 36 percent of it in the United States—were equipped with FGD or other SO_2 control technologies [***3***]. 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 1999 indicated that only about 2 percent of coal-fired generating capacity (at that time, less than 4 gigawatts out of a total of 207 gigawatts) had FGD equipment in place [***4***].

In addition to sulfur dioxide, increased restrictions on emissions of nitrogen oxides, particulates, and carbon dioxide are likely, especially in the industrialized countries. 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 natural-gas-fired generating plants. For nuclear and hydropower, which compete with coal for baseload power generation, the future is unclear. Proposals have been put forth in several of the developed countries to phase out nuclear capacity in full or in large measure. In other countries, it has become difficult to site new capacity because of unfavorable public reaction. The siting of new large hydroelectric dams is also becoming more difficult because of increased environmental scrutiny. In addition, suitable sites for new large hydropower projects in the industrialized countries are limited [***5***].

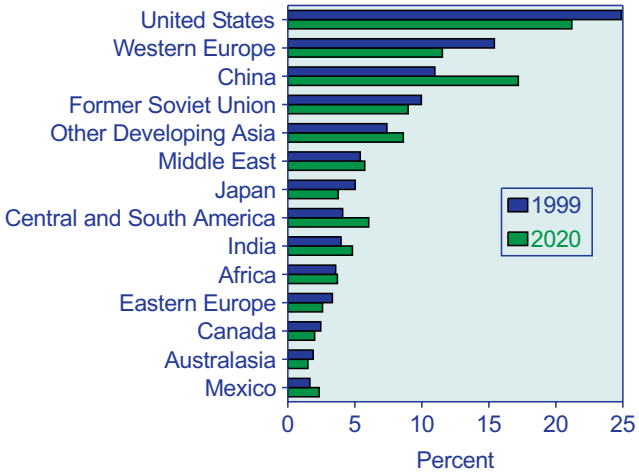
By far the most significant emerging issue for coal is the potential for a binding international agreement to reduce emissions of carbon dioxide and other greenhouse gases. On a Btu basis, the combustion of coal produces more carbon dioxide than the combustion of natural gas or of most petroleum products (combustion of petroleum coke produces slightly more carbon dioxide per unit of heat input than does combustion of coal). 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 [***6***].

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 *IEO2002* forecast to decline to 21 percent by 2020, while China's share is projected to increase to 17 percent (Figure 56). Worldwide, coal is projected to continue as the second largest source of carbon dioxide emissions (after petroleum), accounting for 31 percent of the world total in 2020.

Reserves

Total recoverable reserves of coal around the world are estimated at 1,089 billion tons[8]—enough to last

Figure 56. 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, February 2001). **2020:** EIA, World Energy Projection System (2002).

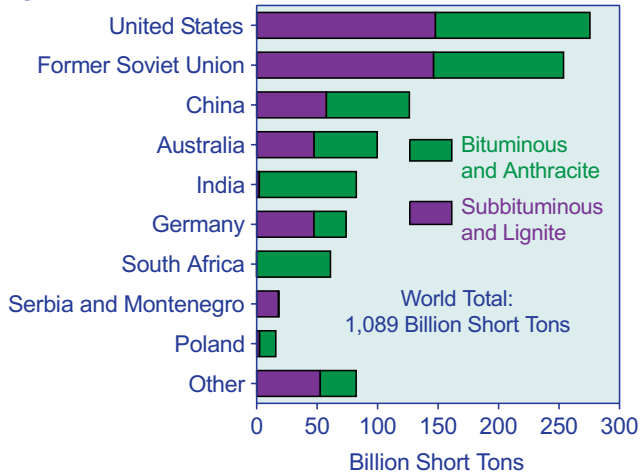
[8]Recoverable reserves are those quantities of coal which geological and engineering information indicates with reasonable certainty can be extracted in the future under existing economic and operating conditions.

approximately 230 years at current consumption levels (Figure 57). Although coal deposits are widely distributed, 60 percent of the world's recoverable reserves are located in three regions: the United States (25 percent); FSU (23 percent); and China (12 percent). Another four countries—Australia, India, Germany, and South Africa— account for an additional 29 percent. In 1999, these seven regions accounted for 80 percent of total world coal production [***7***].

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 supplied 84 percent of the coking coal traded worldwide in 2000 (see Table 16 on page 82).

At the other end of the spectrum are reserves of low-Btu lignite or "brown coal." Coal of this type is not traded to any significant extent in world markets, because of its relatively low heat content (which raises transportation costs on a Btu basis) and other problems related to transport and storage. In 1999, lignite accounted for 19 percent of total world coal production (on a tonnage basis) [***8***]. The top three producers were Germany (178 million tons), Russia (99 million tons), and the United States (84 million tons), which as a group accounted for 41 percent of the world's total lignite production in 1999. On a Btu basis, lignite deposits show considerable variation. Estimates by the International Energy Agency for coal produced in 1999 show that the average heat content of lignite from major producers in countries of the Organization for Economic Cooperation and Development (OECD) varied from a low of 4.7 million Btu per ton in Greece to a high of 12.3 million Btu per ton in Canada [***9***].

Figure 57. 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, February 2001), Table 8.2.

Regional Consumption

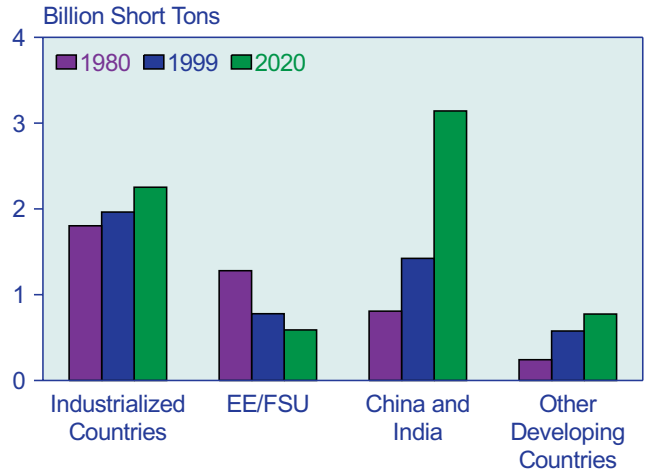
Developing Asia

The countries of developing Asia accounted for 36 percent of the world's coal consumption in 1999. Primarily as a result of substantial growth in coal consumption in China and India over the forecast period, developing Asia, taken as a whole, is projected to account for a 52-percent share of total world coal consumption by 2020.

The large increases in coal consumption projected for China and India are based on an outlook for strong economic growth (7.0 percent per year in China and 5.7 percent per year in India) and the expectation that much of the increased demand for energy will be met by coal, particularly in the industrial and electricity sectors (Figure 58). The *IEO2002* forecast assumes no significant changes in environmental policies in the two countries. It also assumes that necessary investments in the countries' mines, transportation, industrial facilities, and power plants will be made.

In China, 59 percent of the total increase in coal demand is projected to occur in the non-electricity sectors, for steam and direct heat for industrial applications (primarily in the chemical, cement, and pulp and paper industries) and for the manufacture of coal coke for input to the steelmaking process. In 1999, China was the world's leading producer of both steel and pig iron [***10***].

Figure 58. 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, February 2001). **2020:** EIA, World Energy Projection System (2002).

Coal remains the primary source of energy in China's industrial sector, primarily because China has limited reserves of oil and natural gas. In the non-electricity sectors, most of the projected increase in oil use comes from rising demand for energy for transportation. Growth in the consumption of natural gas is expected to come primarily from increased use for space heating in the residential and commercial sectors.

With a substantial portion of the increase in China's demand for both oil and natural gas projected to be met by imports, the government recently has expressed strong interest in developing a coal-to-liquids industry [***11***]. Initial plans call for the construction of several large coal-to-liquids projects over the next 10 years, with work on the first coal liquefaction plant to be initiated in the coal-rich Shanxi Province in late 2001 [***12***]. Compared with South Africa's most recently constructed coal liquefaction plant (built by SASOL at Secunda, South Africa, in 1982), which is capable of producing more than 25 million barrels of coal liquids annually, China's first plant will be relatively small, with an annual production capacity of less than 4 million barrels.

In the electricity sector in China, coal use is projected to grow by 2.2 percent a year, from 10.4 quadrillion Btu in 1999 to 16.4 quadrillion Btu in 2020. In comparison, coal consumption by electricity generators in the United States is projected to rise by 1.2 percent annually, from 19.3 quadrillion Btu in 1999 to 25.1 quadrillion Btu in 2020. One of the key implications of the substantial rise in coal use for electricity generation in China is that large financial investments in new coal-fired power plants and in the associated transmission and distribution systems will be needed. The projected growth in coal demand implies that China will need approximately 300 gigawatts of coal-fired capacity by 2020.[9] At the beginning of 1999, China had 201 gigawatts of coal-fired generating capacity [***13***].

In India, projected growth in coal demand occurs primarily in the electricity sector, which currently accounts for more than two-thirds of India's total coal consumption (see box on page 74). Coal use for electricity generation in India is projected to rise by 2.9 percent per year, from 4.5 quadrillion Btu in 1999 to 8.1 quadrillion Btu in 2020, implying that India will need approximately 125 gigawatts of coal-fired capacity in 2020. At the beginning of 1999, India's total coal-fired generating capacity amounted to 59 gigawatts [***14***].[10]

In the remaining areas of developing Asia, a considerably smaller but significant rise in coal consumption is projected over the forecast period, based on expectations for strong growth in coal-fired electricity generation in South Korea, Taiwan, and the member countries of the Association of Southeast Asian Nations (primarily, Indonesia, Malaysia, the Philippines, Thailand, and Vietnam). In the electricity sector, coal use in the other developing countries of Asia (including South Korea) is projected to rise by 3.4 percent per year, from 2.4 quadrillion Btu in 1999 to 4.9 quadrillion Btu in 2020.

The key motivation for increasing use of coal in other developing Asia is diversity of fuel supply for electricity generation [***15***]. This objective is relatively strong even in countries that have abundant reserves of natural gas, such as Thailand, Malaysia, Indonesia, and the Philippines. In the *IEO2002* forecast, coal's share of fuel consumption for electricity generation in this region is projected to remain fairly constant, decreasing from 28 percent in 1999 to 27 percent by 2020.

Some of the planned additions of coal-fired generating capacity in other developing Asia for 2002 and later include: 6,100 megawatts of new coal-fired capacity for South Korea by 2015; 5,600 megawatts for Malaysia by 2007; and 3,400 megawatts for Thailand by 2007 [***16***]. In addition to planned capacity additions, a number of new coal-fired units have come online in the region between 1999 and 2001, adding a combined total of more than 10,000 megawatts of electric power supply in South Korea (3,700 megawatts), Taiwan (3,720 megawatts), Malaysia (1,000 megawatts), and the Philippines (2,040 megawatts) [***17***]. In Indonesia, several large coal-fired plants also have been completed recently or are near completion (Paiton I, Paiton II and Tanjung Jati-B); however, power purchase agreements with Perusahlaan Umunm Listrik Negara (PLN), Indonesia's state-run utility, are still being negotiated, and power-line transmission capacity to serve the newest generating capacity has not yet been completed [***18***].

Because of environmental concerns and abundant gas reserves, there is considerable uncertainty about additions of planned coal-fired capacity in the region, particularly for countries such as Thailand and Malaysia. A number of individuals and environmental groups argue that a heavy reliance on local supplies of natural gas for electricity generation is a wiser and probably a more economical choice than constructing new coal-fired

[9]Based on the assumption that, on average, coal consumption at China's fleet of coal-fired power plants will rise to a level of 65 trillion Btu per gigawatt by 2020. Higher average utilization rates (or capacity factors) for coal plants, taken as a whole, would increase the amount of coal consumed per unit of generating capacity, while overall improvements in conversion efficiencies would have the opposite effect. In EIA's *Annual Energy Outlook 2002* reference case forecast, U.S. coal-fired power plants are projected to consume an average of 75 trillion Btu of coal per gigawatt of generating capacity in 2020, based on a projected average utilization rate of 84 percent and an average conversion efficiency 33.5 percent.

[10]Based on the assumption that, on average, coal consumption at India's coal-fired power plants will rise to a level of 65 trillion Btu per gigawatt by 2020. See previous footnote for discussion of the factors that affect the amount of coal consumed per unit of generating capacity.

A Profile of Coal in India

Energy consumption in India is dominated by coal. Coal accounts for more than one-half of the energy consumed in the country, and it is expected to remain an important part of the future fuel mix. More than two-thirds of the coal consumed in India is used in the power sector, and coal is also used for steel manufacturing and for such miscellaneous purposes as cooking in rural parts of the country (see figure below).

India has extensive coal reserves, with 80 billion short tons of recoverable anthracite and bituminous coal and 2 billion tons of recoverable lignite and subbituminous coal.[a] Its 82 billion tons of coal reserves account for about 8 percent of the world's total recoverable reserves. Most of the country's coal is subbituminous (non-coking) coal; only 2 to 3 percent is coking coal.[b] As a result, India's steel industry relies on imports of coking coal to meet between 20 and 25 percent of its annual requirements. Indian coal reserves are generally characterized as high in ash content, low in heat value, and relatively low in sulfur content.

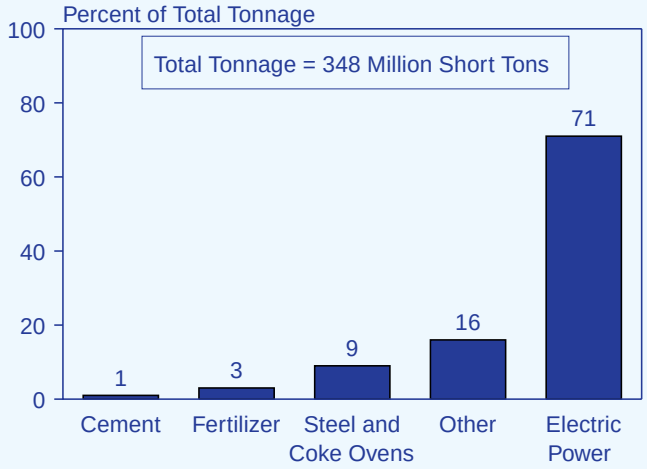
With large coal reserves and heavy use, it is not surprising that India is the third largest producer of coal worldwide. Both surface and underground mining techniques are employed in India. From 1980 to 1997, surface mining increased by a factor of 20, and surface mines currently account for 75 percent of India's total coal output. Underground mining, however, has not developed as rapidly, growing by only 0.7 percent per year from 1980 to 1997, as compared with average growth of 7.6 percent per year for surface mining.[c]

For the most part, coal reserves are located in eastern India in the states of West Bengal, Madhya Pradesh, and Orissa. Coal can also be found in Maharashtra, Uttar Pradesh, and Andhra Pradesh (see map below). The country's lignite reserves are found primarily in the Southern state of Tamil Nadu, as well as Western Gujarat, Rajastan, and Jammu Kashmir.[d]

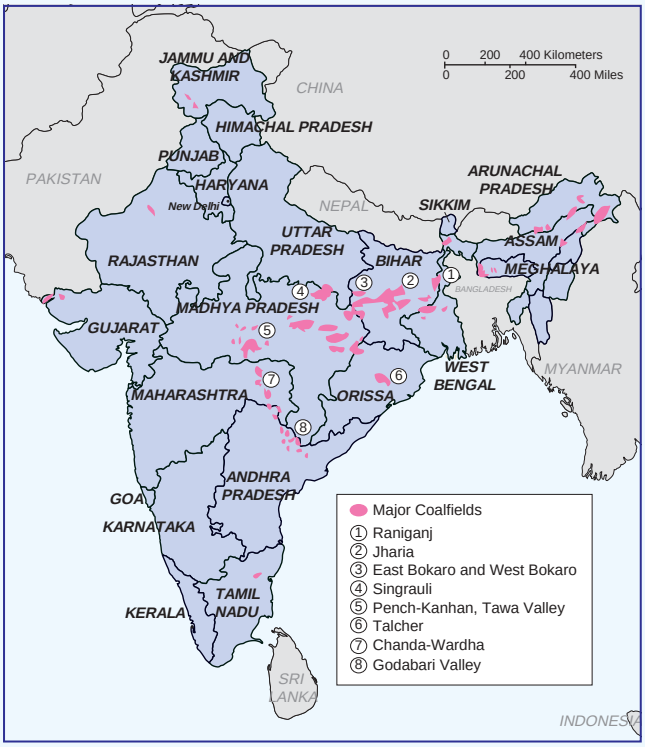
Reserves tend to be located far from the major consuming centers of the central, western, and southern parts of the country. Therefore, transport is a major concern for the Indian coal industry. Some 37 percent of India's non-coking coal is shipped to electric power plants that are located more than 600 miles from the coal mines.[e] Generally, India's coal is shipped by rail, and some is also shipped by road and water. Most commonly, coal

(continued on page 75)

Coal Consumption by End Use Sector, 2000



Source: Tata Energy Research Institute and Fesharaki Associates Consulting and Technical Services, Inc. (FACTS), *Emergence of a New Giant: India's Natural Gas Sector to 2015* (Honolulu, HI, August 2001), p. 2.11; and Energy Information Administration, *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001).



[a]Energy Information Administration, *International Energy Annual 1999*, DOE / EIA-0219(99) (Washington, DC, February 2001), p. 115.
[b]Tata Energy Research Institute, *Tata Energy Data and Directory Yearbook 1999/2000* (New Delhi, India, 1999).
[c]Tata Energy Research Institute, *Tata Energy Data and Directory Yearbook 1999/2000* (New Delhi, India, 1999).
[d]L. Clarke, S. Walker, and O. Montfort, *Coal Prospects in India*, IEAPER / 37 (London, UK: International Energy Agency Coal Research, October 1997), pp. 30-31.
[e]Tata Energy Research Institute, *Tata Energy Data and Directory Yearbook 1999/2000* (New Delhi, India, 1999).

power plants that will rely on imported fuel and produce more pollution than gas-fired plants [**19**].

Industrialized Asia

Among the Asian industrialized countries—Australia, New Zealand, and Japan—Australia is the world's leading coal exporter and Japan is the leading coal importer in the world. In 1999, Australian coal producers shipped 189 million tons of coal to international consumers, and another 141 million tons of Australian coal (both hard coal and lignite) was consumed domestically, primarily for electricity generation. Coal-fired power plants accounted for 78 percent of Australia's total electricity generating needs in 1999 [**20**]. Over the forecast horizon, coal use in Australia is expected to increase slightly. At present, Australia's Queensland district has three new coal-fired power projects in various stages of completion: Callide C power plant (840 megawatts of capacity to come online in 2001); Millmerran plant (840 megawatts of capacity to come online in 2002); and Tarong Power plant (450 megawatts scheduled for 2003) [**21**].

Japan, which is the third largest coal user in Asia and the eighth largest globally, imports most all the coal it consumes, much of it originating from Australia [**22**]. Japan's last two underground coal mines, Ikeshima with an annual production capacity of 1.1 million tons and Taiheiyo with a capacity of 2.2 million tons, were closed in late 2001 and early 2002 [**23**]. Currently, slightly more than one-half of the coal consumed in Japan is used by the country's steel industry (Japan is the world's second largest producer of both crude steel and pig iron) [**24**]. Coal is also used heavily in the Japanese power sector, and coal plants currently generate more than 20 percent of the country's electricity supply [**25**]. In 1999, Japanese power producers consumed 65 million tons of coal,

A Profile of Coal in India (Continued)

is shipped by rail to eastern ports, from which it is then shipped by water to southern destinations. There are 11 ports managed by the Port Trust of India, with Haldia, Vishakapatnam, and Paradip the most important eastern ports. Recently, private-sector participation was invited to develop and build additions to existing port facilities.

The coal industry in India is largely held in the public sector. The Ministry of Coal is the public entity that sets "policies and strategies for exploration and development," for the country's coal mines.[f] Coal India, Ltd. (CIL) acts as the holding company and has eight fully-owned subsidiaries. CIL owns 90 percent of total coal production in India and 97 percent of the coalfields. Four major subsidiaries of CIL are Bharat Coking Coal Ltd. (BCCL), Western Coalfields Ltd. (WCL), South Eastern Coalfields Ltd. (SECL), and Northern Coalfields Ltd. (NCL).[g] The coal industry was largely private until the 1970s, when it was nationalized to plan for growing industrial needs and equitable distribution of the country's coal resources. India's coal industry was nationalized in two stages: coking-coal mines in 1971 and other coal mines in 1973.[h] Only coal mines captive to steel mines were not part of the nationalization process.

Eventually, dissatisfaction arose between the coal industry and electric power industry. Disputes concerned the quality and quantity of coal delivered to electric utilities, as well as disputes about payment for the coal. Several other issues also plagued the coal industry, such as the lack of mechanization of certain processes, monopolistic construct of the coal industry, and the lack of State Electricity Board (SEB) funds.[i] To address some of these issues, an agreement was drawn up in 1977. Since then, there has been intermittent acceptance and adherence to that agreement. In 1998, the Indian Council of Power Utilities drafted a new agreement that was circulated to all the utilities as the model agreement. Some SEBs entered into this agreement with CIL, but others have not.

Environmental issues are also increasingly important in India, and they have begun to affect the coal industry. One of the defining characteristics of Indian coal is its high ash content, which increases the amount of pollutants released when it is burned. The ash content can be reduced before use through a benefication or washing process. Washing plants for coking coal exist, but many are old and low in unit capacity. In an attempt to lessen the pollutants emitted by burning coal, the Ministry of Environment and Forestry decreed that as of June 1, 2001, all coal supplied to power plants located further than 620 miles from the coal fields, or those located in critically polluted and sensitive urban areas, must have an ash content of no more than 34 percent.[j]

[f]India Ministry of Coal, "Aboust Us," web site http://coal.nic.in/vscoal/sub1.html (not dated).
[g]M. Kulshreshtha and J.K. Parikh, "A Study of Productivity in the Indian Coal Sector," *Energy Policy*, Vol. 29, No. 9 (July 2001) pp. 701-713.
[h]"Making Arrangements To Supply Coal," web site www.terrin.org/energy/coal.htm (April 2001).
[i]"Making Arrangements To Supply Coal," web site www.terrin.org/energy/coal.htm (April 2001).
[j]Mining India, "Clamp on Use of Raw Coal in Thermal Power Plants," web site www.miningindia.com/writeups/798/24.htm (not dated).

representing 42 percent of the country's total coal consumption [***26***]. Japanese power companies plan to construct an additional 16 gigawatts of new coal-fired generating capacity between 2001 and 2010 [***27***].

Western Europe

In Western Europe, environmental concerns play an important role in the competition among coal, natural gas, and nuclear power. Recently, other fuels—particularly natural gas—have been gaining economic advantage over coal. Coal consumption in Western Europe has decreased by 39 percent over the past 9 years, from 894 million tons in 1990 to 546 million tons in 1999. The decline was smaller on a Btu basis, at 32 percent, reflecting the fact that much of it resulted from reduced consumption of low-Btu lignite in Germany.

Over the forecast period, Western European coal consumption is projected to decline by an additional 23 percent (on a Btu basis), reflecting a slower rate of decline than was experienced during the previous decade. Factors contributing to further cutbacks in coal consumption include further penetration of natural gas for electricity generation, environmental concerns, and continuing pressure on member countries of the European Union to reduce subsidies that support domestic production of hard coal.

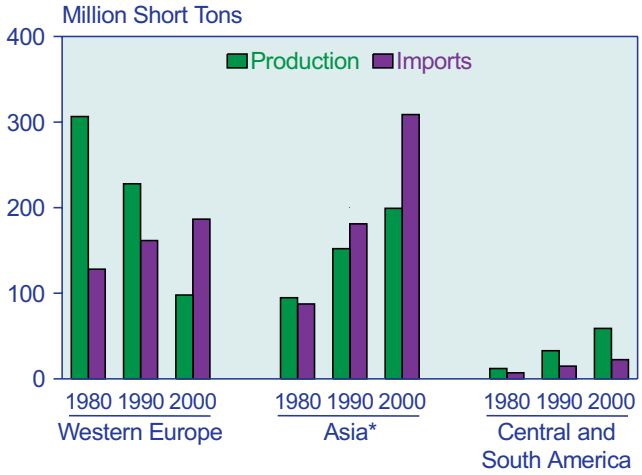
The current set of guidelines for state aid to the European coal industry (Commission Decision No. 3632/93/ECSC of December 28, 1993) is set to expire on July 23, 2002, coinciding with the expiration date of the 50-year European Coal and Steel Community Treaty of 1951. In light of these pending expiration dates, the European Commission has proposed that a new state aid scheme for coal be established to allow for the continuation of subsidies for hard coal production in member states through December 31, 2010 [***28***]. In essence, the Commission wants to establish measures that will promote the development of renewable energy sources as well as maintain a minimum capacity of subsidized coal production in the European Union for the purpose of establishing an "indigenous primary energy base." Under this new scheme, the guiding principle for coal will be that subsidized production will be limited to that which is strictly necessary for enhancing the security of energy supply (i.e., to maintain access to coal reserves, keep equipment in an operational state, preserve the professional qualifications of a nucleus of coal miners, and safeguard technological expertise).

The recent trend in the consumption of hard coal[11] in Western Europe is closely correlated with the trend in the production of hard coal, primarily because coal imports have increased by much less than production has declined (Figure 59). Following the closure of the last remaining coal mines in Belgium in 1992 and Portugal in 1994, only four member States of the European Union (the United Kingdom, Germany, Spain, and France) continue to produce hard coal [***29***], and all have seen their output of hard coal decline since 1990. In the near future, the proposed enlargement of the European Union would add two additional producers of hard coal, Poland and the Czech Republic [***30***].

Hard coal production in the United Kingdom decreased from 104 million tons in 1990 to 40 million tons in 1999, a decline of 64 million tons [***31***]. During the same period, coal consumption fell by 53 million tons. Most of the decline in coal consumption resulted from privatization in the electricity sector, which led to a rapid increase in natural-gas-fired generation at the expense of coal.

The massive switch to natural gas and its adverse impact on the country's coal industry prompted the British government, in mid-1998, to place a moratorium on the construction of new gas-fired plants and, at the same time, request that a study be completed to assess the state of the country's electric power industry [***32***]. The two key issues to be investigated were the design, operation, and structure of the country's wholesale electricity market and the diversity and security of fuel supplies for electricity generation. As a result of the study, revisions in the setup of the country's wholesale electricity market

Figure 59. Production and Imports of Hard Coal by Region, 1980, 1990, and 2000



*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.

[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 the Energy Information Administration, subbituminous coal production is included in the bituminous category.

were introduced, primarily aimed at getting generators to price their electricity more competitively. The revised electricity market, referred to as the New Electricity Trading Arrangements (NETA), went into effect on March 27, 2001, and the moratorium on the construction of new gas-fired generating plants was lifted in November 2000 [***33***]. Although the impact of the NETA measures on Britain's coal-fired generation is not yet known, they are generally seen as an improvement over the country's previous wholesale electricity market (the Electricity Pool). The lifting of the moratorium on the construction of new gas plants, however, opened the door for the planned construction of six new combined-cycle gas plants (representing 4.8 gigawatts of capacity), whose output will likely compete with generation from the country's existing coal-fired plants [***34***].

Currently, the United Kingdom's remaining coal mines are by far the most productive hard coal operations in Western Europe. Substantial improvements in the country's mining operations in recent years have led to an increase in average labor productivity from 1,190 tons per miner-year in 1990 to 3,200 tons per miner-year in 1999 [***35***]. Despite this achievement, the price of coal from domestic mines is essentially at parity with the price of coal imports, and it is likely that production from domestic mines will continue to be sensitive to changes in international coal prices [***36***]. In fact, following several years of sharp declines in international coal prices in 1998 and 1999, the UK government reinstated coal production subsidies for 2000 through 2002 in an effort to protect the country's remaining coal operations (Table 15) [***37***].

In Germany, Spain, and France, subsidies continue to support the domestic production of hard coal,[12] even though there is no hope that their production will ever be competitive with imports. For 2000, the European Commission authorized coal industry subsidies of $4,245 million in Germany, $1,035 million in Spain, and $933 million in France. In each of the three countries, the average subsidy per ton of coal produced exceeds the average value of imported coal (Table 15), and all three are currently taking steps to reduce subsidy payments, acknowledging that some losses in coal production are inevitable.

Germany's hard coal production declined from 86 million tons in 1990 to 48 million tons in 1999 [***38***]. In March 1997, the federal government, the mining industry, and the unions reached an agreement on the future structure of subsidies to the German hard coal industry. At that time, the agreement called for the closure of 8 to 9 of Germany's 19 operating hard coal mines, leading to an estimated decline in production to 33 million tons by 2005 [***39***]. The closure of three coal mines in 2000 (with a combined production capacity of approximately 8.3 million tons) left Germany with 12 operating hard coal mines at the end of the year [***40***].

Between 1990 and 1999, German lignite production declined by 242 million tons, primarily as a result of massive substitution of natural gas for both lignite and lignite-based "town gas"[13] in the eastern states following reunification in 1990 [***41***]. The collapse of industrial output in the eastern states during this period also was a contributing factor. In the *IEO2002* 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 projected to be 219 million tons, a drop of 39 million tons from the 1999 level of 258 million tons.

In Spain, hard coal production declined from 22 million tons in 1990 to 17 million tons in 1999 [***42***]. Spain has adopted a restructuring plan for 1998 through 2005 that provides for a gradual decline in production to 12 million tons [***43***]. In addition to hard coal, two lignite mines in Spain, which produced 10 million tons in 1999, are earmarked for closure within the next 3 to 4 years [***44***].

Table 15. Western European Coal Industry Subsidies, Production, and Import Prices, 2000

Country	Coal Industry Subsidies (Million 2000 U.S. Dollars)	Hard Coal Production (Million Tons)	Average Subsidy per Ton of Coal Produced (2000 U.S. Dollars)	Average Price per Ton of Coal Imported (2000 U.S. Dollars)
Germany	4,245	40.4	105	32
Spain	1,035	16.4	63	32
France	933	4.9	192	36
United Kingdom	132	35.3	4	38

Sources: **Coal Production Subsidies:** Commission of the European Communities, *Proposal for a Council Regulation on State Aid to the Coal Industry* (Brussels, Belgium, July 25, 2001), p. 28, web site www.europa.eu.int; and U.S. Federal Reserve Bank, "Foreign Exchange Rates (Annual)," web site www.bogfrb.fed.us (January 9, 2001). **Production:** Energy Information Administration, Office of Energy Markets and End Use, International Statistics Database. **Average Price of Coal Imports:** International Energy Agency, *Coal Information 2001* (Paris, France, September 2001).

[12] In Spain, subsidies support the production of both hard coal and subbituminous coal.

[13] "Town gas" (or "coal gas"), a substitute for natural gas, is produced synthetically by the chemical reduction of coal at a coal gasification facility.

Currently, the two generating plants that burn the lignite produced by the mines also rely partly on imports of subbitumnous coal. Both plants are expected to increase their take of imported coal over the forecast, as lignite production from the two mines is ramped down.

In France, production of hard coal declined from 12 million tons in 1990 to 6 million tons in 1999 [***45***]. A modernization, rationalization, and restructuring plan submitted by the French government to the European Commission at the end of 1994 foresees the closure of all coal mines in France by 2005 [***46***]. The coal industry restructuring plan was based on a "Coal Agreement" between France's state-run coal company, Charbonnages de France, and the coal trade unions.

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 are expected to reduce coal use over the forecast period. The government of Denmark has stated that its goal is to eliminate coal-fired generation by 2030 [***47***]. In 1999, 51 percent of Denmark's electricity was supplied by coal-fired plants [***48***]. Coal consumption in Italy is projected to remain relatively flat in the *IEO2002* forecast.

Partly 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 [***49***].

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 597 million tons since 1990, 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 *IEO2002* reference case, coal's share of total EE/FSU energy consumption is projected to decline from 22 percent in 1999 to 12 percent in 2020, and the natural gas share is projected to increase from 45 percent in 1999 to 50 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. Between 1990 and 1999, coal production declined by 151 million tons (37 percent) in Russia, by 91 million tons (51 percent) in Ukraine, and by 64 million tons (56 percent) in Kazakhstan [***50***]. While both Kazakhstan and Russia have shown considerable progress in terms of closing uneconomical mining operations and in selling government-run mining operations to the private sector, Ukraine has made considerably less progress in its restructuring efforts. In Kazakhstan, many of the 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 [***51***]. In Russia, the World Bank estimates that 77 percent of the country's coal production in 2001 will originate from mines not owned by the government, and that percentage is expected to increase to 90 percent by the end of 2002 [***52***].

In Ukraine, a coal restructuring program initiated by the government in 1996, with advice and financial support provided by the World Bank, has been mostly unsuccessful at rejuvenating the industry. Key problems that continue to plague the Ukrainian coal industry are : (1) most of the country's mines continue to be highly subsidized, government-run enterprises; (2) dangerous working conditions prevail (several catastrophic mine disasters have occurred in the past several years); (3) wage arrears continue to be a serious problem, with miners currently owed back wages of approximately $3.5 billion; (4) productivity is very low due to antiquated mining equipment and the extreme depths at which coal is extracted (only three of Ukraine's active coal mines are surface operations); and (5) nonpayment for coal by customers is rampant [***53***].

The World Bank has focused its efforts in Ukraine on trying to convince the government that it needs to close additional unprofitable mines [***54***]. In 2001, a spokesperson for the World Bank expressed his belief that an additional 50 to 60 of the country's remaining coal mines need to be closed [***55***]. On the other hand, others indicate that problems with the Ukrainian coal industry will not be solved simply through the closure of the least economical mines. They point to delays in privatization of coal mining operations, the existence of widespread corruption and abuse in the coal sector, worsening geological conditions, and misdirection of government subsidies (e.g., not enough of the government subsidies have been directed toward equipment upgrades at existing mines).

Recent data showing a slight resurgence in coal production in the FSU since 1998, particularly in Russia and Kazakhstan, in combination with draft energy strategies for Russia and Ukraine, indicate an optimistic long-term

outlook for both coal production and consumption [**56**]. The *IEO2002* outlook for FSU coal consumption, however, indicates only slight positive growth between 1999 and 2005 with a declining trend thereafter. Natural gas and oil are expected to fuel most of the projected increase in energy consumption for the region.

In Eastern Europe, Poland is the largest producer and consumer of coal; in fact, it is the second largest coal producer and consumer in all of Europe, outranked only by Germany [**57**]. In 1999, coal consumption in Poland totaled 164 million tons, 45 percent of Eastern Europe's total coal consumption for the year [**58**]. Poland's hard coal industry produced 123 million tons in 1999, and lignite producers contributed an additional 67 million tons. Coal consumption in other Eastern European countries is dominated by the use of low-Btu subbituminous coal and lignite produced from local reserves. The region, taken as a whole, relies heavily on local production, with seaborne imports of coal to the region summing to less than 6 million tons in 1999 [**59**].

In 2001 Poland's hard coal industry operated at a slight loss, but it is expected to operate in the black in 2002 [**60**]. 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 most recent plan was announced by Poland's Ministry of the Economy in March 1998. It called for the closure of 24 of the country's 50 unprofitable mines over the next 4 years, reducing the total number of mines in Poland from 65 in 1998 to 41 by 2002. In addition, the restructuring plan aims to reduce the number of miners by one-half, from 245,000 in 1998 to 128,000 by 2002 [**61**]. The Polish government projects that sales of hard coal from domestic mines will decline from 100 million tons in 1998 to 77 million tons by 2020. As of August 2001, the World Bank had approved a total of $400 million in hard coal sector adjustment loans in support of the Polish government's restructuring program [**62**].

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 1,365 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 46 percent in 2020 [**63**]. To a large extent, EIA's projections of declines in both minemouth coal prices and coal transportation rates are the basis for the expectation that coal will continue to compete as a fuel for U.S. power generation. Increases in coal-fired generation are projected to result from both greater utilization of U.S. coal-fired generating capacity and the addition of 31 gigawatts of new coal-fired power plants by 2020. Over the forecast period, the average utilization rate of coal-fired generating capacity is projected to rise from 68 percent in 1999 to 84 percent by 2020.

In Canada, coal consumption accounted for approximately 12 percent of total energy consumption in 1999 and is projected to more or less maintain that share over the forecast period. In the near term, the restart of six of Canada's nuclear generating units (four at the Ontario Power's Pickering A plant and two at Bruce Power's Bruce A plant) over the next few years is expected to restrain the need for coal in eastern Canada, while increased demand for electricity in western Canada is expected to result in the need for some additional coal-fired generation there [**64**]. Fording, Inc., Canada's lead exporter of metallurgical grade coal, is currently exploring the possibility of building a new 1,000-megawatt coal-fired generation plant in the Province of Alberta, approximately 110 miles southeast of Calgary [**65**].

Mexico consumed 13 million tons of coal in 1999. Two coal-fired generating plants, Rio Escondido and Carbon II, 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 [**66**]. In addition, CFE is currently in the process of switching its six-unit, 2,100 megawatt Petacalco plant, located on the Pacific coast, from oil to coal. The utility estimates that the plant will require more than 5 million tons of imported coal annually. During 2001, CFE awarded a contract for 3.3 million tons of Chinese coal for delivery over a 6-month period ending April 2002 [**67**]. A coal import facility adjacent to the plant, with an annual throughput capacity of more than 9 million tons, serves both the power plant and a nearby integrated steel mill [**68**].

While natural gas is expected to fuel most new generating capacity to be built in Mexico over the *IEO2002* forecast period, some new coal-fired generation is also expected. Several manufacturing companies, such as Kimberly Clark and steelmakers Ispat and Altos Hornos de Mexico, are exploring the possibility of constructing some coal-fired plants near their production facilities [**69**]. The plants would be developed under Mexico's new self-supply provisions, which allow private power producers and large industrials the option of bypassing state-owned CFE as long as the industrial end users hold equity stakes in the projects [**70**]. In addition, based on authorization granted by the government's energy authority in 2001, the CFE is considering the possibility of constructing a new coal-fired plant on Mexico's Pacific coast [**71**].

Africa

Africa's 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 [***72***]. Ranked third in the world in coal exports since the mid-1980s (behind Australia and the United States), South Africa moved up a notch 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 17 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 one-fourth of all liquid fuels consumed in South Africa [***73***].

For Africa as a whole, coal consumption is projected to increase by 35 million tons between 1999 and 2020, primarily to meet increased demand for electricity, which is projected to increase at a rate of 3.6 percent per year. 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.

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 [***74***]. In Nigeria, several initiatives to increase the use of coal for electricity generation have been proposed, including the possible rehabilitation of the Oji River and Markurdi coal-fired power stations and tentative plans to construct a large new coal-fired power plant in southeastern Nigeria [***75***]. Also, Tanzania may move ahead on plans to construct a large coal-fired power plant. The new plant would help to improve the reliability of the country's power supply, which at present relies heavily on hydroelectric generation, and would promote increased use of the country's indigenous coal supply [***76***].

A recently completed coal project in Africa was the commissioning of a fourth coal-fired unit at Morocco's Jorf Lasfar plant in 2001. With a total generating capacity or 1,356 megawatts, this plant accounts for more than one-half of Morocco's total electricity supply and is the largest independent power project in Africa and the Middle East [***77***].

Central and South America

Historically, coal has not been a major source of energy in Central and South America. In 1999, coal accounted for about 5 percent of the region's total energy consumption, and in years past its share has never exceeded 6 percent. 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 (on a tonnage basis), with Colombia, Chile, Argentina, and to a lesser extent Peru accounting for much of the remainder [***78***]. The steel industry in Brazil accounts for more than 75 percent of the country's total coal consumption, relying on imports of coking coal to produce coke for use in blast furnaces [***79***].

In the forecast, Brazil accounts for most of the growth in coal consumption projected for the region, with increased use of coal expected for both steelmaking (both coking coal and coal for pulverized coal injection) and electricity production. With demand for electricity approaching the capacity of Brazil's hydroelectric plants, the government recently introduced a program aimed at increasing the share of fossil-fired electricity generation in the country, primarily promoting the construction of new natural-gas-fired capacity. The plan also includes several new coal-fired plants to be built near domestic coal deposits [***80***]. In addition, serious consideration is being given to the construction of a large coal-fired power plant at the port of Sepetiba, to be fueled by imported coal [***81***].

In Puerto Rico, the construction of a new coal-fired power plant is underway as part of a long-range plan to reduce the country's dependence on oil for electricity generation [***82***]. The 454-megawatt circulating fluidized bed (CFB) plant will require approximately 1.5 million tons of imported coal annually [***83***].

Middle East

Turkey accounts for almost 90 percent of the coal consumed in the Middle East. In 1999, Turkish coal consumption reached 84 million tons, most of it low-Btu, locally produced lignite (approximately 6.8 million Btu per ton) [***84***]. Over the forecast period, coal consumption (both lignite and hard coal) is projected to increase by 20 million tons, primarily to fuel additional coal-fired generating capacity. Two projects currently in the construction phase include a 1,210-megawatt hard-coal-fired plant being built on the southern coast of Turkey near Iskenderun, to be fueled by imported coal, and a 1,440-megawatt lignite-fired plant (Afsin-Elbistan B plant) being built in the lignite-rich Afsin-Elbistan region in southern Turkey [***85***]. When completed between 2003 and 2005, the two plants could add more than 10 million tons to Turkey's annual coal consumption.

Israel, which consumed 10 million tons of coal in 1999, accounts for most of the remaining coal use in the Middle East. In the near term, Israel's coal consumption is

projected to rise by approximately 3 million tons attributable to the completion of two new 575-megawatt coal-fired units at Israel Electric Corporation's Rutenberg plant in 2000 and 2001 [***86***]. Based on plans to complete an additional 1,200 megawatts of coal-fired generating capacity at the Rutenberg site in 2007 and 2008, additional growth in Israel's coal consumption is projected [***87***]. Some environmental groups and government officials in Israel are opposed to the recent go-ahead given to Israel Electric to construct additional coal plants, arguing that sufficient supplies of natural gas from both local and Egyptian sources will be available for electricity generation later in the decade.

Trade

Overview

The amount of coal traded in international markets is small in comparison with total world consumption. In 2000, world imports of coal amounted to 604 million tons (Figure 60 and Table 16), representing 13 percent of total consumption. By 2020, coal imports are projected to rise to 776 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.

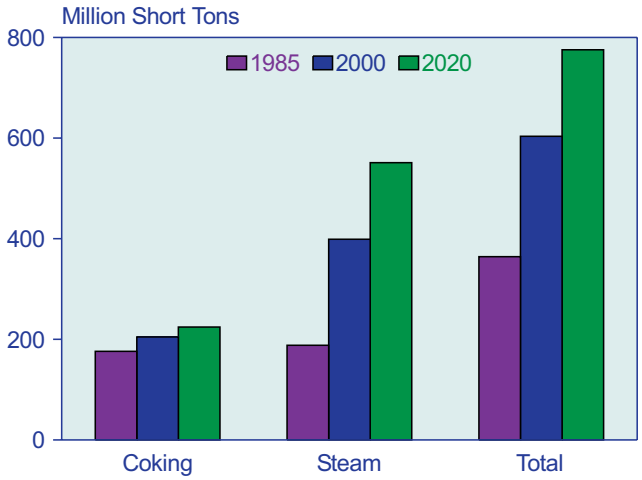
In recent years, international coal trade has been characterized by relatively stable demand for coal imports in Western Europe and expanding demand in Asia (Figure 59). Rising production costs in the indigenous coal industries in Western Europe, combined with continuing pressure to reduce industry subsidies, have led to substantial declines in production there, creating the potential for significant increases in coal imports; however, 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 2000 and 2001, international coal markets have undergone some significant changes on both the supply and demand side. In 2000, international coal markets were affected by several factors, including higher ocean freight rates, strong growth in coal import demand, a recovery in coal export prices (FOB port of exit) late in the year, 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 [***88***]) and a higher delivered cost of coal imports. On the demand side, world coal trade rose substantially, increasing from 548 million tons in 1999 to 604 million tons in 2000.

The year 2001 was marked by continuing growth in coal import demand, further recovery in coal export prices from historical lows reached in 1999 and early 2000, a continuation of favorable exchange rates vis-a-vis the U.S. dollar for several key exporting countries [***89***],[14] and a continuing surge in coal exports from China. One key difference between 2000 and 2001 was a return to much lower coal transportation rates in 2001, increasing the competitiveness of longer range shipments such as exports of Australian coal to Western Europe [***90***].

Between 1998 and 2000 coal exports from China expanded by 67 percent, from 36 million tons in 1998 to 41 million tons in 1999 and 60 million tons in 2000. Preliminary data indicate that China exported 95 million tons of coal during 2001 [***91***], making it the second leading coal export country in the world, ahead of South Africa and Indonesia. The United States, which was the

Figure 60. World Coal Trade, 1985, 2000, and 2020



Sources: **1985:** Energy Information Administration (EIA), *Annual Prospects for World Coal Trade 1987*, DOE/EIA-0363(87) (Washington, DC, May 1987). **2000:** International Energy Agency, *Coal Information 2001* (Paris, France, September 2001); Energy Information Administration, *Quarterly Coal Report, October-December 2000*, DOE/EIA-0121(2000/4Q) (Washington, DC, May 2001). **2020:** Energy Information Administration, National Energy Modeling System run IEO2002.D011402A (January 2002).

[14]The exchange rate for the Australian dollar was US$0.51 in December 2001, 36 percent below its recent historical peak of US$0.80 in May 1996. The exchange rate for the South African Rand was US$0.09 in December 2001, 67 percent below its recent historical peak of US$0.27 in January 1996. Between August 1998 and November 2001, the Russian ruble lost 77 percent of its value compared with the U.S. dollar.

Table 16. World Coal Flows by Importing and Exporting Regions, Reference Case, 2000, 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]
	2000											
Australia	13.8	83.2	2.3	**96.7**	25.7	76.2	6.6	**109.1**	39.5	159.4	8.9	**205.8**
United States	5.8	4.3	15.4	**25.6**	21.6	2.3	8.9	**32.8**	27.4	6.6	24.3	**58.4**
South Africa	55.6	14.4	1.3	**74.3**	0.4	0.3	1.0	**2.8**	56.0	14.7	2.3	**77.1**
Former Soviet Union	18.4	6.0	0.1	**23.3**	3.1	3.7	0.0	**8.0**	21.5	9.7	0.1	**31.3**
Poland	15.7	0.0	0.0	**14.6**	3.3	0.0	0.1	**3.0**	19.0	0.0	0.1	**17.6**
Canada	0.3	3.3	0.7	**5.1**	8.2	19.3	3.6	**32.8**	8.5	22.6	4.3	**37.9**
China	3.2	53.8	0.2	**53.0**	0.3	7.1	0.0	**7.4**	3.5	60.9	0.2	**60.4**
South America[e]	30.4	0.0	15.0	**46.4**	0.4	0.1	0.1	**0.7**	30.8	0.1	15.1	**47.1**
Indonesia[f]	4.5	46.5	2.4	**59.8**	0.5	10.6	0.0	**11.2**	5.0	57.1	2.4	**71.0**
Total	**147.7**	**211.5**	**37.5**	**398.8**	**63.5**	**119.6**	**20.4**	**204.7**	**211.2**	**331.1**	**57.9**	**603.5**
	2010											
Australia	10.0	108.2	0.7	**118.8**	35.6	85.5	8.0	**129.1**	45.6	193.7	8.7	**247.9**
United States	3.1	6.7	8.6	**18.4**	13.4	1.3	15.5	**30.2**	16.5	8.0	24.2	**48.7**
South Africa	70.5	8.2	4.4	**83.0**	1.1	0.5	0.0	**1.7**	71.6	8.7	4.4	**84.7**
Former Soviet Union	19.6	6.1	0.0	**25.6**	3.0	4.3	0.0	**7.3**	22.5	10.4	0.0	**32.9**
Poland	8.0	0.0	0.0	**8.0**	1.1	0.0	0.0	**1.1**	9.1	0.0	0.0	**9.1**
Canada	5.0	0.0	0.0	**5.0**	6.9	13.8	3.3	**24.0**	11.9	13.8	3.3	**29.0**
China	0.0	113.5	0.0	**113.5**	0.0	12.4	0.0	**12.4**	0.0	125.9	0.0	**125.9**
South America[e]	36.4	0.0	34.8	**71.2**	0.0	0.0	0.0	**0.0**	36.4	0.0	34.8	**71.2**
Indonesia[f]	7.6	65.9	0.0	**73.5**	0.5	9.1	0.0	**9.6**	8.1	75.0	0.0	**83.1**
Total	**160.3**	**308.5**	**48.4**	**517.2**	**61.6**	**126.9**	**26.8**	**215.3**	**221.9**	**435.5**	**75.2**	**732.6**
	2020											
Australia	9.3	112.7	0.7	**122.7**	35.8	89.7	12.4	**137.9**	45.1	202.4	13.1	**260.6**
United States	1.9	7.5	7.2	**16.6**	12.1	1.4	18.1	**31.7**	14.1	8.9	25.3	**48.3**
South Africa	67.7	17.0	4.3	**89.0**	0.9	0.6	0.0	**1.5**	68.6	17.6	4.3	**90.5**
Former Soviet Union	16.1	7.2	0.0	**23.3**	3.0	4.7	0.0	**7.7**	19.1	11.9	0.0	**31.0**
Poland	5.5	0.0	0.0	**5.5**	1.1	0.0	0.0	**1.1**	6.6	0.0	0.0	**6.6**
Canada	2.9	0.0	0.0	**2.9**	6.8	14.0	1.7	**22.5**	9.7	14.0	1.7	**25.4**
China	0.0	121.3	0.0	**121.3**	0.0	12.4	0.0	**12.4**	0.0	133.6	0.0	**133.6**
South America[e]	50.0	0.0	36.1	**86.1**	0.0	0.0	0.0	**0.0**	50.0	0.0	36.1	**86.1**
Indonesia[f]	0.0	83.8	0.0	**83.8**	0.4	9.2	0.0	**9.6**	0.4	93.0	0.0	**93.4**
Total	**153.4**	**349.4**	**48.3**	**551.1**	**60.2**	**132.1**	**32.2**	**224.4**	**213.6**	**481.4**	**80.5**	**775.5**

[a]Reported data for 2000 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 2000, total world coal flows include a balancing item used by the International Energy Agency to reconcile discrepancies between reported exports and imports. The 2000 balancing items by coal type were 2.1 million tons (steam coal), 1.2 million tons (coking coal), and 3.3 million tons (total).

[d]Includes 14.4 million tons of coal for pulverized coal injection at blast furnaces shipped to Japanese steelmakers in 2000.

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

[f]In 2000, coal exports from Indonesia include shipments from other countries not modeled for the forecast period. The 2000 non-Indonesian exports by coal type were 6.2 million tons (steam coal), 1.5 million tons (coking coal), and 7.7 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: **2000:** International Energy Agency, *Coal Information 2001* (Paris, France, September 2001); Energy Information Administration, *Quarterly Coal Report, October-December 2000*, DOE/EIA-0121(2000/4Q) (Washington, DC, May 2001). **Projections:** Energy Information Administration, National Energy Modeling System run IEO2002.D011402A (January 2002).

second largest coal exporter from 1984 through 1998, was surpassed by South Africa and Indonesia in 1999 and by China in 2000.

Recent actions by the Chinese government to encourage coal exports include an increase in coal export rebates and a reduction in the export handling fees charged by China's four official coal export agencies [***92***]. China's 10th Five-Year Plan envisions that coal exports will exceed 110 million tons by 2005 [***93***].

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, slightly less than its 2000 share of 27 percent [***94***]. In 2000, Japan produced just over 3 million tons of coal for domestic consumption and imported 160 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 [***95***]. The last two underground mines, Ikeshima and Taiheiyo, were closed in late 2001 and early 2002, respectfully, leaving virtually all of Japan's coal requirements to be met by imports [***96***].

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 [***97***]. 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 [***98***].

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. Through 2000, the new pricing system was 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 [***99***]. The more recent environment of high spot prices for coal in 2001, however, has made the current reference pricing system for coal considerably less attractive to Japanese electricity producers, as they are essentially having to pay prices that are higher than the negotiated "reference price" for much of their purchased tonnage. As a result, Japan's Chubu Electric Power Company has been exploring alternative pricing schemes—reportedly trying to find the best way to minimize the average annual price they pay for coal [***100***].

In essence, 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 projected, 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. Diversification of fuel supply for electricity generation is the key factor underlying plans for additional coal-fired generating capacity in these countries.

During the 1980s, Australia became the leading coal exporter in the world, primarily by meeting increased demand for steam coal in Asia. Considerable 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 34 percent in 2000, is projected to remain near that level over the forecast period [***101***]. Australia should continue as the major exporter to Asia, but its share of the region's total coal import demand is projected to decline from 48 percent in 2000 to 42 percent by 2020.

Recently, coal from China has been displacing some Australian tonnage in several of Asia's major coal-importing countries, such as South Korea, Japan, and Taiwan [***102***]. Factors contributing to China's expanding coal export position in Asia include: (1) the recent completion of projects and further commitments by the Chinese government to improve rail links to ports and to construct new coal export facilities; (2) continuing support for China's coal export industry through state subsidies; (3) aggressive pricing of coal exports, emphasizing market share rather than profits; and (4) the realtively short transport distances from China's coal-exporting ports to Asia's major coal-importing countries, ensuring low shipping costs [***103***]. Over the forecast period, China is expected to capture an increasing share of the region's overall coal import market.

Europe, Middle East, and Africa

Coal imports to Europe, the Middle East, and Africa taken as a whole are projected to remain relatively constant over the forecast period (Figure 61). 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 2000, the leading suppliers of imported coal to Europe were South Africa (27 percent), Australia (19 percent), South America (15 percent), and the United States (13 percent). Over the forecast period, low-cost coal from South America (primarily from Colombia and Venezuela) 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.

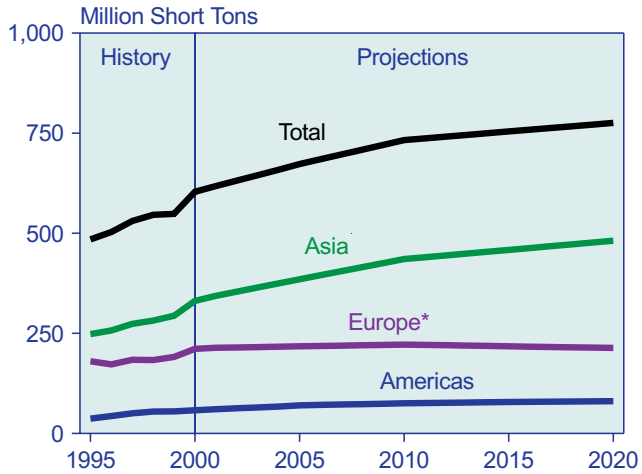
Despite expected gains in South America's foothold in Europe, South Africa is projected to maintain its position as the leading supplier of coal to Europe. Recently announced plans call for an 11-million-ton expansion in South Africa's Richards Bay Coal Terminal by the end of 2003, increasing the facility's annual coal export capacity to 90 million tons [***104***].

The Americas

Compared with European and Asian coal markets, imports of coal to North and South America are relatively small, amounting to only 58 million tons in 2000 (Table 16). Canada imported 33 percent of the 2000 total, followed by Brazil (26 percent) and the United States (22 percent) [***105***]. Most (81 percent) of the imports to Brazil were coking coal, and a majority of the remaining import tonnage was steam coal used for pulverized coal injection at steel mills [***106***].

Over the *IEO2002* forecast period, coal imports to the Americas are projected to increase by 23 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 13 million tons in 2000 to 20 million tons by 2020 [***107***]. 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. Brazil and Mexico are projected to import additional quantities of coal for both electricity generation and steelmaking.

Figure 61. Coal Imports by Major Importing Region, 1995-2020



*Coal imports to Europe include imports to the Middle East and Africa.

Note: Data exclude non-seaborne shipments of coal to Europe and Asia.

Sources: **1995-2000:** International Energy Agency, *Coal Information 2001* (Paris, France, September 2001); Energy Information Administration, *Quarterly Coal Report, October-December 2000*, DOE/EIA-0121(2000/4Q) (Washington, DC, May 2001), and previous issues. **Projections:** Energy Information Administration, National Energy Modeling System run IEO2002.D011402A (January 2002).

Partly offsetting the projected growth in coal imports elsewhere in the Americas, Canadian imports are expected to decline over the next few years as six nuclear generating units at the Pickering and Bruce plants gradually are returned to service, displacing generation from Ontario's coal-fired power plants. Coal plants in Nova Scotia, however, are expected to increase their take of imports after the closure of Canada's Phalen and Prince underground mines in 1999 and 2001 [***108***]. During 2000, Nova Scotia Power purchased 0.8 million tons of domestic coal (primarily from the Prince mine) and 2.3 million tons of imports [***109***].

Coking Coal

Historically, coking coal has dominated world coal trade, but its share has steadily declined, from 55 percent in 1980 to 34 percent in 1999 [***110***]. In the forecast, its share of world coal trade continues to shrink, to 29 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 a 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 [***111***].[15] In 1999, the direct use of pulverized coal at blast furnaces accounted for 17 percent and 19 percent of the coal consumed for steelmaking in the European Union and Japan, respectively [***112***].

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