Chapter 4
Coal

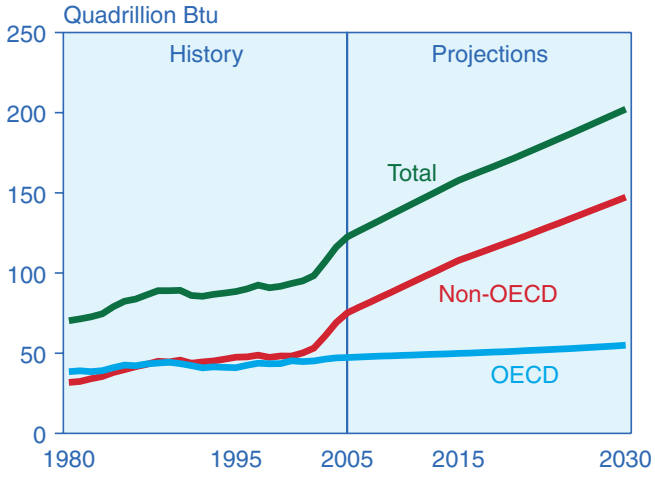
In the IEO2008 reference case, world coal consumption increases by 65 percent and international coal trade increases by 53 percent from 2005 to 2030, and coal's share of world energy consumption increases from 27 percent in 2005 to 29 percent in 2030.

In the *IEO2008* reference case, world coal consumption increases by 65 percent over the projection period, from 122.5 quadrillion Btu in 2005 to 202.2 quadrillion Btu in 2030 (Figure 46). The increase in coal consumption averages 2.6 percent per year from 2005 to 2015, then slows to an average of 1.7 percent per year from 2015 to 2030. World GDP and primary energy consumption also grow more rapidly in the first half than in the second half of the projections, reflecting a gradual slowdown of economic activity, especially in non-OECD Asia. Regionally, increased use of coal in non-OECD countries accounts for 91 percent of the total growth in world coal consumption over the entire period.

In 2005, coal accounted for 27 percent of world energy consumption (Figure 47). Of the coal produced worldwide in 2005, 63 percent was shipped to electricity producers, 34 percent to industrial consumers, and most of the remaining 3 percent went to coal consumers in the residential and commercial sectors. Coal's share of total world energy consumption is projected to increase to 29 percent in 2030, and its share in the electric power sector is projected to rise from 42 percent in 2005 to 46 percent in 2030.

International coal trade increases by 53 percent in the reference case, from 18.4 quadrillion Btu in 2005 to 28.1 quadrillion Btu in 2030. Because the largest increase in consumption is projected for coal that is produced and consumed domestically in China, the share of total world coal consumption accounted for by internationally traded coal declines slightly, from 15 percent in 2005 to 14 percent in 2030.

Figure 46. World Coal Consumption by Country Grouping, 1980-2030



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2008).

World Coal Consumption

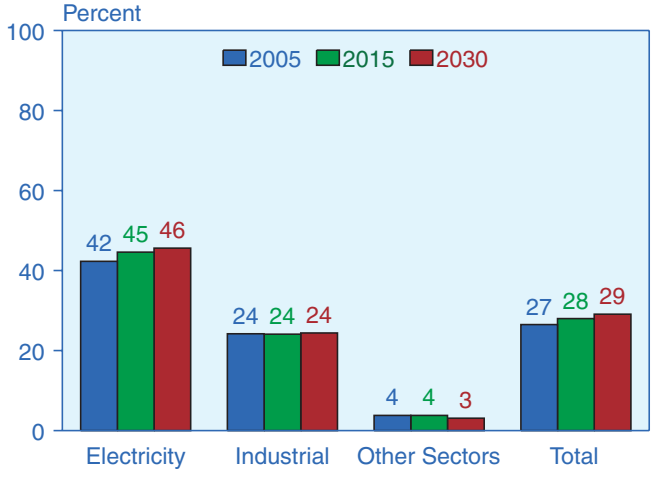
OECD Countries

Coal consumption in the OECD countries increases in the reference case from 47.3 quadrillion Btu in 2005 to 49.9 quadrillion Btu in 2015 and 55.0 quadrillion Btu in 2030 (Figure 48). The increase represents average growth of 0.6 percent per year over the entire period and 0.7 percent per year from 2015 to 2030. Coal consumption in the OECD countries represented 39 percent of the world total in 2005. In 2030 it is only 27 percent of the total, despite increases in North America and OECD Asia.

North America

Coal use in the United States totaled 22.8 quadrillion Btu in 2005, accounting for 92 percent of total coal use in North America and 48 percent of the OECD total. U.S.

Figure 47. Coal Share of World Energy Consumption by Sector, 2005, 2015, and 2030



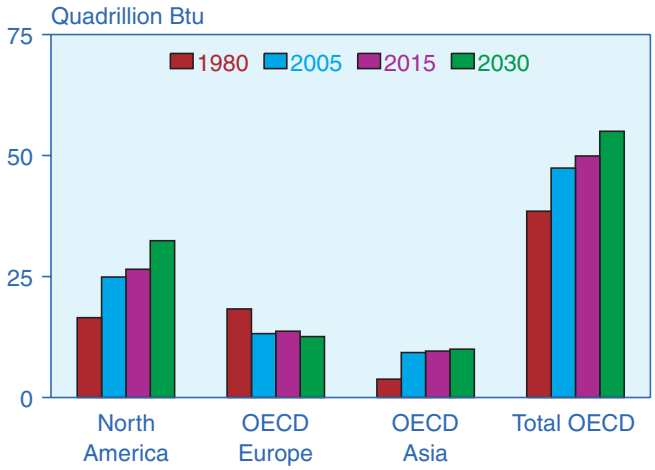
Sources: **2005:** Derived from Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **2015 and 2030:** EIA, World Energy Projections Plus (2008).

coal demand rises to 29.9 quadrillion Btu in 2030 in the *IEO2008* reference case. The United States has substantial coal reserves and relies heavily on coal for electricity generation, a position that continues in the projections. Coal's share of total U.S. electricity generation (including electricity produced at combined heat and power plants in the industrial and commercial sectors) declines from 50 percent in 2005 to 49 percent in 2015, then rises to 54 percent in 2030.

Much of the projected growth in U.S. coal consumption occurs after 2015, when a substantial amount of new coal-fired generating capacity is projected to come on line. Between 2005 and 2015, natural gas continues to be the top choice for new generating capacity, with renewables and coal accounting for most of the remaining additions during the period. After 2015, the combination of increased need for baseload generating capacity, rising natural gas prices, continuing growth in electricity demand, and the absence of national-level restrictions on greenhouse gas emissions gradually tips capacity expansion decisions toward new coal-fired power plants. From 2015 to 2030, 86 gigawatts of new coal-fired capacity is projected to be built, representing 82 percent of all the new coal-fired generating plants built in the United States from 2005 through 2030. The projections could change significantly, however, if changes were made in U.S. laws and policies, particularly those regarding greenhouse gas emissions.

In Canada and Mexico, small increases in coal consumption (0.3 and 0.1 quadrillion Btu, respectively) are expected over the period. As a result, the two countries essentially maintain their combined 8-percent share of North America's total coal consumption through 2030. In Mexico, 0.7 gigawatts of coal-fired generating capacity currently is under construction at Lazaro Cardenas on the Pacific coast. In addition, Mexico's Energy Ministry has indicated the potential for additional coal-fired generating projects in the next decade, contingent on the confirmation of newly discovered coal reserves in the Sabinas region and subject to future fuel prices.

Figure 48. OECD Coal Consumption by Region, 1980, 2005, 2015, and 2030



Sources: **1980 and 2005:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **2015 and 2030:** EIA, World Energy Projections Plus (2008).

OECD Europe

Total coal consumption in the countries of OECD Europe declines slightly in the reference case, from 13.2 quadrillion Btu in 2005 (28 percent of the OECD total) to 12.6 quadrillion Btu in 2030. In 2005, the major coal-consuming countries of OECD Europe included Germany, Poland, the United Kingdom, Spain, Turkey, and the Czech Republic. Low-Btu coal is an important domestic source of energy for the nations of OECD Europe, which also rely heavily on imports of hard coal.[11] In 2005, lignite accounted for 47 percent of their total combined coal consumption on a tonnage basis and 24 percent on a Btu basis [***1***]. Plans to replace or refurbish existing coal-fired capacity in a number of the countries of OECD Europe are an indication that coal will continue to play an important role in their overall energy mix [***2***].

Coal consumption remains fairly flat throughout 2030, as governments enact policies to discourage the use of the fuel, largely in response to environmental concerns. Among the most important factors preventing OECD Europe's coal consumption from increasing in the long term is relatively slow growth in overall energy consumption, averaging 0.5 percent per year. Other factors include continued penetration of natural gas in both the electricity and the industrial sectors, growing use of renewable fuels, and continuing pressure on member countries of the European Union to reduce subsidies that support domestic production of hard coal.

OECD Asia

In addition to remaining prominent consumers of coal, the nations of OECD Asia play an important role in international coal trade. In 2005 they used 9.3 quadrillion Btu of coal, representing 20 percent of total OECD coal consumption. OECD Asia's coal demand is projected to increase by 0.6 quadrillion Btu over the projection period, to 10.0 quadrillion Btu in 2030 (18 percent of the OECD total). In 2005, Australia was the world's leading coal exporter, supplying 6.1 quadrillion Btu of coal to the international market, while Japan and South Korea were the world's leading importers, receiving 4.5 and 1.9 quadrillion Btu of coal, respectively [***3***]. Japan's coal consumption decreases in the long term; Australia,

[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.

New Zealand, and South Korea account for nearly all the projected growth in OECD Asia's demand for coal.

Coal consumption in Australia/New Zealand increases by an average of 0.6 percent per year, from 2.6 quadrillion Btu in 2005 to 3.0 quadrillion Btu in 2030. With substantial coal reserves (primarily in Australia), the region continues to rely heavily on coal for electricity generation; however, coal's share of total generation declines gradually as more natural gas is consumed in the electric power sector. Coal-fired power plants supplied 73 percent of the region's total electricity generation in 2005, as compared with a projected 68-percent share in 2030 in the reference case.

South Korea's total coal consumption increases by 0.7 quadrillion Btu from 2005 to 2030, primarily to fuel existing and planned electric power plants. South Korea's generating companies have announced plans to construct more than 6 gigawatts of new coal-fired capacity at existing sites over the next few years, including three 500-megawatt units that began operation at Korea East-West Power Company's Dangjin plant in 2006 and 2007 [*4*].

Non-OECD Countries

Led by strong economic growth and rising demand for energy in China and India, non-OECD coal consumption is projected to rise to 147.3 quadrillion Btu in 2030, nearly double the quantity consumed in 2005 (Figure 49). The increase of 72.1 quadrillion Btu, which represents 90 percent of the projected increase in total world coal consumption, underscores the growing importance of coal in meeting overall energy demand in the non-OECD nations. Total coal consumption in the non-OECD countries grows at an average annual rate of 3.7 percent from 2005 to 2015, then slows to 2.1 percent per year from 2015 to 2030 as the region's overall rate of economic growth begins to moderate in the later years of the projection period.

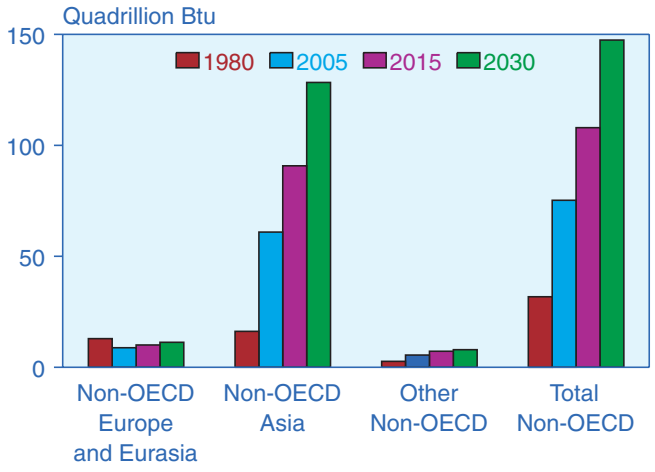
Non-OECD Asia

China and India together account for 79 percent of the projected increase in world coal consumption from 2005 to 2030. Strong economic growth is projected for both countries (averaging 6.4 percent per year in China and 5.8 percent per year in India from 2005 to 2030), and much of the increase in their demand for energy, particularly in the electric power and industrial sectors, is expected to be met by coal.

Coal use in China's electricity sector is projected to increase from 22.2 quadrillion Btu in 2005 to 60.6 quadrillion Btu in 2030, at an average rate of 4.1 percent per year (Figure 50). In comparison, coal consumption in the U.S. electric power sector is projected to grow by 1.1 percent annually, from 20.7 quadrillion Btu in 2005 to 27.5 quadrillion Btu in 2030. At the end of 2005, China had an estimated 299 gigawatts of coal-fired capacity in operation. To meet the demand for electricity that is expected to accompany its rapid economic growth, an additional 735 gigawatts of coal-fired capacity (net of retirements) is projected to be brought on line in China by 2030, requiring large financial investments in new coal-fired power plants and associated transmission and distribution systems.

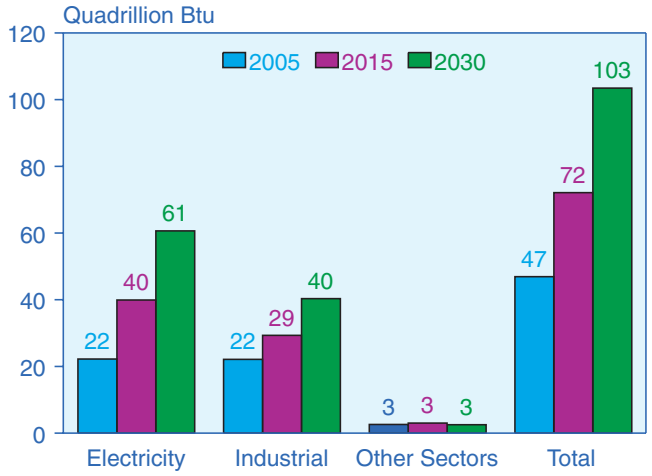
More than one-half (53 percent) of China's coal use in 2005 was in the non-electricity sectors, primarily in the industrial sector. China was the world's leading producer of both steel and pig iron in 2005 [*5*]. Over the projection period, coal demand in China's non-electricity

Figure 49. Non-OECD Coal Consumption by Region, 1980, 2005, 2015, and 2030



Sources: **1980 and 2005:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **2015 and 2030:** EIA, World Energy Projections Plus (2008).

Figure 50. Coal Consumption in China by Sector, 2005, 2015, and 2030



Sources: **2005:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **2015 and 2030:** EIA, World Energy Projections Plus (2008).

sectors is expected to increase by 18.1 quadrillion Btu, to 73 percent above the 2005 level. Despite such substantial growth, however, the non-electricity share of total coal demand declines to 41 percent in 2030. Because China has only limited reserves of oil and natural gas, coal remains the primary source of energy in its industrial sector, even as electricity's share of total industrial energy use rises from 17 percent in 2005 to 27 percent in 2030.

With a substantial portion of the increase in China's demand for both liquids and natural gas projected to be met by imports, the Chinese government is actively pursuing the development of a coal-to-liquids industry. Production of coal-based synthetic liquids is scheduled to commence in late 2008 at the country's first commercial-scale coal-to-liquids plant. Located in the Inner Mongolia Autonomous Region, the direct coal liquefaction facility is being built by the state-owned Shenhua Group and will have an initial capacity of approximately 20,000 barrels per day [*6*]. Although initial plans foresaw an increase in liquids production at the site to 100,000 barrels per day by 2010, the schedule for expansion is now indefinite, depending on the successful startup and commercial operation of the first phase.

A number of other coal-to-liquids projects, representing total productive capacity in excess of 0.2 million barrels per day, are currently at various stages of development, ranging from feasibility studies to early construction phases [*7*]. Shenhua is involved in a number of these projects as well, and two other Chinese companies—the Yankuang and Lu'an Groups—also are moving forward with their own coal-to-liquids projects. Despite strong interest by the Chinese government and industry in developing a coal-to-liquids industry, substantial uncertainty and risks are associated with the move, including potential strains on water resources, the general financial risks associated with technological uncertainties, and the substantial investment requirements. In the *IEO2008* reference case, China's coal-to-liquids production is projected to reach 0.2 million barrels per day in 2030, indicating an annual coal requirement of approximately 1 quadrillion Btu, or about 1 percent of China's total projected coal use in 2030. In comparison, China's coal-to-liquids production in 2030 is projected to be 0.1 million barrels per day in the *IEO2008* low price case and 0.5 million barrels day in the *IEO2008* high price case.

Nearly 74 percent of the growth in India's coal consumption is expected to be in the electric power sector and most of the remainder in the industrial sector. In 2005, India's coal-fired power plants consumed 6.0 quadrillion Btu of coal, representing 70 percent of the country's total coal demand. Coal use for electricity generation in India is projected to grow by 2.5 percent per year, to 11.1 quadrillion Btu in 2030, as an additional 95 gigawatts of coal-fired capacity (net of retirements) is brought on line. As a result, India's coal-fired generating capacity more than doubles in the reference case, from 79 gigawatts in 2005 to 173 gigawatts in 2030.

Currently, India's government has tentative plans to add more than 50 gigawatts of new coal-fired generating capacity during the period covered by its eleventh power plan (a 5-year period ending in March 2012) [*8*]. During India's most recent 5-year power plan period, which ended in March 2007, only about 12 of the 20 gigawatts of new coal-fired generating capacity that had been planned was actually completed. In addition to the coal projects listed in the preliminary documents for the eleventh power plan, including one "ultra mega" coal-fired plant with a capacity of 4 gigawatts, the Indian government is pursuing the development of eight more "ultra mega" projects with a total combined coal-fired generating capability of 32 gigawatts [*9*].

In the other nations of non-OECD Asia, coal consumption is projected to grow by an average of 2.3 percent per year, from 5.3 quadrillion Btu in 2005 to 9.3 quadrillion Btu in 2030, with increases in both the electric power and industrial sectors. In the electric power sector, significant growth in coal consumption is expected in Taiwan, Vietnam, Indonesia, and Malaysia, where considerable amounts of new coal-fired generating capacity are either planned or under construction.

Non-OECD Europe and Eurasia

Coal consumption in non-OECD Europe and Eurasia is projected to increase at an average rate of 0.9 percent per year, from 8.8 quadrillion Btu in 2005 to 11.2 quadrillion Btu in 2030. Russia alone has an estimated 173 billion tons of recoverable reserves (19 percent of the world total), and the other countries of non-OECD Europe and Eurasia have an additional 95 billion tons (10 percent of the world total).[12]

Russia is the largest coal consumer among the nations of non-OECD Europe and Eurasia, at 4.8 quadrillion Btu in 2005, or 54 percent of the total for non-OECD Europe and Eurasia. In 2030, Russia's coal consumption is projected to total 5.7 quadrillion Btu. Coal supplied 16 percent of Russia's total energy requirements in 2005, and coal-fired power plants provided 24 percent of its electricity. In the *IEO2008* reference case, coal's share of Russia's total energy consumption drops slightly to 14 percent in 2030, and its share of electricity generation declines to 22 percent. More than one-half of the projected growth in electricity demand from 2005 to 2030 is met by natural-gas-fired power plants, with coal and nuclear plants accounting for most of the remainder. The

[12]Throughout this chapter, tons refer to short tons (2,000 pounds).

natural gas share of Russia's total electricity generation increases from 40 percent in 2005 to 46 percent in 2030.

In March 2008, the Russian government approved a new long-range plan for the country's electric power sector through 2020 [***10***]. In general, the plan lays out a detailed road map of capacity additions and retirements and new transmission infrastructure. One of the key objectives of the plan on the generation side is to curb growth in natural-gas-fired generation in order to free up natural gas for export. The plan anticipates some additional growth in natural gas consumption in the power sector through 2020, as does the *IEO2008* reference case, but it differs from the *IEO2008* projection in that it anticipates more generation from coal-fired and nuclear power plants and more rapid growth in total electricity generation.

One of the key uncertainties in Russia's new long-range power plan results from the current activities of the country's former power monopoly, Unified Energy System (UES), which is completing the process of selling off the many regional generating companies it once controlled. It remains to be seen how the government's new plan for the power sector will be worked out with the many private-sector companies that own or soon will own the various regional generating entities, as the specific planned additions and retirements outlined in the government plan may not turn out to be the most economical choices from the perspective of the individual generating companies.

In the other non-OECD Europe and Eurasia nations, coal consumption is projected to increase from 4.0 quadrillion Btu in 2005 to 5.5 quadrillion Btu by 2030, growing by 1.2 percent per year on average. Plans for both new coal-fired capacity and the refurbishment of existing capacity in a number of countries, including Albania, Bosnia and Herzegovina, Bulgaria, Montenegro, Romania, Serbia, and Ukraine, are a significant indication that coal will continue to be an important source of energy for the region [***11***].

Africa

Africa's coal consumption is projected to increase by 1.4 quadrillion Btu from 2005 to 2030. South Africa currently accounts for 90 percent of the coal consumed on the continent and is expected to continue to account for much of the increase in Africa's total coal consumption over the projection period in both the electricity and industrial sectors.

In South Africa, increasing demand for electricity in recent years has led to a decision by Eskom, the country's state-owned electricity supplier, to restart three large coal-fired plants (Camden, Grootvlei, and Komati) that have been closed for more than a decade [***12***]. The individual units at those plants, with a combined generating capacity of 3.8 gigawatts, are scheduled to return to service between 2006 and 2011. In addition, Eskom is also proceeding with the construction of a new 4.5-gigawatt coal-fired power plant consisting of six units, which are scheduled to be fully operational by 2015. Recent power shortages and the general lack of spare generating capacity in southern Africa have also led to increased interest in new coal-fired power projects in Botswana, Mozambique, and Tanzania [***13***].

In the industrial sector, increasing use of coal in Africa is expected for several purposes, including the production of steam and process heat for industrial applications, production of coke for the steel industry, and production of coal-based synthetic liquids. Currently, two commercial-size coal-to-liquids plants in South Africa (Sasol II and Sasol III) supply about 25 percent of the country's total liquid fuel requirements [***14***]. The two plants together are capable of producing 150,000 barrels of synthetic liquids per day.

Central and South America

Central and South America consumed 0.9 quadrillion Btu of coal in 2005. Brazil, with the world's tenth-largest steel industry in 2005, accounted for 51 percent of the region's coal demand. Chile, Colombia, Puerto Rico, Peru, and Argentina accounted for most of the remainder [***15***].

In the projections, coal consumption in Central and South America increases by 1.0 quadrillion Btu from 2005 to 2030, with 76 percent of the increase in Brazil, primarily for coke manufacture and electricity generation. Brazil's steel companies currently plan to expand production capacity by a substantial amount over the next few years to meet increasing domestic and international demand for steel [***16***].

Middle East

Countries of the Middle East consumed 0.4 quadrillion Btu of coal in 2005. Israel accounted for 87 percent of the total and Iran most of the remainder. The region's coal use increases only slightly in the reference case, to 0.5 quadrillion Btu in 2030.

World Coal Production

From 2005 to 2030, coal production in China, the United States, and India is projected to increase by 52.4 quadrillion Btu, 6.0 quadrillion Btu, and 4.3 quadrillion Btu, respectively, in the *IEO2008* reference case (Table 7), which assumes that most of the demand for coal in the three countries will continue to be met by domestic production. Coal production in Australia is also projected to rise substantially (by 5.0 quadrillion Btu) over the projection period, primarily to supply an expanding market for world coal trade. The projected increases in coal production for these four countries dominate the overall trends for the OECD and non-OECD, accounting for 99

percent of the increase in net production for all the OECD countries and 82 percent of the increase for the non-OECD countries. Rising international trade also is expected to support production increases in Russia, other non-OECD Asia, Africa, and Central and South America (excluding Brazil).

World Coal Trade

Because relatively few countries export coal, a disruption in one segment of the international coal supply chain can reverberate throughout the global market and limit the availability of coal for trade. In 2007 and 2008, several such disruptions took place. Power shortages at coal mines in South Africa and rail car shortages in Russia restricted the availability of coal in 2007. In early 2008, flooding in Australian coal mines and continued port congestion caused delays and even cancellations of coal deliveries. Also in 2008, heavy snow in China and the rail transportation problems it caused contributed to tight coal markets. As domestic coal stockpiles dwindled, the Chinese government temporarily stopped all coal exports.

Despite the potential for disruptive events, bottlenecks and temporary supply problems in major coal exporting countries are expected to be overcome in the long run, and the volumes of coal traded internationally are projected to increase through 2030. The upward trend in coal trade reflects the worldwide growth in coal consumption projected through 2030. International coal trade made up 15 percent of total world consumption in

Table 7. World Coal Production by Region, 2005-2030
(Quadrillion Btu)

Region	2005	2010	2015	2020	2025	2030	Average Annual Percent Change, 2005-2030
OECD North America	**25.1**	**26.5**	**27.3**	**28.1**	**29.8**	**32.1**	**1.0%**
United States	23.2	24.0	24.7	25.4	27.0	29.2	0.9%
Canada	1.7	2.2	2.5	2.6	2.6	2.7	1.9%
Mexico	0.2	0.2	0.2	0.2	0.2	0.2	-0.3%
OECD Europe	**7.8**	**8.4**	**7.9**	**7.5**	**7.2**	**6.9**	**-0.5%**
OECD Asia	**8.7**	**10.7**	**11.7**	**12.5**	**13.0**	**13.7**	**1.9%**
Japan	0.0	0.0	0.0	0.0	0.0	0.0	—
South Korea	0.1	0.1	0.1	0.1	0.1	0.1	—
Australia/New Zealand	8.6	10.6	11.6	12.4	13.0	13.6	1.9%
Total OECD	**41.6**	**45.5**	**46.9**	**48.1**	**50.1**	**52.7**	**1.0%**
Non-OECD Europe and Eurasia	**10.2**	**10.7**	**12.2**	**12.6**	**12.8**	**13.5**	**1.1%**
Russia	6.1	6.8	7.4	7.7	7.7	8.2	1.2%
Other	4.1	3.9	4.8	4.9	5.1	5.3	1.0%
Non-OECD Asia	**62.7**	**74.5**	**87.8**	**98.9**	**111.1**	**123.3**	**2.7%**
China	48.9	59.9	71.3	81.3	91.5	101.3	3.0%
India	7.8	7.9	8.6	9.5	10.7	12.0	1.8%
Other	6.0	6.7	7.9	8.1	8.9	9.9	2.1%
Middle East	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**—**
Africa	**5.9**	**6.7**	**7.4**	**7.8**	**8.1**	**8.2**	**1.3%**
Central and South America	**1.9**	**2.8**	**3.7**	**4.8**	**5.0**	**5.0**	**3.9%**
Brazil	0.1	0.2	0.2	0.2	0.2	0.2	4.3%
Other	1.8	2.6	3.5	4.6	4.8	4.8	3.9%
Total Non-OECD	**80.7**	**94.7**	**111.1**	**124.0**	**137.0**	**150.0**	**2.5%**
Total World	**122.2**	**140.2**	**158.0**	**172.1**	**187.1**	**202.7**	**2.0%**

Note: With the exception of North America, non-seaborne coal trade is not represented in the *IEO2008* cases. As a result, the projected levels of production assume that net non-seaborne coal trade will balance out across the world regions. Currently, a significant amount of non-seaborne coal trade takes place in Eurasia, represented by exports of steam coal from Kazakhstan to Russia and exports of coking coal from Russia to Ukraine.

Sources: **2005:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2008); and National Energy Modeling System, run IEO2008.D061008B.

2005, and in the *IEO2008* reference case, it is projected to grow at an average annual rate of 1.5 percent, from about 19.7 quadrillion Btu in 2006 to 28.1 quadrillion Btu in 2030 (Table 8). Because the largest increases in coal consumption through 2030 are projected for non-OECD Asia—particularly China, which is expected to meet most of the increase in its coal demand with domestic supply rather than imports—the share of coal trade as a percentage of global coal consumption declines slightly, to 14 percent in 2030. Australia and Indonesia are geographically well situated to continue as the leading suppliers of internationally traded coal, especially to Asia, over the period. South America is projected to expand its role as an international supplier of coal, primarily as a result of increasing coal production in Colombia.

Although both steam and metallurgical coal are traded internationally, most of the trade is in steam coal, which is projected to represent 72 percent of world coal trade in 2030. In 2006, 56 percent of the world's exported steam coal was imported by Asian countries, and their share of the total in 2030 is projected to be 61 percent. The share of metallurgical coal imports destined for Asian countries also increases, from 61 percent in 2006 to 65 percent in 2030.

Coal Exporters

The top four exporters of steam coal in 2006 were Indonesia, Australia, South America (Colombia and Venezuela), and southern Africa (South Africa, Mozambique, and Botswana). Although Indonesia currently is the world's largest exporter of steam coal, Australia is expected to be the leading exporter in most years of the *IEO2008* projections. China is only the sixth-largest exporter of steam coal in 2030. For coking coal, Australia, Canada, and the United States continue to be ranked among the top three exporters over the projection period. Among the countries expected to expand their international coal trade in 2030 are Australia, Russia, and Colombia. Indonesia and Vietnam, like China, are projected to see increasing domestic demand for coal, which is expected to constrain their coal exports.

Already the world's leading exporter of coal, Australia is projected to dominate future international coal trade. Australia continues to improve its inland transportation and port infrastructure to expedite coal shipments to international markets. For example, expansions and new terminals at the port of Newcastle could add more than 1.0 quadrillion Btu of additional coal export capacity in New South Wales [***17***]. Queensland's Dalrymple Bay port is expected to complete its Phase I expansion to 1.8 quadrillion Btu in early 2008, followed by an increase to about 2.3 quadrillion Btu in subsequent expansions [***18***]. Australia remains the primary exporter of metallurgical coal to Asian markets, supplying 75 percent of Asia's import demand for coking coal over the projection period.

After the breakup of the Soviet Union in 1991, Russian coal supply was characterized by low mine productivity, relatively poor coal quality, and long distances between mines and markets. The productivity of its coal mines has improved since then, however, lowering mining costs and compensating in part for the expense of transporting coal to ports. Rail and port infrastructure investments are critical for the continued expansion of Russia's coal exports, and in addition, growth in the country's domestic coal consumption could limit the availability of coal for export. Nevertheless, Russia is expected to play a growing role in seaborne world coal trade. Europe (particularly, the United Kingdom) has increasingly sought Russia's low-sulfur coal as its own mines have closed. In 2030, Eurasia's coal exports are projected to total 2.5 quadrillion Btu—63 percent more than in 2006—largely as a result of growth in Russian exports.

South America is projected to be the second-largest exporter of coal worldwide in 2030, primarily as a result of increases in exports from Colombia. The expansion will require investments in mine capacity, rail infrastructure, and port capacity, such as the current proposal to build a tunnel that would expedite coal transportation to Pacific Ocean ports. In Colombia, an expansion project is under development at the Bocas de Ceniza port [***19***], and an additional increase of 0.7 quadrillion Btu of capacity has been proposed for its other Caribbean ports [***20***].

In non-OECD Asia, China, Indonesia, and Vietnam are examples of countries that have the potential to export more coal but are focused instead on meeting domestic demand. From 2003 to 2006, China successively decreased the amount of coal it exported each year. In the wake of domestic supply shortages in 2007, China again diverted coal from the export market for domestic consumption. Thus, the past few years have shown that China has the ability to turn exports on and off depending on domestic needs, contributing to uncertainty and volatility in international coal markets. Overall, China is expected to hold a lower share of world coal trade as its exports stay fairly flat and other suppliers provide more coal.

In the international market for steam coal, Indonesia's coal exports are expected to peak sometime before 2010 as some coal is redirected for domestic consumption. Indonesia has low-cost reserves of low-sulfur coal; many ports, some with the capability to take capesize ships; and proximity to the expanding markets of Asia. Indonesia has also demonstrated its capacity for significant growth, tripling its exports in the past decade. From

Table 8. World Coal Flows by Importing and Exporting Regions, Reference Case, 2006, 2015, and 2030
(Quadrillion Btu)

Exporters	Importers											
	Steam				Coking				Total			
	Europe[a]	Asia	Americas	Total[b]	Europe[a]	Asia[c]	Americas	Total[b]	Europe[a]	Asia	Americas	Total[b]
2006												
Australia	0.10	2.57	0.18	**2.85**	0.82	2.31	0.21	**3.33**	0.91	4.88	0.39	**6.18**
United States	0.12	0.01	0.34	**0.48**	0.45	0.04	0.26	**0.75**	0.57	0.05	0.60	**1.22**
Southern Africa[d]	1.53	0.07	0.02	**1.68**	0.02	0.00	0.00	**0.03**	1.55	0.07	0.03	**1.71**
Eurasia	1.08	0.29	0.02	**1.39**	0.07	0.10	0.00	**0.17**	1.15	0.39	0.02	**1.56**
Poland	0.25	0.00	0.00	**0.25**	0.03	0.00	0.00	**0.03**	0.28	0.00	0.00	**0.28**
Canada	0.01	0.05	0.02	**0.08**	0.21	0.36	0.10	**0.67**	0.21	0.41	0.12	**0.75**
China	0.06	1.44	0.00	**1.51**	0.01	0.10	0.00	**0.12**	0.07	1.55	0.00	**1.62**
South America[e]	0.88	0.00	0.84	**1.72**	0.00	0.00	0.00	**0.00**	0.88	0.00	0.84	**1.72**
Vietnam	0.00	0.52	0.00	**0.52**	0.00	0.00	0.00	**0.00**	0.00	0.52	0.00	**0.52**
Indonesia[f]	0.62	2.90	0.13	**3.66**	0.00	0.53	0.00	**0.53**	0.62	3.43	0.13	**4.19**
Total	**4.65**	**7.85**	**1.55**	**14.12**	**1.60**	**3.45**	**0.57**	**5.63**	**6.25**	**11.30**	**2.12**	**19.74**
2015												
Australia	0.03	4.77	0.00	**4.80**	0.76	3.01	0.36	**4.13**	0.79	7.78	0.36	**8.93**
United States	0.25	0.02	0.18	**0.45**	0.24	0.00	0.42	**0.66**	0.50	0.02	0.59	**1.11**
Southern Africa[d]	1.29	1.06	0.12	**2.47**	0.02	0.00	0.02	**0.04**	1.31	1.06	0.15	**2.51**
Eurasia	1.52	0.54	0.00	**2.06**	0.08	0.23	0.00	**0.31**	1.59	0.77	0.00	**2.36**
Poland	0.14	0.00	0.01	**0.15**	0.03	0.00	0.00	**0.03**	0.17	0.00	0.01	**0.18**
Canada	0.04	0.00	0.00	**0.04**	0.47	0.36	0.13	**0.96**	0.51	0.36	0.13	**1.00**
China	0.00	1.07	0.00	**1.07**	0.00	0.03	0.00	**0.03**	0.00	1.10	0.00	**1.10**
South America[e]	1.95	0.00	1.12	**3.07**	0.00	0.00	0.00	**0.00**	1.95	0.00	1.12	**3.07**
Vietnam	0.00	0.27	0.00	**0.27**	0.00	0.01	0.00	**0.01**	0.00	0.27	0.00	**0.27**
Indonesia[f]	0.00	3.03	0.09	**3.12**	0.00	0.50	0.00	**0.50**	0.00	3.54	0.09	**3.63**
Total	**5.21**	**10.76**	**1.53**	**17.50**	**1.60**	**4.13**	**0.94**	**6.66**	**6.81**	**14.88**	**2.46**	**24.16**
2030												
Australia	0.09	5.39	0.04	**5.51**	0.89	3.79	0.45	**5.13**	0.97	9.18	0.48	**10.64**
United States	0.01	0.01	0.29	**0.31**	0.20	0.00	0.33	**0.53**	0.21	0.01	0.62	**0.84**
Southern Africa[d]	1.20	1.37	0.18	**2.75**	0.01	0.00	0.03	**0.04**	1.22	1.37	0.20	**2.79**
Eurasia	1.45	0.66	0.00	**2.11**	0.16	0.27	0.00	**0.43**	1.61	0.93	0.00	**2.54**
Poland	0.07	0.00	0.03	**0.10**	0.01	0.00	0.00	**0.01**	0.09	0.00	0.03	**0.11**
Canada	0.00	0.00	0.00	**0.00**	0.40	0.47	0.26	**1.13**	0.40	0.47	0.26	**1.13**
China	0.00	1.07	0.00	**1.07**	0.00	0.03	0.00	**0.03**	0.00	1.10	0.00	**1.10**
South America[e]	2.18	0.10	2.12	**4.39**	0.00	0.00	0.00	**0.00**	2.18	0.10	2.12	**4.39**
Vietnam	0.00	0.27	0.00	**0.27**	0.00	0.01	0.00	**0.01**	0.00	0.27	0.00	**0.27**
Indonesia[f]	0.00	3.53	0.22	**3.75**	0.00	0.50	0.00	**0.50**	0.00	4.03	0.22	**4.25**
Total	**5.00**	**12.38**	**2.88**	**20.26**	**1.67**	**5.07**	**1.07**	**7.80**	**6.66**	**17.46**	**3.94**	**28.06**

[a]Europe/Mediterranean, including coal shipments to the Middle East and Africa.
[b]In 2006, total world coal flows include a balancing item used to reconcile discrepancies between reported exports and imports. The 2006 balancing items by coal type were 0.069 quadrillion Btu (steam coal), 0.003 quadrillion Btu (coking coal), and 0.071 quadrillion Btu (total).
[c]Includes 0.49 quadrillion Btu of coal for pulverized coal injection at blast furnaces shipped to Japanese steelmakers in 2006.
[d]Southern Africa includes South Africa, Mozambique, and Botswana.
[e]Coal exports from South America are projected to originate from mines in Colombia and Venezuela.
[f]Includes shipments from other countries not modeled for the projection period. The 2006 exports from other countries by coal type were 0.07 quadrillion Btu (steam coal), 0.03 quadrillion Btu (coking coal), and 0.10 quadrillion Btu (total).
Notes: Data exclude non-seaborne shipments of coal to Europe and Asia. Totals may not equal sum of components due to independent rounding.
Sources: **2006:** SSY Consultancy and Research, Ltd., *SSY's Coal Trade Forecast*, Vol. 16, No. 1 (London, UK, June 2007); and Energy Information Administration, *Quarterly Coal Report*, October-December 2006, DOE/EIA-0121(2006/4Q) (Washington, DC, March 2007). **2015 and 2030:** Energy Information Administration, National Energy Modeling System, run IEO2008.D061008B.

2006 to 2030, Indonesia's annual coal exports are projected to average about 4 quadrillion Btu; however, continued strength in Indonesia's coal exports depends on investment in resource exploration and the development of new mines over the period. Some areas of uncertainty for Indonesian exports include the rate of growth in its domestic coal demand consumption, the adequacy of its internal transportation infrastructure, and environmental concerns. As long as international coal demand is strong and coal exports are profitable, Indonesia is expected to continue to supply coal to other nations.

Despite strong growth in coal exports between 2003 and 2007, the Vietnamese government plans to restrict exports in the future. State-owned Vinacomin, the largest coal producer in Vietnam, has announced plans to reduce exports by 17 percent in 2008 and to begin importing coal from Indonesia [***21***]. Vietnam has been slow to implement coal export reduction policies, however, and was still exporting about 0.7 quadrillion Btu in 2006 and 2007 [***22***]. In the *IEO2008* reference case, Vietnam's coal exports decline to about 0.2 quadrillion Btu in 2013 from an estimated 0.5 quadrillion Btu in 2006 and to remain below 0.3 quadrillion Btu through 2030.

The African countries of Botswana, Mozambique, and Tanzania are expected to play an emerging role in coal trade as importing countries seek to secure additional sources of supply. For example, India and Brazil are investing in mines and infrastructure projects in Africa. India's Tata Steel has acquired a 35-percent stake in a coking coal mine in Mozambique [***23***], and an expansion of the Mozambique port of Beira to a capacity of 0.5 quadrillion Btu to accommodate coal exports is being proposed [***24***].

South Africa currently is the sole source of seaborne coal exports from Africa. In early 2008, an electricity shortage forced the temporary closure of some of the country's coal mines, leading to reduced production and the diversion of some coal, originally intended for export, to domestic power plants. Although South Africa has domestic infrastructure and energy supply problems to solve, and its coal exports have remained flat over the past few years, coal mining is expected to continue playing an important role in its economy. A scheduled expansion of the Richards Bay Coal Terminal to add about 0.5 quadrillion Btu of export capacity in 2009 will support South Africa's continued role as an international coal supplier [***25***].

Coal Imports

Asia

Asia poses a large area of uncertainty for world coal trade projections. In particular, China has the potential to influence the market both as an importer and as an exporter. For example, a significant increase in China's coal imports could put upward pressure on world coal prices. In 2030, China's coal imports are projected to total 3.4 quadrillion Btu and its exports 1.1 quadrillion Btu. Even with a substantial increase in imports, however, most of the coal consumed in China will continue to be supplied by its own coal mines.

In India, demand for coal imports in 2030 is projected to be nearly triple its 2006 demand, as the country continues to encounter problems with domestic coal production and transportation. India is projected to increase imports of both coking coal and steam coal substantially. Its large electricity plants planned for the coast are to be fueled by imported thermal coal. India has domestic resources of coking coal, but their quality is poor in comparison with imports from foreign sources. India plans to expand its steel industry to between 165 and 198 million tons by 2020 from about 50 million tons in 2005 [***26***], with increased imports of coking coal supporting the expansion. Steel production is necessary for India to expand and improve infrastructure essential for economic development.

Although 2001 marked the final year of significant Japanese coal production [***27***], Japan has continued to rely on coal and is expected to remain the world's largest importer of coal through 2030. Japan relies on Australia for about 60 percent of its coal imports (both steam and metallurgical coal) and on China for about 20 percent of its steam coal imports. In addition, its purchases of coal from Indonesia have increased recently, and it has initiated investments in coal production in other countries, including Russia, in order to improve the security of its coal supply [***28***]. Japan is a leader in steel production, ranking second among world steel producers [***29***], and is projected to continue to import coking coal for use in its steelmaking plants in 2030.

South Korea also is expected to continue importing most of the coal it consumes. With planned increases in coal-fired capacity, South Korea and Taiwan together are projected to maintain a share of world imports at about 18 percent in 2030 despite sizable increases in steam coal imports by other countries. Thailand is also projected to increase steam coal imports by 2015, when new coal-fired plants are constructed [***30***].

Europe, Middle East, and Africa

In the *IEO2008* reference case, total coal imports to the Europe/Mediterranean market (including the Middle East and Africa) in 2030 are only slightly above 2006 levels (Figure 51). With most European countries placing greater emphasis on natural gas in the power sector, coal becomes a less significant component of the fuel mix for electricity generation. In Turkey, however, electricity demand and steel industry growth are projected to offset some of the decline in Europe's coal imports. Italy's conversion of power plants from oil to coal also is

projected to increase its coal imports. The initial increase in coal trade to Europe in the projections result in large part from the phaseout of European mining subsidies and higher demand for lower sulfur coal. Germany's hard-coal-fueled power plants are projected to require imported coal when its hard coal mines close by 2018 [*31*]. In the Middle East, Israel accounts for the largest portion of the increase in coal imports over the projection period as it expands its use of coal-fired generation. The demand for lower sulfur coal leads to an increase in the projected share of Europe's coal imports originating from South America and Eurasia.

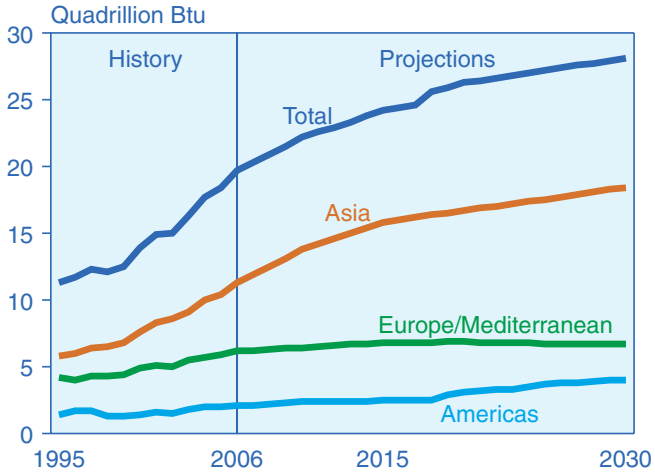
The Americas

In 2008 Kinder Morgan Energy Partners LP will complete a 0.4 quadrillion Btu expansion of its import terminal at Hampton Roads, Virginia; however, with high international coal prices in the near term, the terminal is expected to remain idle while U.S. exports increase to meet short-term international demand [*32*]. In the mid- to long term, port expansions are expected to facilitate U.S. coal imports, which increase by about 1.2 quadrillion Btu from 2006 to 2030. Although imports remain a relatively small share of U.S. coal consumption in 2030 (7 percent), the increase represents a shift for the United States from a net exporter to a net importer of coal. With declining productivity and mining difficulties in Central Appalachia, and with rising domestic demand for coal, imports are expected to become increasingly competitive for coastal States in the East and Southeast. South America (Colombia, in particular) is expected to be an important source of U.S. coal imports.

Although Canada has been the largest importer of U.S. coal in recent years, exports of U.S. steam coal to Canada in 2030 are projected to be about 0.2 quadrillion Btu below their 2006 level. It is expected that a portion of Ontario's coal-fired generating capacity will be shut down for environmental reasons.

Brazil's steelmaking capacity is projected to double by 2011 [*33*]. With rich reserves of iron ore but no coking-grade coal, Brazil's steel industry will need more imports of coking coal from Australia, Southern Africa, Canada, and the United States. Overall, South America's imports of coking coal—driven primarily by demand in Brazil—are projected to grow from about 0.4 quadrillion Btu in 2006 to 0.9 quadrillion Btu in 2030.

Figure 51. Coal Imports by Major Importing Region, 1995-2030



Sources: **History:** SSY Consultancy and Research, Ltd., *SSY's Coal Trade Forecast*, Vol. 16, No. 1 (London, UK, June 2007); International Energy Agency, *Coal Information 2007* (Paris, France, August 2007), and previous issues; and Energy Information Administration (EIA), *Quarterly Coal Report*, October-December 2006, DOE/EIA-0121(2006/4Q) (Washington, DC, March 2007), and previous issues; Btu conversions from short tons are estimates by EIA's Office of Integrated Analysis and Forecasting. **Projections:** EIA, National Energy Modeling System run IEO2008.D061008B.

World Coal Reserves

Total recoverable reserves of coal around the world are estimated at 930 billion tons—reflecting a current reserves-to-production ratio of 143 (Table 9).[13] Historically, estimates of world recoverable coal reserves, although relatively stable, have declined gradually from 1,174 billion tons in 1990 to 1,083 billion tons in 2000 and 930 billion tons in 2006 [*34*]. The most recent assessment of world coal reserves includes a substantial downward adjustment for India, from 102 billion tons in 2003 to 62 billion tons in 2006. Estimated reserves for OECD Europe of 32 billion tons in the most recent assessment are also substantially lower than the 2003 assessment of 43 billion tons. Much of the downward adjustment for OECD Europe is a result of lower estimates for Poland, Turkey, and the Czech Republic. Poland's reassessment of estimated recoverable coal reserves from 15 billion tons in 2003 to 8 billion tons in 2006 reflects the use of more restrictive criteria for geologic reliability [*35*].

Although coal deposits are widely distributed, 76 percent of the world's recoverable reserves are located in five countries: the United States (28 percent), Russia (19 percent), China (14 percent), Australia (9 percent) and India (7 percent). In 2005 those five countries, taken together, produced 4.8 billion tons (94.0 quadrillion Btu) of coal, representing 73 percent (77 percent on a Btu

[13]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. Because recoverable reserves are a subset of total coal resources, recoverable reserve estimates for a number of countries, including China and the United States, could increase substantially as coal mining technology improves and as additional geological assessments of the coal resource base are completed. The reserves-to-production ratio is based on the reserves estimates and data on world coal production for 2005 shown in Table 9.

basis) of total world coal production [*36*]. By rank, anthracite and bituminous coal account for 51 percent of the world's estimated recoverable coal reserves on a tonnage basis, subbituminous coal accounts for 32 percent, and lignite accounts for 18 percent.

Quality and geological characteristics of coal deposits are important parameters for coal reserves. Coal is a heterogeneous source of energy, with quality (for example, characteristics such as heat, sulfur, and ash content) varying significantly by region and even within individual coal seams. At the top end of the quality spectrum are premium-grade bituminous coals, or coking coals, used to manufacture coke for the steelmaking process. Coking coals produced in the United States have an estimated heat content of 26.3 million Btu per ton and relatively low sulfur content of approximately 0.9 percent by weight [*37*]. At the other end of the spectrum are reserves of low-Btu lignite. On a Btu basis, lignite reserves show considerable variation. Estimates published by the International Energy Agency for 2005 indicate that the average heat content of lignite in major producing countries varies from a low of 4.4 million Btu per ton in Greece to a high of 12.4 million Btu per ton in Canada [*38*].

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Table 9. World Recoverable Coal Reserves as of January 1, 2006
(Billion Short Tons)

Region/Country	Recoverable Reserves by Coal Rank				2005 Production	Reserves-to-Production Ratio (Years)
	Bituminous and Anthracite	Subbituminous	Lignite	Total		
World Total	**471.8**	**293.6**	**165.0**	**930.4**	**6.5**	**143**
United States[a]	120.6	109.8	33.4	**263.8**	1.1	233
Russia	54.1	107.4	11.5	**173.1**	0.3	540
China	68.6	37.1	20.5	**126.2**	2.4	52
Other Non-OECD Europe and Eurasia	49.1	19.0	27.3	**95.3**	0.3	307
Australia and New Zealand	40.9	2.5	41.6	**85.1**	0.4	203
India	57.6	0.0	4.7	**62.3**	0.5	132
Africa	54.5	0.2	0.0	**54.7**	0.3	198
OECD Europe	9.3	3.4	19.0	**31.7**	0.7	47
Other Central and South America	8.0	2.2	0.0	**10.2**	0.1	138
Other Non-OECD Asia	2.5	2.7	4.5	**9.7**	0.3	34
Brazil	0.0	7.8	0.0	**7.8**	0.0	1,131
Canada	3.8	1.0	2.5	**7.3**	0.1	101
Other[b]	2.9	0.5	0.1	**3.4**	0.0	207

[a]Data for the United States represent recoverable coal estimates as of January 1, 2007.
[b]Includes Mexico, Middle East, Japan, and South Korea.
Sources: **United States:** Energy Information Administration (EIA), unpublished data from the Coal Reserves Database (March 2008). **All Other Countries:** World Energy Council, *2007 Survey of Energy Sources*, 21st Edition (London, UK: Elsevier, September 2007), and EIA, *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea.

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