

Chapter 5

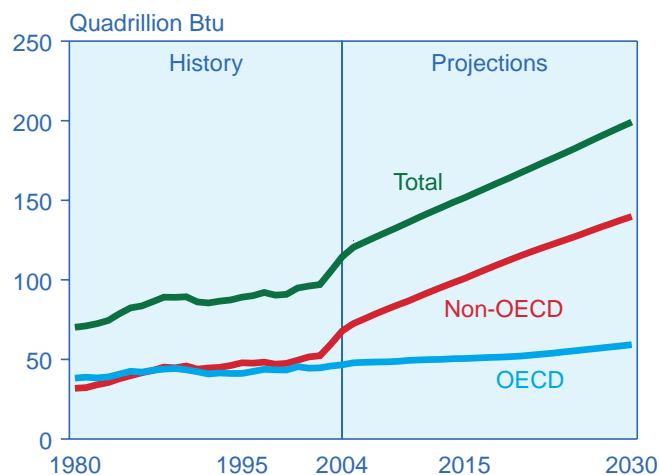
Coal

In the IEO2007 reference case, world coal consumption increases by 74 percent from 2004 to 2030, international coal trade increases by 44 percent from 2005 to 2030, and coal's share of world energy consumption increases from 26 percent in 2004 to 28 percent in 2030.

In the IEO2007 reference case, world coal consumption increases by 74 percent over the projection period, from 114.4 quadrillion Btu in 2004 to 199.0 quadrillion Btu in 2030 (Figure 54). Coal consumption increases by 2.6 percent per year on average from 2004 to 2015, then slows to an average increase of 1.8 percent annually 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 growth in non-OECD Asia. Regionally, increased use of coal in non-OECD countries accounts for 85 percent of the total growth in world coal consumption projected over the entire IEO2007 projection horizon.

In 2004, coal accounted for 26 percent of total world energy consumption (Figure 55). Of the coal produced worldwide in 2004, 65 percent was shipped to electricity producers, 31 percent to industrial consumers, and most of the remaining 4 percent to coal consumers in the residential and commercial sectors. Coal's share of total world energy consumption is projected to increase to 28 percent in 2030, and in the electric power sector its share is projected to rise from 43 percent in 2004 to 45 percent in 2030.

Figure 54. World Coal Consumption by Region, 1980-2030

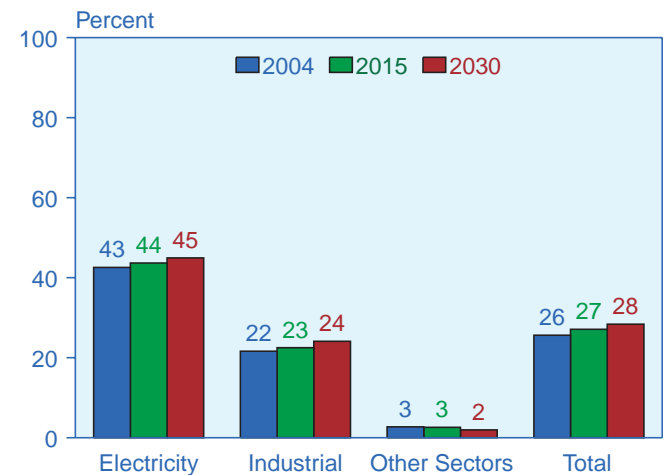


Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

Although coal currently is the second-largest fuel source of energy-related carbon dioxide emissions (behind oil), accounting for 39 percent of the world total in 2004, it is projected to become the largest source by 2010. The two key factors underlying the increase are a more rapid projected growth rate for world coal consumption than for oil consumption and the fact that carbon dioxide emissions per unit of energy output are higher for coal than for oil or natural gas. In 2030, coal's share of energy-related carbon dioxide emissions is projected to be 43 percent, compared with 36 percent for oil and 21 percent for natural gas.

International coal trade increases in the reference case from 18.4 quadrillion Btu in 2005 to 26.5 quadrillion Btu in 2030—an increase of 44 percent. Because the largest increase in consumption is projected for coal that is both produced and consumed domestically in China, the share of total world coal consumption accounted for by internationally traded coal falls from 15 percent in 2004 to 13 percent in 2030.

Figure 55. Coal Share of World Energy Consumption by Sector, 2004, 2015, and 2030



Sources: **2004:** Derived from Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **2015 and 2030:** EIA, System for the Analysis of Global Energy Markets (2007).

World Coal Reserves

Total recoverable reserves of coal¹⁰ around the world are estimated at 998 billion tons¹¹—reflecting a current reserves-to-production ratio of 164¹² (Table 8) [1]. 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 998 billion tons in 2003 [2]. The most recent assessment of world coal reserves includes a substantial downward adjustment for Germany, from 73 billion tons of recoverable coal reserves to 7 billion tons. The reassessment primarily reflects more restrictive criteria for the depth and thickness parameters associated with both underground and surface minable seams of coal [3].

Although coal deposits are widely distributed, 67 percent of the world's recoverable reserves are located in four countries: the United States (27 percent), Russia (17 percent), China (13 percent), and India (10 percent). In 2004, these four countries, taken together, accounted for 66 percent of total world coal production [4]. By rank, anthracite and bituminous coal account for 53 percent of the world's estimated recoverable coal reserves (on a tonnage basis), subbituminous coal accounts for 30 percent, and lignite accounts for 17 percent.

Quality and geological characteristics of coal deposits are important parameters for coal reserves. Coal is a heterogeneous source of energy, with quality (e.g., 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 27.4 million Btu per ton and relatively low sulfur content of approximately 0.8 percent by weight [5]. 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 2004 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 12.3 million Btu per ton in Canada [6].

World Coal Production

From 2004 to 2030, coal production in China, the United States, and India, driven by growing coal consumption, is projected to increase by 50.4 quadrillion Btu, 11.1 quadrillion Btu, and 5.7 quadrillion Btu, respectively (Table 9). It is assumed that most of the demand for coal in

Table 8. World Recoverable Coal Reserves as of January 1, 2003
(Billion Short Tons)

Region/Country	Bituminous and Anthracite	Subbituminous	Lignite	Total
World Total	528.8	298.1	170.9	997.7
United States ^a	123.7	110.3	33.5	267.6
Russia	54.1	107.4	11.5	173.1
China	68.6	37.1	20.5	126.2
India	99.3	0.0	2.6	101.9
Other Non-OECD Europe and Eurasia	50.1	18.7	31.3	100.1
Australia and New Zealand	42.6	2.7	41.9	87.2
Africa	55.3	0.2	*	55.5
OECD Europe	19.5	5.0	18.8	43.3
Other Non-OECD Asia	1.4	2.0	8.1	11.5
Brazil	0.0	11.1	0.0	11.1
Other Central and South America	8.5	2.2	0.1	10.8
Canada	3.8	1.0	2.5	7.3
Other ^b	1.8	0.4	0.1	2.3

^aData for the United States represent recoverable coal estimates as of January 1, 2006.

^bIncludes Mexico, Middle East, Japan, and South Korea.

*Less than 0.05 billion short tons.

Sources: **United States:** Energy Information Administration, unpublished data from the Coal Reserves Database (April 2007). **All Other Countries:** World Energy Council, *2004 Survey of Energy Resources*, Eds. J. Trinnaman and A. Clarke (London, UK: Elsevier, December 2004).

¹⁰Recoverable 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.

¹¹Throughout this chapter, tons refer to short tons (2,000 pounds).

¹²Ratio based on reserves data supplied in Table 8 and data on world coal production for 2004.

China, the United States, and India will continue to be met by domestic production. The projected increases in coal production for the three countries dominate the overall trends in the OECD and non-OECD regions, accounting for 71 percent of the increase in production for the entire OECD region and 79 percent of the increase in the non-OECD region. Increased demand for international trade is expected to support production increases in Australia/New Zealand, Russia, other non-OECD Asia, Africa, and Central and South America (excluding Brazil).

World Coal Consumption

OECD Countries

Coal consumption in the OECD countries rises at a relatively even pace in the reference case, from 46.6 quadrillion Btu in 2004 to 50.7 quadrillion Btu in 2015 and 59.3 quadrillion Btu in 2030 (Figure 56). The increases represent average growth of 0.9 percent per year over the entire period and a slightly higher rate of 1.1 percent per year from 2015 to 2030.

Table 9. World Coal Production by Region, 2004-2030
(Quadrillion Btu)

Region	2004	2010	2015	2020	2025	2030	Average Annual Percent Change, 2004-2030
OECD North America	24.6	27.0	28.3	29.4	33.3	37.0	1.6%
United States	22.8	24.6	25.8	26.7	30.4	33.9	1.5%
Canada	1.5	1.9	2.1	2.2	2.4	2.5	2.0%
Mexico	0.2	0.4	0.4	0.4	0.5	0.5	3.3%
OECD Europe	7.9	8.0	7.7	7.1	6.6	6.6	-0.7%
OECD Asia	8.1	9.7	10.4	11.2	11.9	12.7	1.7%
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	0.9%
Australia/New Zealand	8.1	9.6	10.2	11.1	11.9	12.6	1.7%
Total OECD	40.6	44.7	46.4	47.7	51.9	56.2	1.3%
Non-OECD Europe and Eurasia ...	10.0	11.5	12.5	13.3	13.6	13.7	1.2%
Russia	5.9	7.1	7.5	7.9	8.2	8.5	1.4%
Other	4.1	4.4	5.0	5.3	5.4	5.3	0.9%
Non-OECD Asia	55.2	70.6	82.4	94.7	105.4	116.7	2.9%
China	43.0	55.4	64.6	74.3	83.4	93.4	3.0%
India	7.3	8.1	9.5	10.8	12.0	13.0	2.3%
Other	4.9	7.1	8.3	9.6	10.0	10.3	2.9%
Middle East	*	*	*	*	*	*	-1.2%
Africa	5.9	7.1	7.7	8.0	8.6	8.9	1.6%
Central and South America	1.8	2.7	3.1	4.0	4.3	4.3	3.4%
Brazil	0.1	0.1	0.2	0.2	0.2	0.2	3.3%
Other	1.7	2.5	2.9	3.8	4.1	4.1	3.4%
Total Non-OECD	72.8	91.9	105.7	120.1	131.9	143.7	2.6%
Total World	113.4	136.6	152.1	167.7	183.8	199.9	2.2%

*Less than 0.05 quadrillion Btu

Note: With the exception of North America, non-seaborne coal trade is not represented in the *IEO2007* 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: **2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007) and National Energy Modeling System run IEO2007.D032707B.

Much of the increase in coal consumption projected for the OECD countries from 2004 to 2030 is the result of expected strong growth in U.S. coal demand, under the assumption that existing laws and policies remain in effect indefinitely. Moderate increases in coal consumption are projected for most of the OECD countries, including South Korea, Canada, Australia/New Zealand, and Mexico. In OECD Europe, natural gas is expected to capture an increasing share of the region's total energy mix, primarily displacing coal and liquids and, to a lesser extent, nuclear energy. Slow economic growth in Japan is projected to result in sluggish growth in overall energy demand, and as a result, the projection for Japan's coal consumption in 2030 is only slightly lower than its 2004 total.

North America

In 2004, the United States consumed 22.6 quadrillion Btu of energy from coal, accounting for 94 percent of total coal consumption in North America and 48 percent of the OECD total. U.S. coal consumption rises to 34.1 quadrillion Btu in 2030 in the reference case. The United States has substantial coal reserves and has come to rely heavily on coal for electricity generation, a trend that continues in the projections. Coal's share of total electricity generation in the United States (including electricity produced at combined heat and power plants in the industrial and commercial sectors) declines slightly, from 50 percent in 2004 to 49 percent in 2015, then rises to 57 percent in 2030.

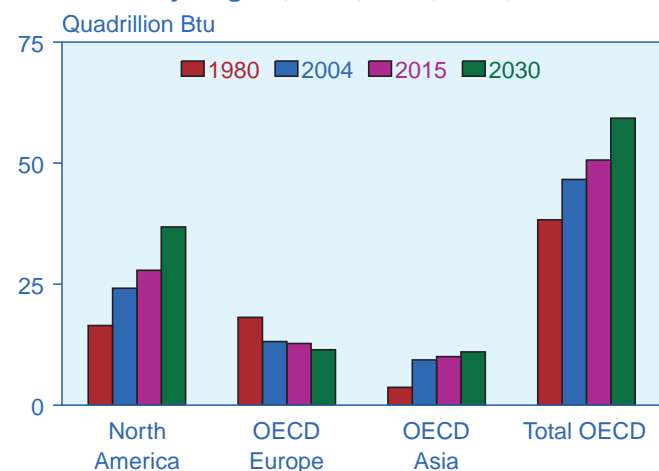
Much of the projected growth in U.S. coal consumption occurs after 2015. Between 2005 and 2015, natural gas prices are projected to decline, remaining competitive

with coal prices for electricity generation. Although some new natural-gas-fired capacity is projected to come on line during the period, much of the growth in electricity generation from natural gas is based on increasing utilization of the nearly 200 gigawatts of new natural-gas-fired capacity that came on line from 1999 through 2004. After 2015, rising natural gas prices gradually tilt economic decisions toward new coal-fired power plants. From 2015 to 2030, 140 gigawatts of new coal-fired capacity is projected to be built, representing 89 percent of the total coal builds projected for the years 2005 through 2030. These projections could change significantly if existing laws and policies, particularly those related to greenhouse gas emissions, were to change.

Canada's coal consumption is projected to increase from 1.2 quadrillion Btu in 2004 to 1.8 quadrillion Btu in 2030. In the short term, Canada's coal consumption remains near current levels, as the Ontario government moves ahead with plans to shut down the Province's 6.5 gigawatts of remaining coal-fired generating capacity by 2014 [7]. The government has indicated, however, that the shutdown will not be completed until generation from alternative sources can be secured. The decision to close the plants is based primarily on the premise that the adverse health and environmental impacts of the plants' operation are unacceptable. In western Canada, where most of the country's coal resources are located, increasing demand for electricity is expected to result in the need for additional coal-fired generating capacity.

In Mexico, relatively strong growth in overall energy demand leads to an increase in total coal consumption of 0.5 quadrillion Btu from 2004 to 2030. Mexico is projected to use more coal in 2030 both in the electric power sector and in the industrial sector.

Figure 56. OECD Coal Consumption by Region, 1980, 2004, 2015, and 2030



Sources: **1980 and 2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **2015 and 2030:** EIA, *System for the Analysis of Global Energy Markets* (2007).

¹³Internationally, 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.

OECD Europe

Coal consumption in OECD Europe declines by 1.7 quadrillion Btu (13 percent) from 2004 to 2030 in the *IEO2007* reference case; however, the region is and will continue to be a major market for coal. Coal consumption in OECD Europe, at 13.1 quadrillion Btu in 2004, represented 28 percent of total OECD coal use. It is projected to drop to 11.5 quadrillion Btu in 2030, or 19 percent of total OECD coal use.

The major coal-consuming countries of the region, all with consumption of 0.7 quadrillion Btu or more in 2004, include Germany, Poland, the United Kingdom, Spain, Turkey, and the Czech Republic. Although OECD Europe relies heavily on imports of hard coal,¹³ low-Btu lignite represents an important domestically produced source of energy. In 2004, lignite accounted for 47 percent of the region's total coal consumption on a tonnage basis and 23 percent on a Btu basis [8].

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 the region's overall energy mix. In addition to some recent additions of coal-fired capacity (primarily in Turkey), electricity producers in Germany, Spain, France, Italy, Poland, the Czech Republic, and Slovakia have revealed plans to upgrade or replace existing coal-fired generating facilities over the next two decades. Power producers in Germany plan to build nearly 11 gigawatts of new coal-fired generating capacity by 2012, primarily to replace existing, less efficient, coal-fired capacity [9]. A key incentive for the new coal builds in Germany is a provision guaranteeing carbon dioxide emission rights for the new capacity during the first 14 years of its operation.

Among the most important factors that keep coal consumption in OECD Europe from increasing in the projections is the region's relatively slow growth in overall energy consumption (0.4 percent per year). Contributing factors include continued penetration of natural gas in both the electricity and industrial sectors, growing use of renewable fuels in the region, and continuing pressure on members of the European Union to reduce subsidies that support domestic production of hard coal.

OECD Asia

In 2004, the countries of OECD Asia (Australia, New Zealand, Japan, and South Korea) consumed 9.3 quadrillion Btu of coal, representing 20 percent of total OECD coal consumption. In addition to being an important coal-consuming region, OECD Asia also plays an important role in international coal trade. In 2004, Australia was the world's leading coal exporter, supplying 5.6 quadrillion Btu of coal to the international market, while Japan and South Korea were the world's leading importers, receiving 4.6 and 2.0 quadrillion Btu of coal, respectively, from other countries [10].

In the *IEO2007* reference case, coal consumption in OECD Asia increases by 1.7 quadrillion Btu, to 11.0 quadrillion Btu in 2030. With little change projected for Japan's coal consumption, South Korea and Australia/New Zealand account for virtually all of the increase in the region.

Coal consumption in Australia and New Zealand is projected to increase by an average of 1.2 percent per year, from 2.4 quadrillion Btu in 2004 to 3.3 quadrillion Btu in 2030. With substantial coal reserves, the Australia/New Zealand region continues to rely heavily on coal for electricity generation; however, coal's share of total generation in the region is projected to decline gradually, as more natural gas is used for power generation. Coal-fired power plants in the two countries supplied 73 percent of their total electricity generation in 2004. That

share declines gradually in the reference case, to 63 percent in 2030.

South Korea's total annual coal consumption is projected to increase by 0.9 quadrillion Btu from 2004 to 2030, primarily to fuel electric power plants. Construction plans that have been announced by South Korea's generating companies indicate additional builds of 7.3 gigawatts of coal-fired capacity at existing sites over the next few years, including two 500-megawatt units that came on line at Korea East-West Power Company's Dangjin plant in 2005 and 2006 [11].

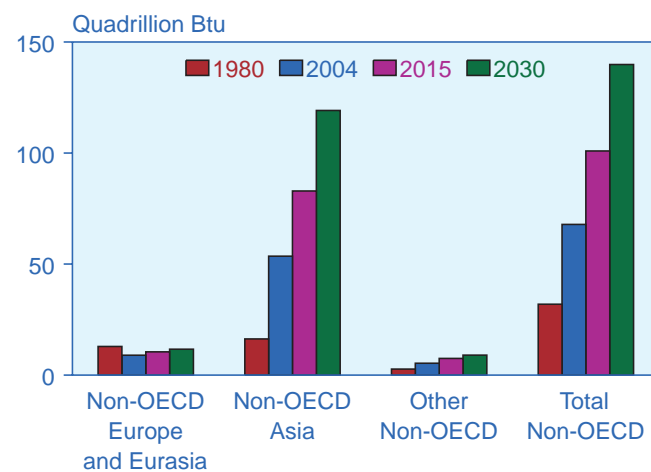
Non-OECD Countries

Led by strong economic growth and rising demand for energy in China and India, non-OECD coal consumption is projected to rise to 139.8 quadrillion Btu in 2030, more than double the quantity consumed in 2004 (Figure 57). The increase of 71.9 quadrillion Btu represents 85 percent of the projected increase in total world coal consumption. Coal's share of total energy consumption in the non-OECD region is projected to increase from 33 percent in 2004 to 35 percent in 2030. Total coal consumption in the non-OECD countries is projected to grow at an average annual rate of 3.7 percent from 2004 to 2015 and at a slower rate of 2.2 percent per year from 2015 to 2030, as the region's overall rate of economic growth begins to slow in the later years of the projection period.

Non-OECD Asia

China and India together account for 72 percent of the projected increase in world coal consumption from 2004 to 2030. Strong economic growth (averaging 6.5 percent

Figure 57. Non-OECD Coal Consumption by Region, 1980, 2004, 2015, and 2030



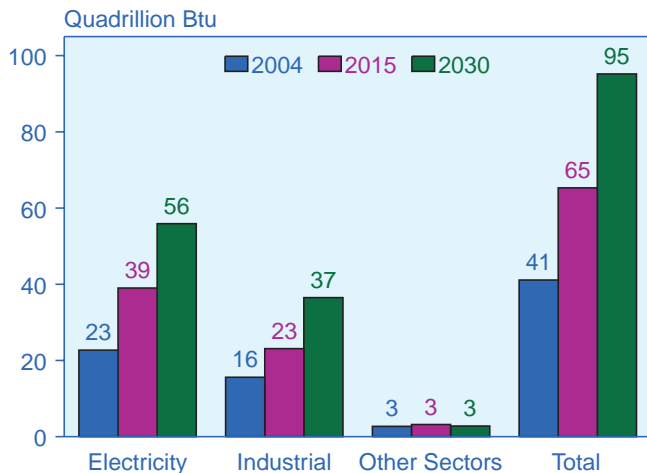
Sources: **1980 and 2004:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea. **2015 and 2030:** EIA, *System for the Analysis of Global Energy Markets* (2007).

per year in China and 5.7 percent per year in India from 2004 to 2030) is projected for both countries, and much of the increase in their demand for energy, particularly in the industrial and electricity sectors, is expected to be met by coal.

Coal use in China's electricity sector is projected to increase from 22.7 quadrillion Btu in 2004 to 55.9 quadrillion Btu in 2030, at an average rate of 3.5 percent per year (Figure 58). In comparison, coal consumption in the U.S. electricity sector is projected to grow by 1.7 percent annually, from 20.3 quadrillion Btu in 2004 to 31.1 quadrillion Btu in 2030. At the end of 2004, China had an estimated 271 gigawatts of coal-fired capacity in operation. To meet the demand for electricity that is expected to accompany its rapid economic growth, an additional 497 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.

Nearly one-half (45 percent) of China's coal use in 2004 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 2004 [12]. Over the projection period, coal demand in China's non-electricity sectors is expected to more than double, increasing by 20.9 quadrillion Btu. Despite such substantial growth, however, the non-electricity share of total coal demand is projected to decline slightly, to 41 percent of total coal demand in 2030. Coal remains the primary source of energy in China's industrial sector, primarily because the country has only limited reserves of oil and natural gas.

Figure 58. Coal Consumption in China by Sector, 2004, 2015, and 2030



Sources: **2004:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea. **2015 and 2030:** EIA, *System for the Analysis of Global Energy Markets* (2006).

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 promoting the development of a large coal-to-liquids industry. Initial production of coal-based synthetic liquids in China is scheduled to commence in late 2007 with the completion of the country's first coal-to-liquids plant, located in the Inner Mongolia Autonomous Region [13]. It is being built by the Shenhua Coal Liquefaction Corporation and will have an initial capacity of approximately 20,000 barrels per day, tentatively scheduled to be increased to 100,000 barrels per day by 2010.

In another development, China's Shenhua and Ningxia Industry Groups are proceeding with feasibility studies for the construction of two 80,000 barrel per day coal-to-liquids plants to be sited in the Ningxia Autonomous Region and the Shaanxi Province. Although China's government and industry have proposed to build as much as 1.0 million barrels of daily coal-to-liquids capacity by 2020, considerable uncertainty and risks are associated with the emergence of such a massive coal-to-liquids industry, including potential strains on water resources and the general financial risks associated with the technological uncertainties and huge capital investments.

Nearly 70 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 2004, India's coal-fired power plants consumed 5.6 quadrillion Btu of coal, representing 69 percent of the country's total coal demand. Coal use for electricity generation in India is projected to grow by 2.4 percent per year, to 10.5 quadrillion Btu in 2030, as an additional 104 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 *IEO2007* projections, from 82 gigawatts in 2004 to 186 gigawatts in 2030.

Currently, India's government indicates that 11 gigawatts of new coal-fired generating capacity will be completed during its tenth power plan period (a 5-year period ending in March 2007), and it is planning to complete more than 50 gigawatts of new coal-fired capacity during its eleventh plan period (ending in March 2012) [14]. In addition, India's government is also pursuing the development of between five and seven large coal-fired power projects that would have between 20 and 28 gigawatts of combined generating capability [15].

In other non-OECD Asia, coal consumption is projected to grow by an average of 2.8 percent per year, from 4.3 quadrillion Btu in 2004 to 8.8 quadrillion Btu in 2030, with increases in both the industrial and electric power 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 1.0 percent per year, from 9.0 quadrillion Btu in 2004 to 11.7 quadrillion Btu in 2030. The region has substantial coal reserves: Russia alone has an estimated 173 billion tons of recoverable reserves (17 percent of the world total), and the other countries in the region have an additional 100 billion tons (10 percent of the world total).

Russia is the largest coal consumer in the region, with total consumption of 4.8 quadrillion Btu in 2004, corresponding to 54 percent of total coal consumption in non-OECD Europe and Eurasia. In 2030, Russia's coal use is projected to total 6.1 quadrillion Btu. Coal supplied 16 percent of Russia's total energy requirements in 2004, and coal-fired power plants provided 20 percent of its electricity. In the *IEO2007* reference case, coal's share of Russia's total energy consumption is projected to drop slightly, to 15 percent in 2030, and its share of electricity generation is projected to decline to 16 percent in 2030. In most cases, natural gas is expected to be the most economical option for new generating capacity in Russia, although nuclear generation also is expected to increase substantially through 2030. The natural gas share of Russia's total electricity generation is projected to rise from 44 percent in 2004 to 48 percent in 2030.

Although Russia's long-term energy strategy calls for considerable new nuclear generating capacity, the government maintains that fossil-fuel-fired plants will continue in their role as the primary source for electric power generation through 2020 [16]. For new fossil-fired generating capacity, Russia's energy strategy promotes the construction of advanced coal-fired capacity in the coal-rich Siberian region (central Russia) and recommends a focus on efficient natural-gas-fired capacity for the western and far eastern areas of the country.

In other non-OECD Europe and Eurasia, coal consumption is projected to increase from 4.2 quadrillion Btu in 2004 to 5.6 quadrillion Btu by 2030, growing by 1.1 percent per year on average. Plans for both new coal-fired capacity and the refurbishment of existing capacity in a number of countries, including Bosnia and Herzegovina, Serbia and Montenegro, Bulgaria, Romania, and Ukraine, are a significant indication that coal will continue to be an important source of energy for the region [17].

Africa

Africa's coal consumption is projected to increase by 2.6 quadrillion Btu from 2004 to 2030. South Africa currently accounts for 94 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 [18]. The plants, with a combined generating capacity of 3.8 gigawatts, are scheduled to return to service in 2007. Recent power shortages and the general lack of spare generating capacity in southern Africa have led to increased interest in new coal-fired power projects not only in South Africa but also in Mozambique, Zimbabwe, Tanzania, and Botswana [19].

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-sized coal-to-liquids plants in South Africa (Sasol II and Sasol III) supply about 28 percent of the country's total liquid fuel requirements [20]. The two plants together are capable of producing 150,000 barrels of synthetic liquids per day.

Central and South America

The countries of Central and South America consumed 0.8 quadrillion Btu of coal in 2004. Brazil, with the world's eighth-largest steel industry in 2004, accounted for 56 percent of the region's coal demand. Chile, Colombia, Puerto Rico, Peru, and Argentina accounted for most of the remainder [21].

In the projections, coal consumption in Central and South America increases by 0.9 quadrillion Btu from 2004 to 2030, with 72 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 [22]. In addition, Brazil's three southernmost states, Rio Grande do Sul, Santa Catarina, and Parana, which contain most of the country's coal reserves, are actively promoting the construction of several new coal-fired power plants [23]. The new projects being promoted by the government of Rio Grande do Sul represent a key component of its plan to become more self-sufficient in electricity supply.

Middle East

Countries of the Middle East consumed 0.4 quadrillion Btu of coal in 2004. Israel accounted for 86 percent of the total and Iran most of the remainder. The region's coal consumption increases only slightly in the projections, to 0.6 quadrillion Btu in 2030.

World Coal Trade

In addition to overall energy demand and the price of coal, many factors have the potential to influence different countries' ability and interest in exporting and importing coal. They include mine productivity, inland transportation infrastructure, and the port capacity of both importing and exporting countries. Shifts in public policy, as well as environmental concerns related to either coal production or coal consumption, can affect the amounts of coal traded. Uncertainty in the outlook for international coal trade includes potential changes in each of those factors.

Internationally traded coal made up 15 percent of total world consumption in 2004. In the *IEO2007* reference case, world coal trade is projected to grow at an average annual rate of 1.5 percent, from about 18.4 quadrillion Btu in 2005 to 26.5 quadrillion Btu in 2030 (Table 10). Because the largest increases in coal consumption through 2030 are projected for non-OECD Asia—particularly China, which is expected to satisfy most of the increase in its coal demand from domestic mines rather than imports—the share of coal trade as a percentage of global coal consumption is projected to fall to 13 percent in 2030. Australia and Indonesia are geographically well situated to continue as the leading suppliers of internationally traded coal (particularly to Asia) over the period.

Both steam and metallurgical coal are traded internationally, but most of the trade is in steam coal, which is projected to continue to represent most (70 percent) of the coal traded in 2030. In 2005, 55 percent of the world's exports of steam coal was imported by Asian countries, and their share is projected to rise to 61 percent in 2030. The share of metallurgical coal imports destined for Asian countries is projected to increase from 61 percent in 2005 to 68 percent in 2030.

Coal Exporters

Coal-exporting countries typically have large reserves of high-quality coal and production capacity exceeding their own domestic demand requirements. The top four exporters of steam coal in 2005 were Australia, Indonesia, China, and South Africa. In the projections, Indonesia is expected to surpass Australia as the largest exporter of steam coal in most years, and 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. Countries projected to expand their contributions to international trade include Australia, Indonesia, and Russia. China and Vietnam are projected to constrain their export expansion.

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. It has plans to expand coal terminals at Abbot Point, Dalrymple Bay, Hay Point, RG Tanna, Barney Point, and Fisherman Islands by about 55 million tons by 2010 and to expand rail transportation capacity in Queensland, where most of Australia's metallurgical coal is mined, to about 280 million tons (6.8 quadrillion Btu¹⁴) [24]. Australia also is projected to remain the primary exporter of metallurgical coal to Asian markets, supplying 73 percent of Asia's demand for coking coal.

In the international market for steam coal, Indonesia is expected to play a growing role, surpassing Australia as the largest exporter of steam coal in most years of the *IEO2007* projections. 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's export trade grew by 125 percent (79 million tons or 1.6 quadrillion Btu) from 2000 to 2005 [25]. For 2006, Indonesia is expected to beat its 2005 export volume by 0.7 quadrillion Btu. From 2005 to 2030, its annual exports are projected to increase by 1.7 quadrillion Btu, depending on its investment in resource exploration and the development of new mines over the period. Other areas of uncertainty for Indonesian exports include the potential for domestic coal demand to compete with coal exports, the adequacy of its internal transportation infrastructure, and domestic environmental concerns.

In the period following the breakup of the Soviet Union in 1991, exports of steam coal from Eurasia (the countries of the former Soviet Union) fell from 11 million tons (0.2 quadrillion Btu) in 1991 to 3 million tons (0.08 quadrillion Btu) in 1998 [26]. Russia, the region's largest exporter, was largely dismissed as a growing coal exporter because of its low mine productivity, relatively poor coal quality, and long distances between mines and markets. Since then, however, the productivity of its coal mines has improved, lowering mining costs and compensating in part for the expense of transporting the coal to ports.

Europe, particularly the United Kingdom, has increasingly sought Russia's low-sulfur coal as its own mines have closed. From 1998 to 2005, Eurasia's annual coal exports increased by 56 million tons (1.2 quadrillion Btu) [27], and Russia is continuing to increase the capacity of its coal ports. Current plans call for an additional increase in export capacity from about 72 million tons (1.6 quadrillion Btu) in 2005 to 97 million tons (2.1

¹⁴Throughout this section, British thermal units appearing in parentheses are estimates by Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table 10. World Coal Flows by Importing and Exporting Regions, Reference Case, 2005, 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
2005												
Australia	0.08	2.57	0.15	2.81	0.79	2.26	0.22	3.27	0.86	4.83	0.37	6.07
United States	0.08	0.03	0.36	0.47	0.44	0.10	0.22	0.77	0.52	0.13	0.58	1.23
South Africa	1.54	0.10	0.03	1.70	0.02	0.00	0.00	0.03	1.56	0.10	0.03	1.73
Eurasia	0.92	0.29	0.00	1.22	0.08	0.10	0.00	0.18	1.00	0.40	0.00	1.40
Poland	0.33	0.00	0.00	0.34	0.04	0.00	0.00	0.04	0.37	0.00	0.00	0.37
Canada	0.00	0.02	0.01	0.04	0.24	0.38	0.11	0.72	0.24	0.41	0.12	0.76
China	0.07	1.62	0.01	1.70	0.00	0.14	0.00	0.14	0.07	1.76	0.01	1.84
South America ^d	0.86	0.00	0.77	1.63	0.00	0.00	0.00	0.00	0.86	0.00	0.77	1.63
Vietnam	0.00	0.28	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.28
Indonesia/Other ^e	0.42	2.06	0.08	2.57	0.00	0.46	0.00	0.46	0.42	2.52	0.08	3.03
Total	4.30	6.98	1.41	12.75	1.61	3.44	0.56	5.60	5.91	10.41	1.97	18.35
2015												
Australia	0.00	3.33	0.00	3.33	0.64	3.20	0.27	4.10	0.64	6.53	0.27	7.43
United States	0.07	0.03	0.19	0.29	0.33	0.03	0.35	0.71	0.41	0.06	0.54	1.00
South Africa	1.69	0.31	0.13	2.13	0.02	0.00	0.02	0.04	1.71	0.31	0.15	2.17
Eurasia	1.35	0.54	0.00	1.89	0.08	0.23	0.00	0.31	1.43	0.77	0.00	2.20
Poland	0.13	0.00	0.02	0.15	0.03	0.00	0.00	0.03	0.16	0.00	0.02	0.18
Canada	0.00	0.00	0.00	0.00	0.29	0.54	0.13	0.96	0.29	0.54	0.13	0.96
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 ^d	1.42	0.00	1.25	2.66	0.00	0.00	0.00	0.00	1.42	0.00	1.25	2.66
Vietnam	0.00	0.16	0.00	0.16	0.00	0.01	0.00	0.01	0.00	0.16	0.00	0.16
Indonesia/Other ^e	0.00	3.66	0.13	3.79	0.00	0.43	0.00	0.43	0.00	4.09	0.13	4.22
Total	4.67	9.10	1.70	15.48	1.39	4.46	0.76	6.61	6.06	13.56	2.47	22.09
2030												
Australia	0.00	4.17	0.00	4.17	0.84	3.88	0.41	5.13	0.84	8.05	0.42	9.31
United States	0.00	0.01	0.16	0.17	0.26	0.04	0.46	0.76	0.26	0.05	0.62	0.93
South Africa	1.44	0.73	0.18	2.36	0.00	0.00	0.02	0.02	1.44	0.73	0.21	2.38
Eurasia	1.25	0.66	0.00	1.90	0.16	0.27	0.00	0.43	1.41	0.93	0.00	2.33
Poland	0.07	0.00	0.03	0.10	0.01	0.00	0.00	0.01	0.08	0.00	0.03	0.11
Canada	0.00	0.00	0.00	0.00	0.28	0.66	0.11	1.04	0.28	0.66	0.11	1.04
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 ^d	1.58	0.00	2.19	3.77	0.00	0.00	0.00	0.00	1.58	0.00	2.19	3.77
Vietnam	0.00	0.80	0.00	0.80	0.00	0.01	0.00	0.01	0.00	0.80	0.00	0.80
Indonesia/Other ^e	0.00	3.90	0.35	4.26	0.00	0.43	0.00	0.43	0.00	4.33	0.35	4.68
Total	4.33	11.35	2.93	18.61	1.55	5.31	1.00	7.86	5.88	16.65	3.93	26.47

^aEurope/Mediterranean, including coal shipments to the Middle East and Africa.

^bIn 2005, total world coal flows include a balancing item used to reconcile discrepancies between reported exports and imports. The 2005 balancing items by coal type were 1.062 quadrillion Btu (steam coal), 0.003 quadrillion Btu (coking coal), and 0.065 quadrillion Btu (total).

^cIncludes 0.37 quadrillion Btu of coal for pulverized coal injection at blast furnaces shipped to Japanese steelmakers in 2005.

^dCoal exports from South America are projected to originate from mines in Colombia and Venezuela.

^eIncludes shipments from other countries not modeled for the projection period. The 2005 exports from other countries by coal type were 0.08 quadrillion Btu (steam coal), 0.03 quadrillion Btu (coking coal), and 0.11 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: **2005:** SSS Consultancy and Research, Ltd., *SSS's Coal Trade Forecast*, Vol. 15, No. 2 (London, UK, August 2006); and Energy Information Administration, *Quarterly Coal Report*, October-December 2005, DOE/EIA-0121(2005/4Q) (Washington, DC, March 2006). **2015 and 2030:** Energy Information Administration, National Energy Modeling System, run IEO2007.D032707B.

quadrillion Btu) by 2008 [28]. In 2030, Eurasia's coal exports are projected to be 0.93 quadrillion Btu, or 67 percent, higher than the 2005 level.

In non-OECD Asia, China and Vietnam are examples of countries that have the potential to export more coal but are focused instead on meeting domestic coal demand. Whereas China in the past had offered an export tax rebate of 8 percent to encourage exports, it has now imposed a 5-percent export tax on coking coal and may apply an export tax on steam coal in the future [29]. China has also lowered its export cap to 46 million tons (1.1 quadrillion Btu) for 2007 [30], equivalent to about one-half of China's steam coal exports in 2003. Australia, Indonesia, and other suppliers are projected to compensate for the shortfalls in China's coal exports, as occurred in 2005 when China reduced its exports by 16 million tons (0.4 quadrillion Btu) from their 2004 level [31].

Vietnam's coal exports have risen quickly in recent years, from 7 million tons (0.1 quadrillion Btu) in 2003 to 14 million tons (0.3 quadrillion Btu) in 2005, and are projected to increase to 19 million tons (0.4 quadrillion Btu) in 2006. More recently, however, despite previous indications of plans to expand its export capacity, Vietnam has moved to restrict exports. In 2006, the Vietnamese government sanctioned a tariff of 10 percent on exported coal, where previously there had been none; and in late 2006, the Prime Minister approved a plan to restrict coal exports through 2010 in favor of preserving coal production for domestic uses [32]. In the *IEO2007* reference case, Vietnam's coal exports are projected to decline to 0.2 quadrillion Btu in 2010 but increase thereafter, to 0.8 quadrillion Btu in 2030.

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 either as an importer or an exporter. If China's imports increase significantly, it may be difficult for some other countries to find adequate coal supplies at affordable prices. Likewise, if China opts to export significantly less coal, other exporting countries may divert supplies to countries such as Japan, Taiwan, and Korea, which are accustomed to receiving coal from China. In *IEO2007*, in line with the projection of continued strong growth in its coal consumption, China's coal imports are projected to total 3.2 quadrillion Btu in 2030, while its exports are projected to total 1.1 quadrillion Btu. Most of the coal consumed in China is expected to come from its own coal mines.

In India, demand for coal imports in 2030 is projected to be almost double the demand in 2005, as the country continues to encounter problems with coal production and transportation within its borders. Japan, lacking coal resources of its own, is expected to remain the

world's largest importer of coal in 2030. Historically, Japan has relied on China for coal imports, but recently it has initiated investments in coal production in other countries (including Russia) in order to improve the security of its coal supply [33]. South Korea also is projected 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 their share of world steam coal imports at about 21 percent in 2030.

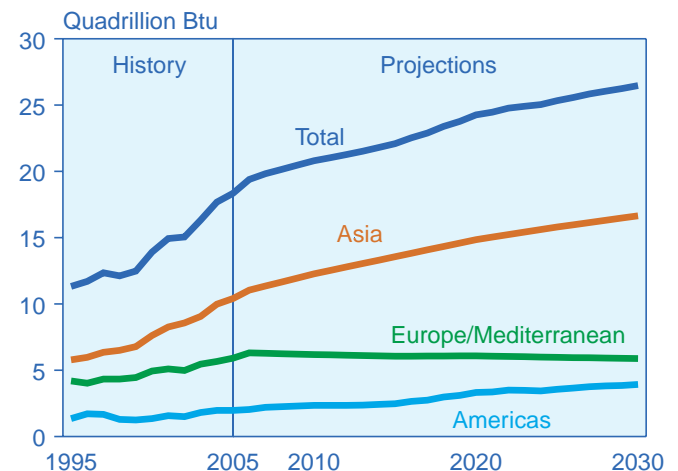
Europe, Middle East, and Africa

Total coal imports to the Europe/Mediterranean market (including the Middle East and Africa) will remain fairly flat at their 2005 levels throughout the projection period (Figure 59). For most European countries with increasing emphasis on natural gas in the power sector, coal becomes a less significant component of the fuel mix for electricity generation. In Turkey, however, economic expansion and steel industry growth partially offset the decline in Europe's coal imports. The initial increase in coal trade to Europe in the projections also is the result of the phaseout of European mining subsidies and higher demand for lower sulfur coal. The demand for lower sulfur coal causes an increase in the projected share of Europe's coal imports that originates from South America and Eurasia.

The Americas

The United States is projected to import 2.1 quadrillion Btu of coal in 2030, 1.3 quadrillion Btu more than in 2005.

Figure 59. Coal Imports by Major Importing Region, 1995-2030



Sources: **History:** SSY Consultancy and Research, Ltd., *SSY's Coal Trade Forecast*, Vol. 15, No. 3 (London, UK, November 2006); International Energy Agency, *Coal Information 2006* (Paris, France, August 2006), and previous issues; and Energy Information Administration (EIA), *Quarterly Coal Report*, October-December 2005, DOE/EIA-0121(2005/4Q) (Washington, DC, March 2006), 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 IEO2007.D032707B.

Although still a small share of U.S. consumption, at 6.1 percent, that would represent a shift for the United States from being a net exporter to being a net importer. With declining productivity and mining difficulties in Central Appalachia, and with rising demand for coal in the Southeast, imports are expected to become increasingly competitive with domestic U.S. coal production. Already, plans are being made to expand U.S. ports to accommodate coal imports. For example, Kinder Morgan Energy Partners LP is adding 9 million tons (roughly 0.2 quadrillion Btu) of coal import capacity at its Virginia port facilities in early 2008 [34].

South America is expected to be an important source of coal imports to the United States and the third-largest exporter of coal worldwide in 2030. In recent years, Canada has been the largest importer of U.S. coal. Although Ontario's revised plan to close its four remaining coal-fired generation plants by 2014 could be delayed, exports of U.S. steam coal to Canada in 2030 are projected to be about 10 million tons (0.2 quadrillion Btu) below their 2005 level [35].

Brazil is planning a 39-percent increase in steelmaking capacity by 2010 [36]. With rich reserves of iron ore but no coking-grade coal, Brazil's steel industry will require an increase in imports of coking coal from Australia, South Africa, Canada, and the United States. Its total imports of coking coal are projected to grow from about 0.3 quadrillion Btu in 2005 to 0.7 quadrillion Btu in 2030. Much of the steam coal imported by the countries of Central and South America is expected to come from producers in South Africa and also from Colombia.

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