3 The Worldwide Distribution of Coal

Coal is the dominant fuel source in the entire world. Current production and consumption, along with projected usage, was discussed in Chapter 1. This chapter presents information on coal resources and recoverable reserves in the world, with an emphasis on coals and coalfields in the United States, to illustrate the vast resources of this fuel source. By the end of 2007, recoverable coal reserves in the United States, which contains the world's largest coal reserves, totaled 264 billion short tons [1] compared to a total world reserve of 930 billion short tons (as of 2006) [2]. On an oil-equivalent basis, there is more than twice as much recoverable coal in the world as there is oil and natural gas combined [3]. Consequently, coal has been and will continue to be a major economic/energy resource.

3.1 Coal Distribution and Resources

Coal deposits are broadly categorized into resources and reserves. Resources refer to the quantity of coal that may be present in a deposit or coalfield but may not take into account the feasibility of mining the coal economically. Reserves generally tend to be classified as proven or measured and probable or indicated, depending on the level of exploration of the coalfield. The basis for computing resources and reserves varies among countries, which makes it difficult to do direct comparisons. In addition, the techniques are constantly being refined, thereby resulting in variability from year to year. Walker [4] discusses some of the various measurement criteria used by the major coal-producing countries in the world in detail. Similarly, EIA discusses measurement criteria as well [2].

Figure 3.1 illustrates the relationship between coal resources (as of 1997) and reserves (as of 2007) in the United States [1, 5]. The United States has a total of nearly 4,000 billion short tons of coal resources, with approximately 19 billion short tons classified as recoverable reserves at active mines out of 263 billion short tons that are economically recoverable.

The definitions used in Figure 3.1 are as follows:

- *Total resources*—coal that can currently or potentially in the future be extracted economically
- *Measured resources*—the quantity of coal that has been determined to a high degree of geologic assurance
- *Indicated resources*—the quantity of coal that has been determined to a moderate degree of geological assurance

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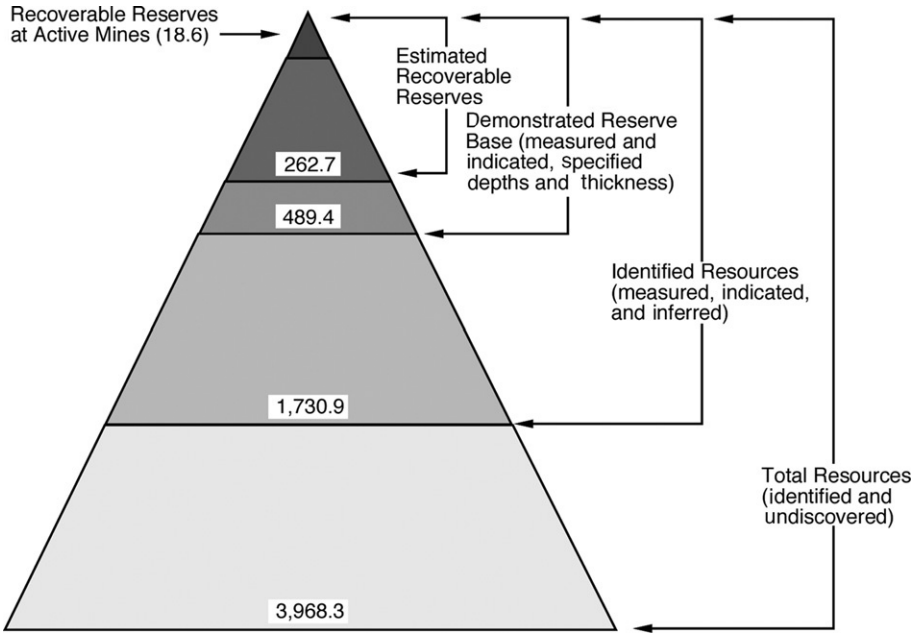

Figure 3.1 U.S. coal resources and reserves in billion short tons.
Source: From EIA, Annual Energy Review 2007 (2008), and EIA, U.S. Coal Reserves: 1997 Update (1999).

- *Inferred resources*—the quantity of coal that has been determined with a low degree of geologic assurance
- *Recoverable reserves*—coal that can be recovered economically with technology that is currently available or in the foreseeable future

Terminology also varies among countries and can contribute to confusion when comparing coal resources and reserves. For purposes of discussion in this section, recoverable coal reserves will primarily be used when comparing world coal deposits to lessen confusion.

3.1.1 Coal Reserves throughout the World

Coal is the most abundant fossil fuel in the world. BP [2008] reports that as of 2008, oil reserves were 186 gigatons (Gt) (converted to short tons from metric tons), representing a reserve-to-production (R/P) ratio of 42 years, while natural gas reserves were 175 gigatons of oil equivalent (Gtoe), with a R/P ratio of 60 years. Coal was calculated to have reserves of approximately 444 Gtoe (based on a hard coal:brown coal/lignite ratio of 0.6:0.4) and a R/P ratio of 147 years—roughly 45 percent more than oil and natural gas combined. Coal reserves are also more widely distributed throughout the world, as shown in Figure 3.2. All major regions of the world contain appreciable quantities of coal except for the Middle East, which is

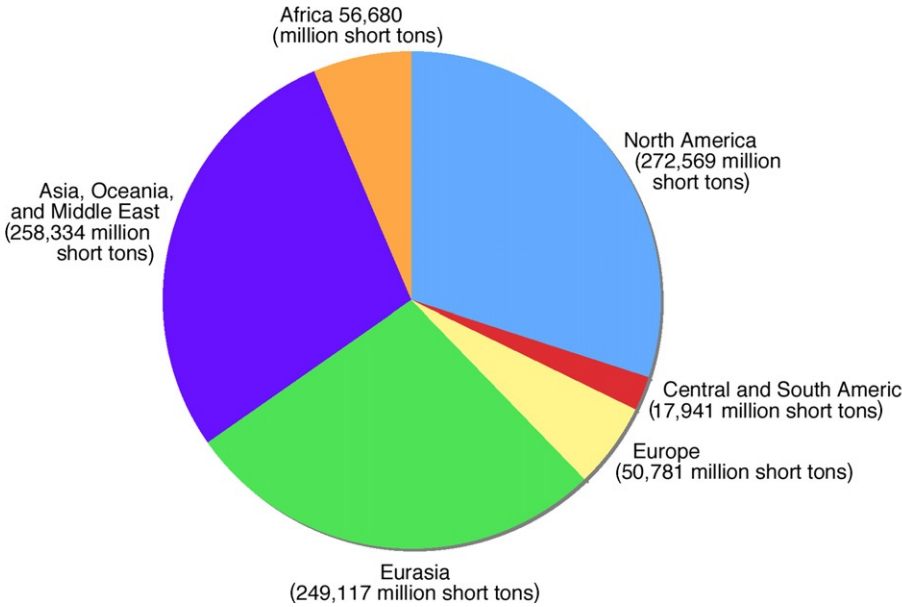

Figure 3.2 Distribution of recoverable coal reserves in the world.
Source: From Energy Information Administration, Annual Energy Review 2007.

not shown separately on Figure 3.2 because only Iran has coal reserves, totaling 462 million short tons, which is only 0.04 percent of the world total. The Middle East, on the other hand, contains almost two-thirds of the world oil reserves and over 41 percent of the natural gas reserves [3].

Coal is available in almost every country worldwide, with recoverable reserves in around 70 countries. Total recoverable reserves of coal around the world are estimated at more than 930 billion short tons [1]. According to the Energy Information Administration [1], this is enough coal to last approximately 150 years at current consumption levels. However, this could be extended still further by the discovery of new reserves through ongoing and improved exploration activities and by advances in mining techniques that will allow previously inaccessible reserves to be reached.

Historically, estimates of world recoverable coal reserves have declined from 1,174 billion short tons in 1990 to 1,001 billion short tons in 2003 to 930 billion short tons in 2007 [2, 6]. Recent assessments of world coal reserves include a significant downward adjustment for Germany, from about 73 billion short tons of recoverable coal reserves to 7 billion short tons. The reassessment reflects more restrictive criteria for various parameters. This downward trend is also observed in other countries as well.

A detailed breakdown of EIA's estimated recoverable world coal reserves of 930 billion short tons is provided in Table 3.1 [1]. This table classifies the recoverable coal reserves in two major categories: recoverable anthracite and bituminous coal (i.e., hard coal) and recoverable lignite and subbituminous coal—for the major regions and countries of the world.

Table 3.1 World Estimated Recoverable Coal Reserves (million short tons)

Region/Country	Anthracite and Bituminous Coal	Lignite and Subbituminous Coal	Total
North America			
Canada	3,826	3,425	7,251
Greenland	0	202	202
Mexico	948	387	1,335
United States	122,001	141,780	263,781
Total	**126,776**	**141,780**	**272,569**
Central and South America			
Brazil	0	7,791	7,791
Chile	34	1,268	1,302
Colombia	7,251	420	7,671
Peru	154	0	154
Other	529	494	1,023
Total	**7,969**	**9,973**	**17,941**
Europe[a]			
Bulgaria	6	2,195	2,200
Czech Republic	1,844	3,117	4,962
Former Serbia and Montenegro	7	15,299	15,306
Germany	168	7,227	7,394
Greece	0	4,299	4,299
Hungary	219	3,420	3,640
Poland	6,627	1,642	8,270
Romania	13	452	465
Turkey	0	2,000	2,000
United Kingdom	171	0	171
Other	241	1,834	2,076
Total	**9,296**	**41,485**	**50,781**
Eurasia[b]			
Kazakhstan	31,052	3,450	34,502
Russia	54,110	118,964	173,074
Ukraine	16,922	20,417	37,339
Uzbekistan	1,102	2,205	3,307
Other	0	895	895
Total	**103,186**	**145,931**	**249,117**
Africa			
Botswana	44	0	44
South Africa	52,911	0	52,911

Table 3.1 *Cont'd*

Region/Country	Anthracite and Bituminous Coal	Lignite and Subbituminous Coal	Total
Zimbabwe	553	0	553
Other	980	192	1,172
Total	**54,488**	**192**	**54,680**
Middle East, Asia, and Oceania[a]			
Australia	40,896	43,541	84,437
China	68,564	57,651	126,215
India	57,585	4,694	62,278
Indonesia	1,897	2,874	4,771
Korea, North	331	331	661
Pakistan	1	2,184	2,185
Thailand	0	1,493	1,493
Other	2,249	1,046	3,295
Total	**171,522**	**113,813**	**285,334**
World Total	**473,236**	**457,186**	**930,423**

[a]Excludes countries that were part of the former U.S.S.R.
[b]Includes only countries that were part of the former U.S.S.R.

Source: From Energy Information Administration, Annual Energy Review 2007.

Although coal deposits are widely distributed, 82 percent of the world's recoverable reserves are located in six countries: the United States (~28 percent; ~264 billion short tons), Russia (~19 percent; ~172 billion short tons), China (13 percent; 126 billion short tons), Australia (~9 percent; 84 billion short tons), India (~7 percent; ~62 billion short tons), and South Africa (~6 percent; ~53 billion short tons). Figure 3.3 shows the ten countries that have the largest recoverable coal reserves. Approximately 70 countries contain recoverable coal, but those in the figure contain more than 856 billion short tons, or more than 92 percent of the world's total.

Table 3.2 lists the major coal-producing countries/regions and their reserves-to-production (R/P) ratio in years. These data are based on recoverable reserves and production from IEA [2] as of 2009, and they differ slightly from BP data [3] (e.g., BP reports a world R/P ratio of 147 years, and IEA reports a world R/P ratio of 143 years). The IEA data are reported here because they provide a clearer breakdown of coal rank (i.e., subdividing subbituminous coal and lignite), whereas BP combines the two lower-rank coals into one category. The data are comparable between the two data sets, but what is especially worth noting is that the R/P ratio varies from 30 to 50 years for some countries/regions with heavy usage and/or low reserves to more than 1,000 years for countries with little or no production. Most major coal-producing countries are in the almost 100- to 250-year range, except for China. Note that China, which is a country with the third largest recoverable reserves in the world, has an R/P ratio of 52 years. This is low compared to

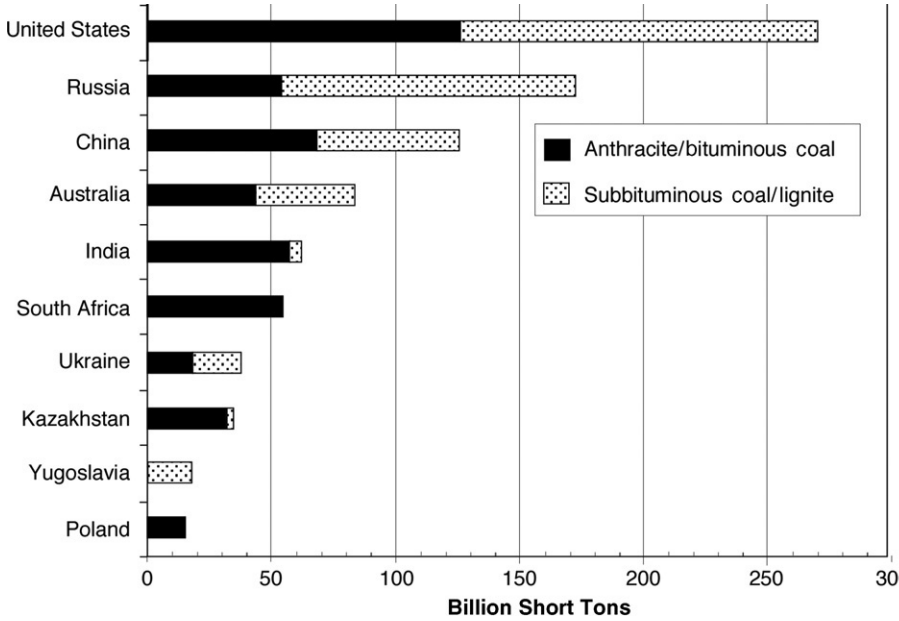

Figure 3.3 Countries with the largest recoverable coal reserves.

countries such as the United States (233 years) or Russia (540 years), which are the two leading countries with recoverable reserves.

3.2 Major Coal-Producing Regions in the World

Coal is found on all inhabited continents of the world. It is very likely that coal is also on Antarctica, particularly when one looks at the coal-forming periods in history and the corresponding locations of the present-day continents. A review of the major coal-producing countries in the world, summarized by coal-producing region, follows.

3.2.1 North America

The recoverable coal reserves of North America are the second largest in the world, with more than 272,000 million short tons identified (see Table 3.1). Coal is found in the United States, Canada, Mexico, and, to a much lesser extent, Greenland.

United States

The coal reserves of the United States are the largest of any country in the world, with about 263,000 to 264,000 million short tons [1, 7]. Recoverable coal reserves are found in 32 of the states, with the major coalfields shown in Figure 1.16. The 11 states with the largest recoverable coal reserves are listed in Table 3.3, and they contain approximately 91 percent of the total coal in the United States [7].

Table 3.2 World Recoverable Coal Reserves (billion short tons) and Reserves-to-Production Ratio (years)

	2006–2008 Recoverable Reserves by Coal Rank					
	Bituminous Coal and Anthracite	Subbituminous Coal	Lignite	Total	2005 Production	R/P Ratio (years)
World Total	**471.8**	**293.6**	**165.0**	**930.4**	**6.5**	**143**
United States	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	196
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	**3.8**	**2.7**	**4.5**	**9.7**	**0.3**	**34**
Brazil	0.0	7.8	0.0	7.8	<0.1	1,131
Canada	3.8	1.0	2.5	7.3	0.1	101
Other	2.9	0.5	0.1	3.4	<0.1	207

Source: From Energy Information Administration, Annual Energy Review 2007.

The top five states contain more than 70 percent of the total recoverable coal reserves in the United States. After New Mexico and North Dakota, which each have recoverable reserves of about 6,900 million short tons, the state with the next largest reserve total is Missouri, with almost 3,800 million short tons. After that, recoverable reserve totals for the other states are less than 3,000 million short tons per state.

Of the four ranks of coal in the United States—that is, anthracite, bituminous, subbituminous, and lignite—bituminous coal accounts for 53 percent of demonstrated reserve base (see Figure 3.1). Bituminous coal is concentrated primarily east of the Mississippi River, with the greatest amounts in Illinois, West Virginia, Kentucky, Pennsylvania, and Ohio (see Table 3.3). All subbituminous coal, which accounts for 37 percent of the demonstrated reserve base, is located west of the Mississippi River and is concentrated in Montana and Wyoming. Lignite accounts for about 9 percent of the demonstrated reserve base and is found mostly in

Table 3.3 Top 11 States with the Largest Recoverable Coal Reserves (million short tons), 2007

State	Underground Mineable Coal	Surface Mineable Coal	Total
Montana	35,922	38,934	74,856
Wyoming	22,946	16,728	39,674
Illinois	27,893	10,064	37,957
West Virginia	15,395	2,274	17,669
Kentucky	7,265	7,417	14,682
Pennsylvania	10,595	1,026	11,621
Ohio	7,692	3,755	11,447
Colorado	5,946	3,746	9,692
Texas	—	9,449	9,449
New Mexico	2,788	4,156	6,944
North Dakota	—	6,849	6,849
Total	**136,442**	**104,398**	**240,840**
Percentage of U.S. Total	**91.3**	**92.5**	**91.2**

Source: From Energy Information Administration, Coal Reserves Current and Back Issues (2009).

Montana, Texas, and North Dakota. Anthracite only accounts for about 1.5 percent of the demonstrated reserve base, and is found only in Pennsylvania.

Estimated low-sulfur coal comprises the largest portion of the total recoverable coal reserves at 36 percent [5]. Low-sulfur coal is defined as less than 0.8 and 0.5 percent by weight (as received) sulfur for high-grade bituminous coal and high-grade lignite, respectively. These sulfur contents are a quantitative rating and have been correlated with U.S. sulfur emissions regulations from coal-fired power plants and the various stages of control that are required [5]. Estimated medium (0.8–2.2 percent for bituminous coal and 0.5–1.3 percent for lignite) and high (>2.2 and >1.3 percent for bituminous coal and lignite, respectively) sulfur recoverable reserves account for 31 and 33 percent of the total, respectively.

The U.S. Geological Survey has divided the reserves into seven provinces: Eastern Province, Interior Province, Gulf Province, Northern Great Plains Province, Rocky Mountain Province, Pacific Coast Province, and Alaskan Province. The provinces are further subdivided into regions, fields, and districts. Carboniferous coal deposits in the eastern United States occur in a band of coal-bearing sediments that include the Appalachian and Illinois basins. Coal deposits in the western United States range from Upper Jurassic to Tertiary in age.

The Eastern Province includes the anthracite regions of Pennsylvania and Rhode Island, the Atlantic Coast region of middle Virginia and North Carolina, the vast Appalachian basin that extends from Pennsylvania to eastern Ohio, western Kentucky, West Virginia, western Virginia, Tennessee, and Alabama. The Eastern Province is about 900 miles long and 200 miles wide at is broadest point [8]. This province also contains the greatest reserves of anthracite in the United States, with more than 760 million short tons in eastern Pennsylvania.

The Appalachian basin contains the largest deposits of bituminous coal in the United States. In the northern region of the Appalachian basin the coal rank ranges from high volatile bituminous in the west to low-volatile bituminous coal in the east. In the central region of the basin, the coal includes low- to high-volatile bituminous ranks. In the southern region, the coals are mainly of high-volatile bituminous rank, with some medium- and low-volatile bituminous coals [4]. Coals are used for steam production, electricity generation, and metallurgical coke production. These coals have high heating values, low to medium ash content (up to 20 percent), and variable sulfur content, with much of the coal that contains sulfur in the 2 to 4 percent range.

The Interior Province is subdivided into three regions: the Northern region consists of Michigan; the Eastern region or Illinois basin consists of Illinois, southern Indiana, and western Kentucky; and the Western region consists of Iowa, Missouri, Nebraska, Kansas, Oklahoma, Arkansas, and western Texas. The Eastern region is the most important region of this province, with vast reserves in Illinois (i.e., nearly 38,000 million short tons) and western Kentucky (nearly 9,000 million short tons of the approximate 15,000 million short tons listed in Table 3.3). The coal in the Interior Province is mainly bituminous in rank and tends to be lower in rank and higher in sulfur than the Eastern Province bituminous coals. Coals are used for steam production, electricity generation, and metallurgical coke production. Coal composition in this province is quite variable, with coals from the Illinois basin noted for having high-sulfur content (3 to 7 percent). The ash content is variable.

The Gulf Province consists of the Mississippi region in the east and the Texas region in the west. The coals in this province, which extends from Alabama through Mississippi, Louisiana, into Texas, are lignitic in rank and are the lowest-rank coals in the United States, with moisture contents of up to 40 percent.

The Northern Great Plains Province contains the large lignite deposits of North and South Dakota and eastern Montana, along with the subbituminous fields of northern and eastern Montana and northern Wyoming. These lignite deposits are contained in the Fort Union Region and are the largest lignite deposits in the world [8]. The coals are used primarily as power station fuels. The lignite contains high moisture (38 percent), low ash (6 percent), and medium sulfur (<1 percent) contents and a heating value of approximately 6,800 Btu/lb.

The Northern Great Plains Province also contains extensive subbituminous coal reserves from the Powder River basin. Wyoming and Montana have the largest recoverable coal reserves in the United States. Wyoming's coal reserves are split between the Northern Great Plains Province and the Rocky Mountain Province. The Powder River basin coals are used primarily as power station fuels and average about 1 percent sulfur with generally low ash content (3–10 percent).

The Rocky Mountain Province includes the coalfields of the mountainous districts of Montana, Wyoming, Utah, Colorado, and New Mexico. The coals range in rank from lignite through anthracite in this province. The most important Rocky Mountain Province coals are the coals from Wyoming, primarily those from the Green River, Hanna, and Hanna Fork coalfields. These coals are subbituminous in rank, typically contain low sulfur, and are used in power generation stations.

The Pacific Coast Province is limited to small deposits in Washington, Oregon, and California. The coals range in rank from lignite to anthracite. The fields are small and scattered and are not being utilized to any great extent.

The Alaskan Province contains coal in several regions [9]. These coals vary in rank from lignite to bituminous, with a small amount of anthracite. The total reserves are estimated to be 15 percent bituminous coal and 85 percent subbituminous coal and lignite. However, extensive mining is not performed due to the low population density and pristine wilderness environment. Only fields close to main lines of transportation have been developed. The coals are used primarily for steam generation and as power station fuels.

Canada

Canada has about 7,300 million short tons of recoverable coal ranging in rank from anthracite to lignite. The coal deposits formed in late Jurassic, Cretaceous, and early Tertiary times. Most of the recoverable reserves are in British Columbia, Alberta, and Saskatchewan, which is an extension of the Great Plains Province coals from the United States. Coals from western Canada tend to be low in sulfur, with those from Alberta and Saskatchewan used as power station fuels, while British Columbia metallurgical coal is exported to the Far East.

Coals from eastern Canada, primarily the Cape Breton Island coalfield in Nova Scotia, are the most important in the Atlantic region. The coals are of high-volatile bituminous rank and vary from medium to high sulfur. Coal production in Nova Scotia is a small percentage of the national output and is expected to decline further [4].

3.2.2 Eurasia

Eastern Europe and the FSU contain extensive recoverable coal reserves totaling over 279,000 million short tons, or 27 percent of the world's total. Russia, Ukraine, and Kazakhstan contain over 98 percent of the recoverable reserves for this region.

Russia

Russia has extensive coal reserves, more than 173,000 million short tons (~19 percent of the world total), of which 119,000 million short tons are subbituminous and lignitic in rank. The coal resources in eastern Siberia and the Russian Far East remain largely unused because of their remoteness and lack of infrastructure [4].

Russia's main coal basins contain coals ranging from Carboniferous to Jurassic in age. Most hard coal reserves are in numerous coalfields in European and central Asian Russia, particularly in the Kuznetsk and Pechora basins and the Russian sector of the Dontesk basin. The Kansk-Achinsk basin in eastern Siberia is the country's main source of subbituminous coal. The Moscow basin contains significant lignite reserves, but production there has virtually stopped [4].

The Kuznetsk basin, which is located to the east of Novosibirsk, contains coals exhibiting a wide range in quality and rank from brown coal to semianthracite. The ash content of the coal is variable, and the sulfur content is generally low.

High-quality coals with low moisture, ash, and sulfur contents are used for coking and steam coal production. This basin is now the largest single producer in Russia of coking and steam coal.

The Pechora basin is located in the extreme northeast of European Russia. The coal rank in the basin increases from brown coal in the west to bituminous coal and anthracite in the east. Ash content varies considerably from 9 to 43 percent, while sulfur content, for the most part, does not exceed 1.5 percent. This basin is the principal supplier of coking coal.

The Dontesk basin is located in eastern Russia and western Ukraine and contains the whole range of coal rank from brown coal to anthracite, which increases toward its central and eastern sections. These coals tend to have ash contents of 15 to 20 percent and sulfur contents of 2 to 4 percent and are used as coking and steam coals.

The Kansk-Achinsk basin, located adjacent to the east side of the Kuznetsk basin, contains brown coals that are described as lignites or subbituminous coals; however, their heating value is higher than that of most lignites. These coals have low to medium ash contents (6–20 percent) and low sulfur contents (<1 percent), which make them attractive for power station fuel.

Ukraine

The Ukraine has significant coal reserves totaling more than 37,000 million short tons, which is nearly evenly split between hard coal (bituminous and anthracite) and brown coal, as shown earlier in Table 3.2 [1]. Most of the coal resources are found in two coal basins: the Donetsk and Dneiper basins.

The Donetsk basin, which is Carboniferous in age, is located in the east (and crosses over into Russia) and contains most of the country's hard coal resources. These coals contain medium ash (15–20 percent) and medium-to-high sulfur (2–4 percent) content, and they are used for steam production, power station fuels, and metallurgical applications. The Dneiper basin is adjacent to the eastern edge of the Donetsk basin and it stretches across much of central Ukraine. This basin contains Ukraine's brown coal reserves and currently is of relatively minor importance [4].

Kazakhstan

Kazakhstan contains total recoverable coal reserves similar to Ukraine, with approximately 34,500 million short tons. Unlike Ukraine, however, most of Kazakhstan's reserves are hard coals that total more than 31,000 million short tons. The coal deposits are late Carboniferous and Jurassic in age and are located mainly in the Karaganda and Ekibastuz basins, which produce hard coal. The coal deposits of these basins lie along the southern edge of the Siberian platform [4]. In the Karaganda basin, coking and steam coals are produced that have sulfur contents ranging from 1.5 to 2.5 percent and high ash content (20–35 percent). Coals from the Ekibastuz basin typically have high ash (39 percent on average) and low sulfur (<1 percent) contents and are predominately used for thermal power generation.

3.2.3 Middle East, Asia, and Oceania

This region contains significant recoverable coal reserves totaling over 285,000 million short tons, or approximately 31 percent of the world total. China, Australia, and India comprise most of this total, with more than 126,000, 84,000, and 62,000 million short tons, respectively.

China

China contains more than 126,000 million short tons of recoverable coal reserves in the world, third behind only the United States and Russia [1]. These recoverable reserves are nearly equally divided between hard coal and lignite deposits (i.e., 68,600 and 57,700 million short tons, respectively), with the hard coals being of Carboniferous, Permian, and Jurassic age and the lignite Tertiary in age. Coalfields are scattered throughout China, with the largest deposits in western China stretching from north to south, with most of the reserves in the northern part, specifically in the Inner Mongolia, Shanxi, and Shaanxi Provinces. Significant anthracite deposits are found in the Shanxi and Guizhou Provinces. Bituminous coal deposits occur in the Heilongjiang, Shanxi, Jiangxi, Shandong, Henan, Anhui, and Guizhou Provinces [4].

China is the world's largest coal producer, with most of the coal being used internally for industry and electricity generation. The rank of hard coal appears to increase slightly northward from the Yangtze River, while locally seam quality is very variable [4].

Australia

Australian recoverable coal reserves total more than 84,000 million short tons, which is nearly equally divided between hard coal and lignite deposits (i.e., 41,000 and 43,500 million short tons, respectively), with the hard coals being of Carboniferous and Permian age and the lignite Tertiary in age.

Coal is mined in all of the states except for the Northern Territory. New South Wales and Queensland produce both steam and metallurgical coal for export, while production in Victoria, South Australia, and Western Australia is for thermal electricity generation [4]. Hard coal is mined in New South Wales, Queensland, and Western Australia, while subbituminous and brown coal is mined in South Australia and Victoria. The major coal reserves are found in eastern Australia, with the Bowen, Sydney, and Gippsland basins being the most important.

The Bowen basin is located in Queensland and developed during early Permian times. The rank varies in this basin, increasing from west to east, with the higher-rank coals ranging from low-volatile bituminous coal in the west to semianthracites and anthracites in the east. The coals have low sulfur content (typically 0.3–0.8 percent) and ash contents of 8 to 10 percent and 8 to 16 percent for coking and thermal coals, respectively.

The Sydney basin is located in New South Wales, is of Permian age, and consists of several coalfields. In general, the Sydney basin coals are medium- to high-volatile bituminous coal, with the highest rank contained in the northern portion of the

basin. The coals in this basin have low sulfur content (<1 percent), and ash contents typically ranging from 6 to 24 percent, with one coalfield exceeding 40 percent ash.

The brown coal resources found in the Gippsland basin lie within the Latrobe Valley in Victoria and are of Tertiary age. This area is noted for its thick coal seams ranging from 330 to 460 feet in thickness. The brown coals have low heating values (3,400–5,200 Btu/lb) due to high and very variable moisture contents, which range from 49 to 70 percent. Ash contents, on the other hand, are low and range from 0.5 to 2 percent.

India

India's recoverable coal reserves rank fifth in the world, with more than 62,000 million short tons. These reserves vary in rank from lignites to bituminous coal, with most of it being hard coal (i.e., nearly 56,000 million short tons), although the coal quality is generally poor. India's coalfields are located mainly in the east in the states of Assam, Bihar, Uttar, Pradesh, Madhya, Pradesh, Andhra Pradesh, Orissa, and West Bengal [4]. India's coals are principally of Permian age, with some of Tertiary age.

The most significant deposits are in the Raniganj and Jharia basins of northeast India. In the Raniganj basin, the rank increases from noncaking bituminous coal in the east to medium coking coal in the west. Ash content is variable though, varying from 15 to 35 percent. Sulfur content is low (<1 percent). The Jharia coalfield is India's major source of prime coking coal, although it also contains significant noncoking coal as well. As with Raniganj basin coals, ash content varies from 15 to 35 percent, with low sulfur contents in the Jharia basin.

Most of India's lignite mining occurs in southern India in the Neyveli coalfield, although other areas contain larger resources. The lignite contains low ash (2–12 percent) and low sulfur (<1 percent) contents, but the moisture content is high, varying between 45 and 55 percent. India's coal is used primarily for power production. Although India has substantial recoverable resources, coal imports are steadily rising to meet demands for coking coal as well as for steam coal as new power plants begin operation [4].

3.2.4 Europe

Europe contains approximately 51,000 million short tons of recoverable coal reserves, with the majority of the reserves spread fairly evenly among eight countries except for Former Serbia and Montenegro (at ≈15,000 million short tons) and Poland (at 8,300 million short tons). The recoverable reserves in the other six primary countries vary from 2,000 to 7,000 million short tons.

Poland

Poland contains recoverable coal reserves of more than 8,000 million short tons, of which than 6,600 million short tons are hard coal. The hard coal deposits are found in three main basins located in the southern half of the country: the Upper Silesian,

the Lower Silesian, and the Lublin basins. These basins are of Carboniferous age. Poland uses its hard coal in world export markets.

Poland's lignite deposits are found in a number of Tertiary basins across the central and southwestern parts of the country. Poland ranks fourth in world lignite production and is the second largest European producer after Germany. The lignite is used as a fuel for electricity generation. Polish lignite has variable ash contents (4–25 percent) and low to medium sulfur contents (0.2–1.7 percent).

Germany

For decades, Germany has been a major European coal producer and consumer. In the last several years, Germany has revised its recoverable coal reserves downward due to more restrictive criteria, although some question whether the new figures are accurate. Germany revised its estimates from nearly 73,000 million short tons of recoverable coal reserves in 2001 to approximately 7,000 million short tons in 2007. Germany's three main areas of lignite resources are the Rhineland, Lusatian, and Central German basins, which are of Tertiary age. In addition, Germany has hard coal capacity, which is of Carboniferous age, located in the Ruhr and Saar basins.

Of the three main lignite basins, the Rhineland deposits are now the most important and are located between the River Rhine and the German/Dutch/Belgian border. The Central German and Lusatian basins are located in eastern Germany. The lignites have heating values of 3,350 to 5,400 Btu/lb and moisture contents that vary from 40 to 60 percent. Ash and sulfur contents vary from 1.5 to 8.5 percent and 0.2 to 2.1 percent, respectively, with the Rhineland basin lignite containing sulfur contents of less than 0.5 percent. These coals are used for producing electricity in generating stations.

Because of restructuring of the hard coal mining sector, which began in 1999, the Ruhr coalfield has greater economic significance than the Saar coalfield, as mines continue to close and overall production declines [4]. The Ruhr coalfield primarily consists of bituminous coal, much of which is coking coal. The basin contains two small areas of anthracite, where the ash and sulfur contents of the coals are 4 to 9 percent and less than 1 percent, respectively. The coals are used primarily for electricity generation along with some industrial applications.

3.2.5 Africa

Africa contains 61,000 million short tons of recoverable coal, with approximately 55,000 million short tons of those reserves in South Africa. Thirteen other countries contain the balance [10], but only Zimbabwe contains almost 550 million short tons, with the rest containing a total of almost 1,200 million short tons (refer to Table 3.2).

South Africa

South Africa's recoverable coal reserves of 53,000 million short tons consist entirely of hard coal. These coals are of Carboniferous and Permian age, with significant deposits in the Great Karoo basin. This basin extends about 300 miles from west to east

across northern Free State Province and south and east Mpumalanga, and about 700 miles from southern Mpumalanga in the north to the center of Kwazulu-Natal in the south [4]. Although the Great Karoo basin is the largest, several other basins and 19 coalfields exist throughout South Africa.

The hard coal consists of bituminous coals, anthracite, and semianthracite. The ash content ranges from 7 percent for some anthracites to more than 30 percent for bituminous coals. Sulfur contents range from less than 1 percent to nearly 3 percent. Domestically, the coal is used for electricity generation and conversion into synthetic liquid fuels and chemical feedstocks. South Africa exports significant quantities of steam coal, with minor amounts of coking coal and anthracite.

3.2.6 Central and South America

Central and South America contain approximately 18,000 million short tons of recoverable coal reserves, or 2.2 percent of the world's total. Coal is found in several countries, including Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, and Venezuela. Two of these countries, however, contain the majority of these reserves: Brazil with 7,800 million short tons and Colombia with 7,700 million short tons. Brazil's coals are subbituminous and lignitic in rank, while Colombia's coals are primarily high-volatile bituminous with a small amount of subbituminous coals. These coals formed during late Cretaceous to Tertiary times.

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