Bituminous Coal Production in the Appalachian Basin: Past, Present, and Future

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Chapter D.3 of
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By Robert C Milici[1] and Désirée E. Polyak[1]

Introduction

Although small quantities of coal first were produced from the Appalachian basin in the early 1700s, the first production statistics of significance were gathered during the census of 1830 (Eavenson, 1942). Since then, about 35 billion short tons of bituminous coal have been produced from the Appalachian basin from an original potential coal reserve ($PCR_{(o)}$) estimated to range from about 60 to 90 billion short tons. The term "reserve" refers to economically producible coal, and a "potential coal reserve" ($PCR_{(n)}$) is an estimate of the amount of coal economically recoverable in a region (State, coal field) over a defined time period (n = number of years) and under a range of economic, societal, and technological conditions. Thus, the current cumulative production plus the $PCR_{(n)}$ equals an estimated cumulative production ($ECP_{(n)}$). The maps in this report (oversized figures 1, 2, 3, and 4) were produced from a digital database of historical and current coal production records by county. Sources of the original data include various State geological surveys, the U.S. Geological Survey, the former U.S. Bureau of Mines, and the U.S. Department of Energy's Energy Information Administration. This report is part of the U.S. Geological Survey's National Coal Resource Assessment Project.

The Appalachian basin consistently has lead all other regions of the country in coal production and, until 1970, produced 70 percent or more of the coal produced in the Nation (fig. 5). Since 1970, however, the relative amount of coal coming from the Appalachian basin has declined from about 70 percent to 43 percent. Historically, coal production from the Appalachian basin may be divided into three economically driven cycles: (1) from the inception of exploration and development of the resource through World War I (1914) to the Depression (1929 to the early 1940s); (2) from the Depression through World War II (1944) to the production decline in 1961; and (3) from 1961 through the current period of increasing demand for coal by the electric power industry (fig. 6). Annual coal production from the Appalachian basin peaked in 1997 at 476.8 million tons and has since declined to 375.3 million tons as of 2003.

This report on Appalachian basin coal production consists of four plates and associated graphs and tables that were used to construct the maps. Figure 1 shows the decade of greatest coal production by county. Figure 2 shows the amount of coal produced for each county (in thousands of short tons) during the year of greatest coal production. These data are sorted by decade. Figure 3 illustrates the cumulative coal production (in thousands of short tons) for each county since about the beginning of the 20th century. Figure 4 shows 2003 production by county in thousands of short tons.

Year of Greatest Coal Production by County

Figure 1 shows the decade in which each county attained its year of greatest coal production and is designed to be used in conjunction with the other three plates in this report (figs. 2, 3, and 4). General conclusions about the remaining coal reserves in any given county may be made from these plates. For example, a county that produced 20 to 40 million tons of coal in 1935, has a cumulative production greater than 1 billion tons, and currently is producing less than 5 million tons of coal a year probably is near economic depletion.

Greatest production of coal from individual counties generally occurred first around the edges of the Appalachian basin and near the major population centers, especially in the industrial northeast. During the past 14 years, however, production reached a maximum in several counties in the central part of the basin in eastern Kentucky, southern West Virginia, and southwestern Virginia. Greene County, Pa., currently the most productive county in the Appalachian basin, peaked at 44.3 million tons in 2001 and had declined to 38.3 million tons by 2003.

[1]U.S. Geological Survey, Reston, Va.

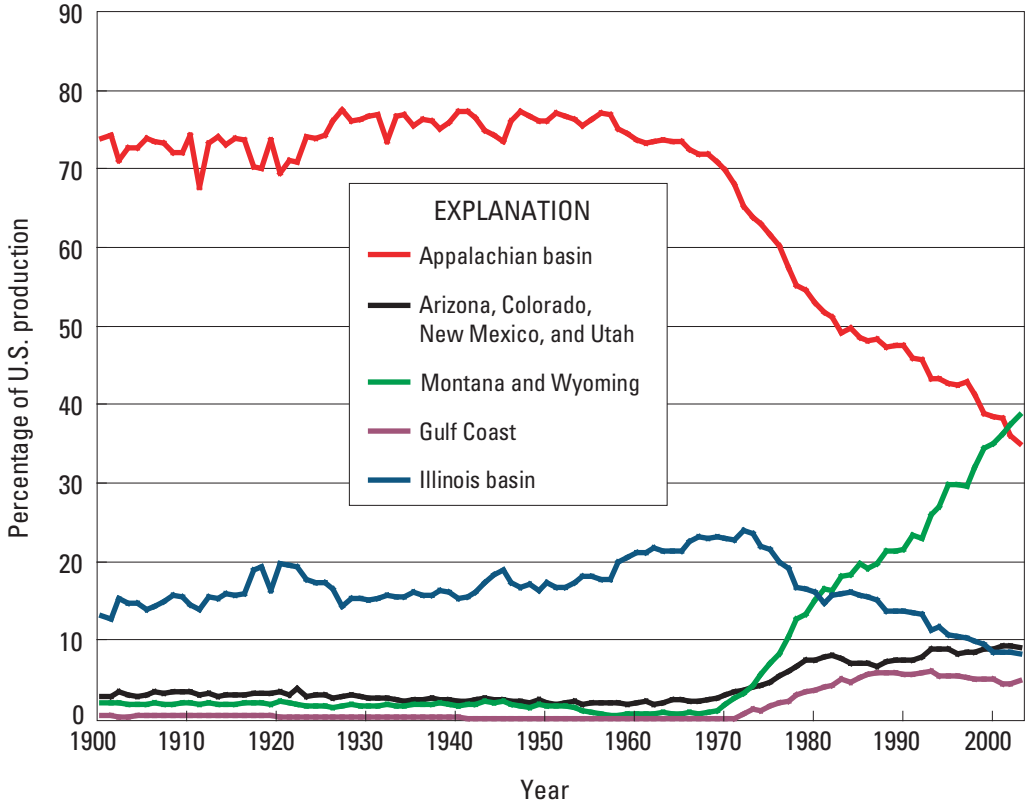

Figure 5. Graph showing U.S. coal production by region as a percentage of total U.S. production.

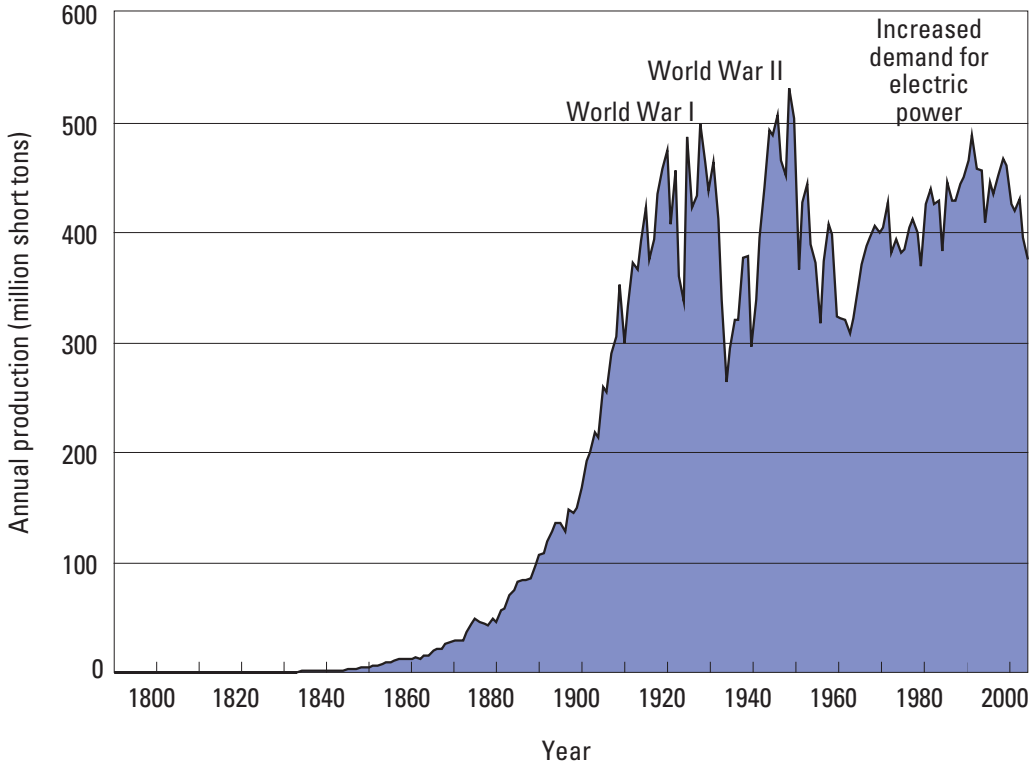

Figure 6. Graph showing coal production in the Appalachian basin.

Greatest Annual Coal Production by County

Figure 2 illustrates the greatest amount of coal that was produced in any one year, by county (table 1). Most of the coal in the Appalachian basin has been produced from relatively few counties in three general locations (supply regions). These major supply regions, or "sweet spots," occur in (1) southwestern Pennsylvania, (2) southern West Virginia, eastern Kentucky, and southwestern Virginia, and (3) to a lesser extent, in Alabama.

During the current (third) cycle of increased coal production in the Appalachian basin, only seven major coal-producing counties (those with greater than 500 million tons cumulative production), including Greene County, Pa.; Boone, Kanawha, Logan, Mingo, and Monongalia Counties, W. Va.; and Pike County, Ky.; exhibit a general increase in coal production (figs. 7–9). Production in other major coal-producing counties has either declined to a small percentage of their greatest production or is being maintained at moderate levels (figs. 7, 9, 10). In general, the areas with current high coal production either have large blocks of coal that are suitable for mining underground with highly efficient longwall methods or are occupied by very large scale, relatively low cost surface-mining operations.

Cumulative Production Data by County

The cumulative production map (fig. 3) highlights the "sweet spots" of the Appalachian basin once again. Eight counties, three in the central part of the basin and five in the northern part of the basin, each have produced more than 1 billion tons of coal. In addition, Boone, Mingo, and Monongalia Counties, W. Va., and Buchanan County, Va., have the potential to attain a cumulative production of 1 billion tons or more.

Cumulative coal production data may be analyzed at several levels of aggregation, by county, State, and basin. For example, the cumulative production curve for Cambria County, Pa. (fig. 11), indicates that estimated cumulative production ($ECP_{(100)}$) from the county will range from 1.1 to 1.2 billion tons sometime in this century. In contrast, coal is being produced from Greene County, Pa. (fig. 11), at a relatively high rate because of the use of highly productive, low-cost longwall mining operations. The flattening of the combined cumulative production curve for nine of the most productive counties in Pennsylvania (Allegheny, Cambria, Clearfield, Fayette, Greene, Indiana, Somerset, Washington, and Westmoreland) reflects the continuously declining annual production in the northern part of the basin (fig. 12). In contrast, overall production from the twelve most productive counties in the central (Buchanan, Wise, Perry, Pike, Boone, Kanawha, Logan, Mingo, Fayette, McDowell, Raleigh, and Wyoming) and southern (Tuscaloosa, Jefferson, and Walker) parts of the basin has not yet begun to decline (figs. 13, 14).

Cumulative production data plotted on a logarithmic scale by State (fig. 15) indicate that Pennsylvania and West Virginia will attain an estimated cumulative production ($ECP_{(100)}$) of about 15 to 20 billion tons each sometime during this century. Eastern Kentucky coal production is carried to a large extent by Pike County, which has limited available and recoverable coal resources. This suggests that eastern Kentucky will attain an $ECP_{(100)}$ of 10 billion tons or less in the current production cycle, which is driven by the demand for electric power. Estimated cumulative production from Ohio, Virginia, and Alabama each appears to range from 3 to 5 billion tons. Tennessee, Maryland, and Georgia each may attain an $ECP_{(100)}$ of less than 1 billion tons. The plot for cumulative production for combined bituminous coal production also indicates an $ECP_{(100)}$ of 100 billion tons or less for the Appalachian basin. In general, it is anticipated that remaining resources will be progressively of lower quality and higher cost to mine and will become economic only as new technologies for extraction, beneficiation, and consumption are developed and if prices for coal increase.

Current (2003) Annual Coal Production by County

The map of 2003 coal production from the Appalachian basin (fig. 4) illustrates the current state of the industry. In the northern part of the basin, only Greene County, Pa., produced more than 10 million tons in 2003. Ten counties in the central part of the basin, including two in Virginia, four in Kentucky, and four in West Virginia, continue to produce more than 10 million tons each annually. Tuscaloosa County, Ala., was the only county in the southern part of the basin to produce more than 10 million tons of coal in 2003. The production patterns in the Appalachian basin illustrate the current emphasis of industry in mining the low-sulfur coals in West Virginia, eastern Kentucky, Virginia, and Alabama. In the Appalachian basin, intermediate- to high-sulfur coals occur generally in a broad band that extends from western Pennsylvania, western Maryland, and northern West Virginia, westward into Ohio. The very high content of sulfur in Ohio's coals (greater than 2.5 percent) limits its use for power generation into the foreseeable future.

Estimated Cumulative Production of Coal From the Appalachian Basin

Future cumulative production of coal ($ECP_{(100)}$) from the Appalachian basin may be estimated by calculating the economic recoverability of known coal resource tonnages and (or) by projecting historical production trends into the future.

Table 1. Coal production for major producing counties, by State.

State and county	Year of maximum production	Maximum annual production (thousand short tons)	Cumulative production through 2003 (thousand short tons)
Alabama			
Jefferson	1942	10,608	802,775
Tuscaloosa	2003	10,633	252,577
Walker	1985	8,819	464,962
Kentucky, eastern			
Floyd	1990	11,292	448,590
Harlan	1936	15,098	862,328
Knott	1993	14,406	326,572
Letcher	2001	10,649	522,175
Martin	1985	14,010	368,924
Perry	1994	15,050	590,578
Pike	1996	35,598	1,359,290
Pennsylvania			
Allegheny	1923	20,224	957,132
Cambria	1918	20,569	1,115,918
Clearfield	1978	10,140	649,844
Fayette	1916	34,250	1,282,723
Greene	2001	44,303	1,031,423
Indiana	1983	13,437	786,212
Somerset	1920	10,533	635,810
Washington	1923	24,499	1,345,833
Westmoreland	1913	33,259	1,029,531
Virginia			
Buchanan	1990	20,877	786,344
Wise	2003	15,625	733,956
West Virginia			
Boone	2001	32,677	933,030
Fayette	1947	15,404	733,756
Harrison	1947	15,099	574,737
Kanawha	2003	16,613	802,677
Logan	1947	24,028	1,376,630
Marion	1967	15,040	668,576
McDowell	1942	27,808	1,449,926
Mingo	1996	24,881	720,510
Monongalia	1990	18,509	835,194
Raleigh	1943	16,185	908,184
Wyoming	1967	15,894	63,858

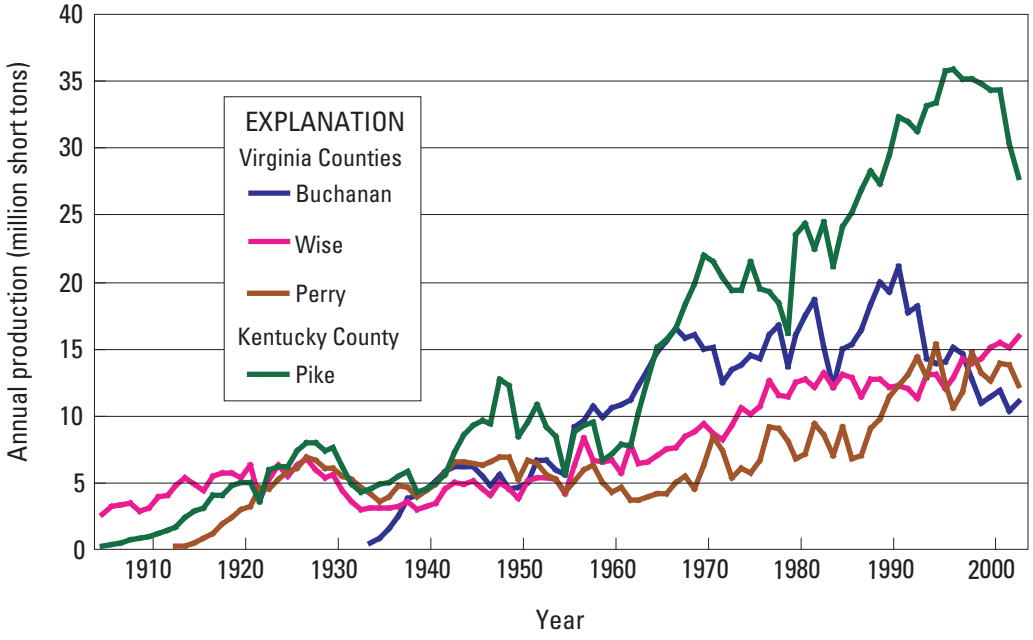

Figure 7. Graph showing increasing coal production in eastern Kentucky and Virginia counties where cumulative tonnage is greater than 500 million tons.

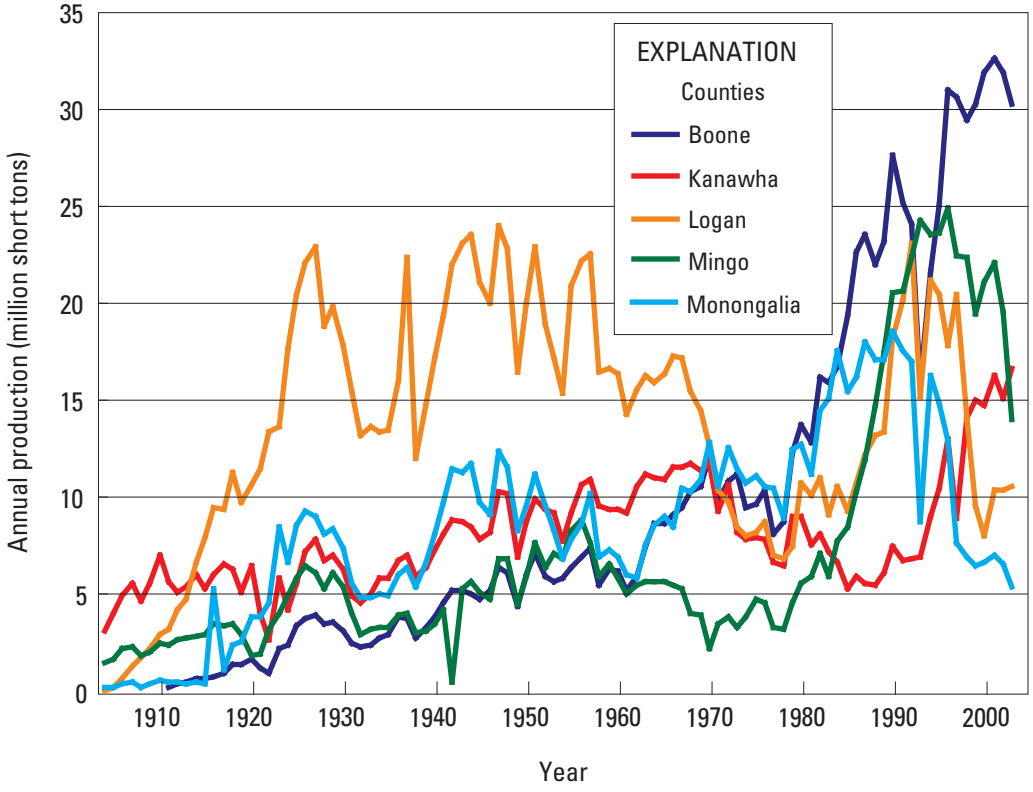

Figure 8. Graph showing increasing coal production in West Virginia counties where cumulative tonnage is greater than 500 million tons.

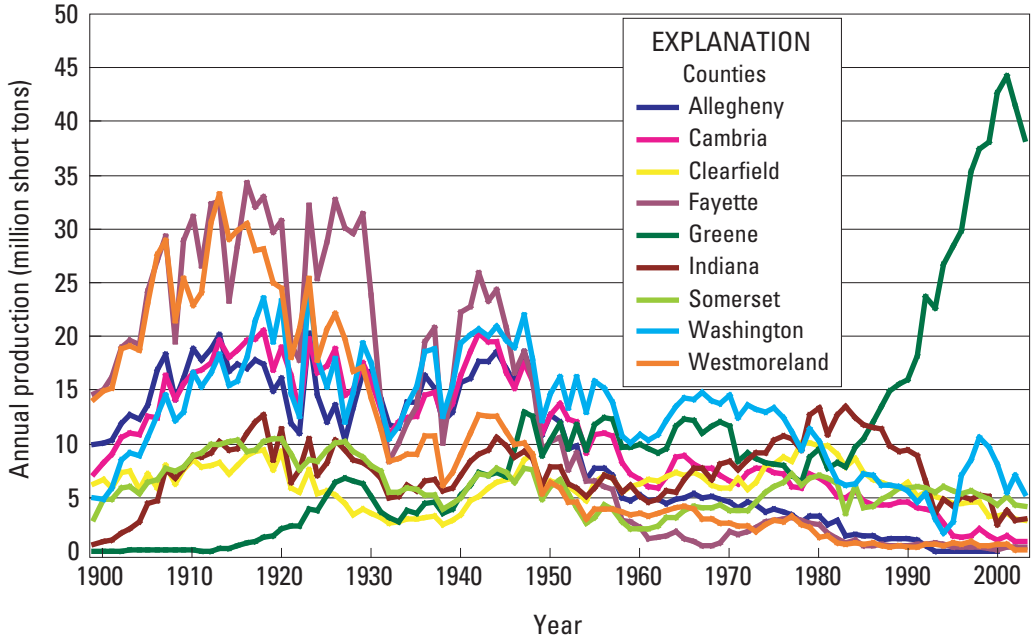

Figure 9. Graph showing variable coal production in Pennsylvania counties where cumulative tonnage is greater than 500 million tons.

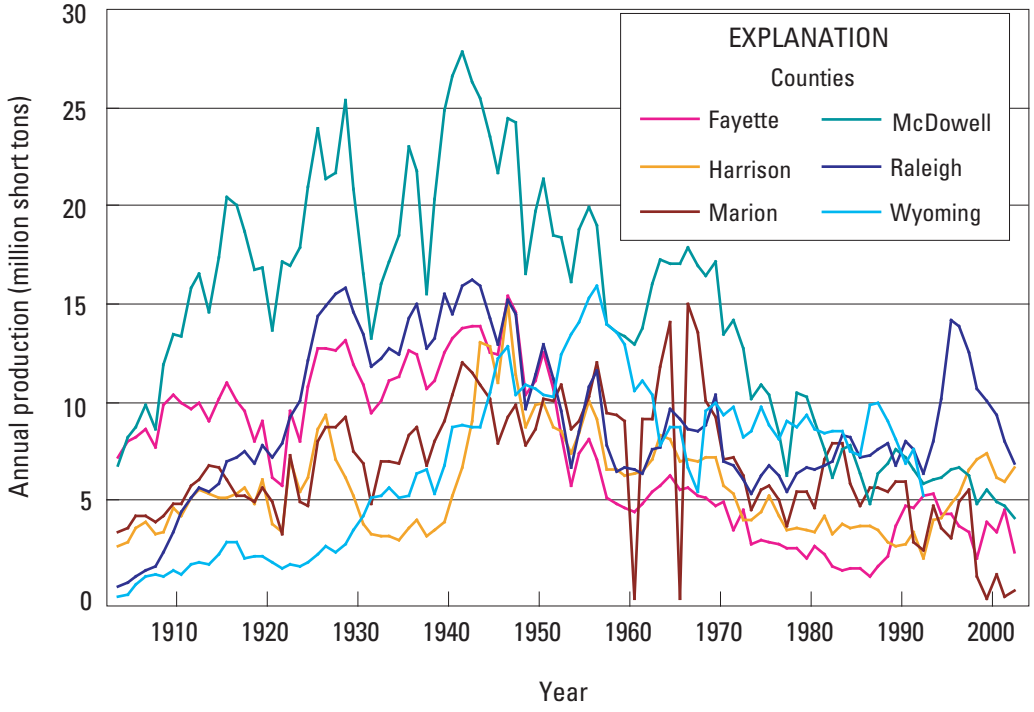

Figure 10. Graph showing declining coal production in West Virginia counties where cumulative tonnage is greater than 500 million tons.

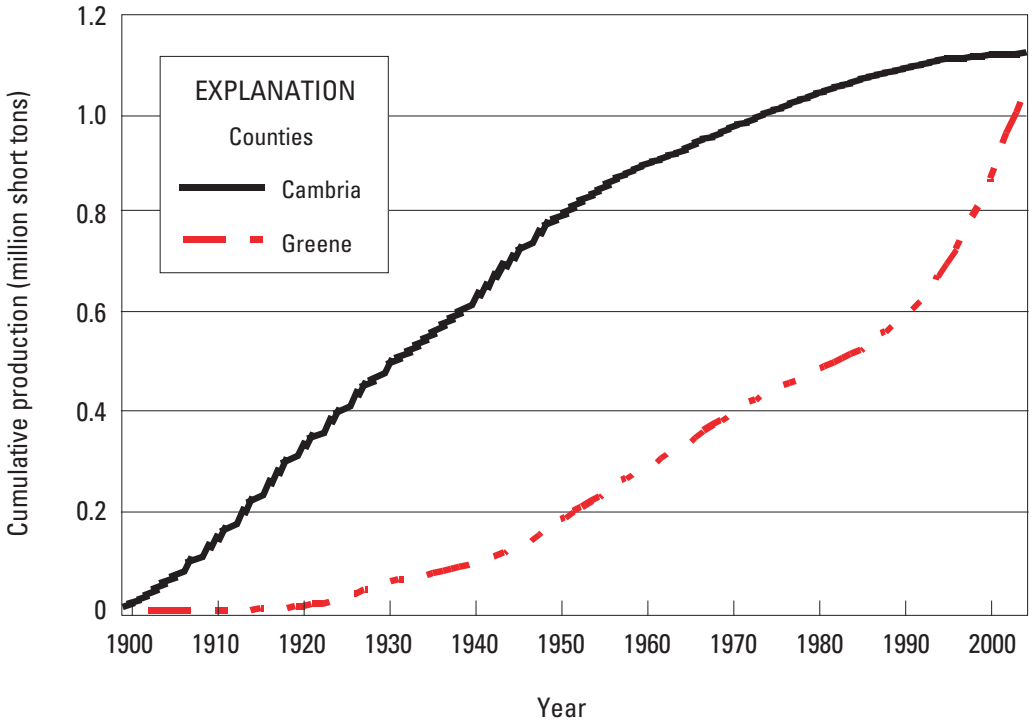

Figure 11. Graph showing cumulative production for Cambria and Greene Counties, Pa.

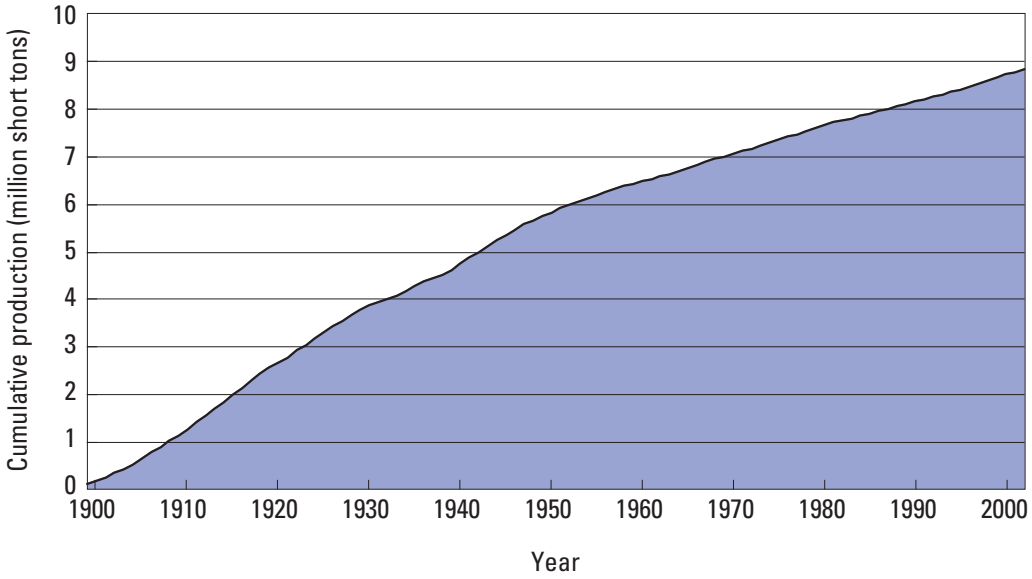

Figure 12. Graph showing cumulative production for the nine most productive counties in Pennsylvania.

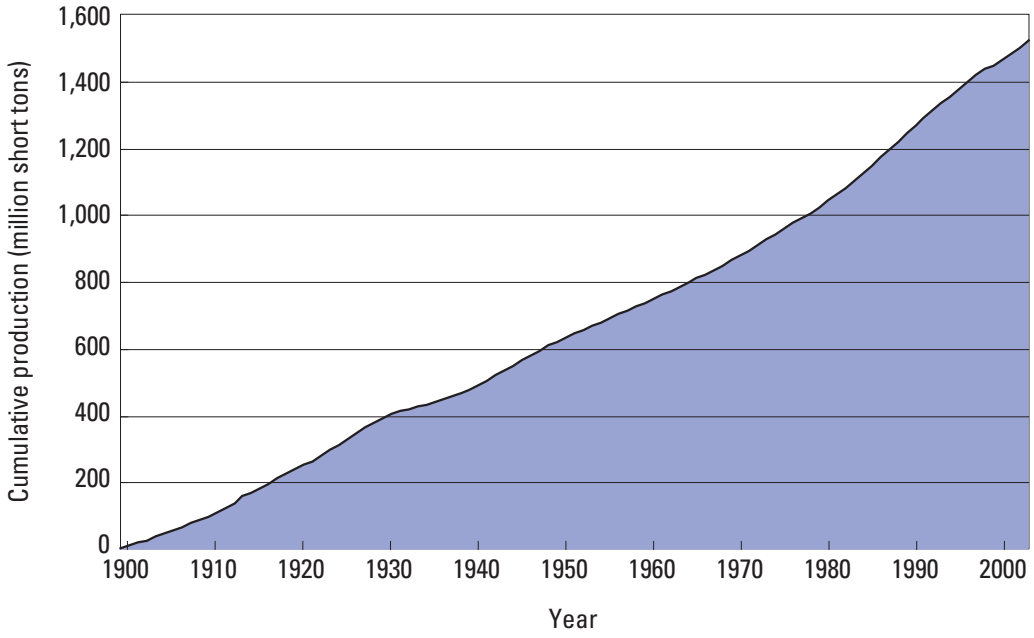

Figure 13. Graph showing cumulative production for Jefferson, Walker, and Tuscaloosa Counties, Ala.

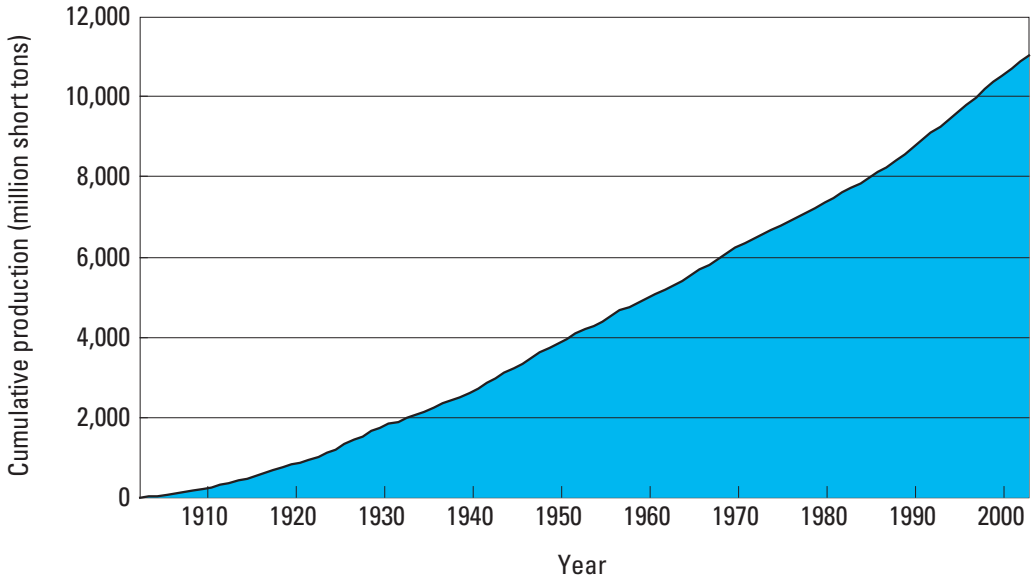

Figure 14. Graph showing cumulative production for the twelve major producing counties in eastern Kentucky, West Virginia, and Virginia.

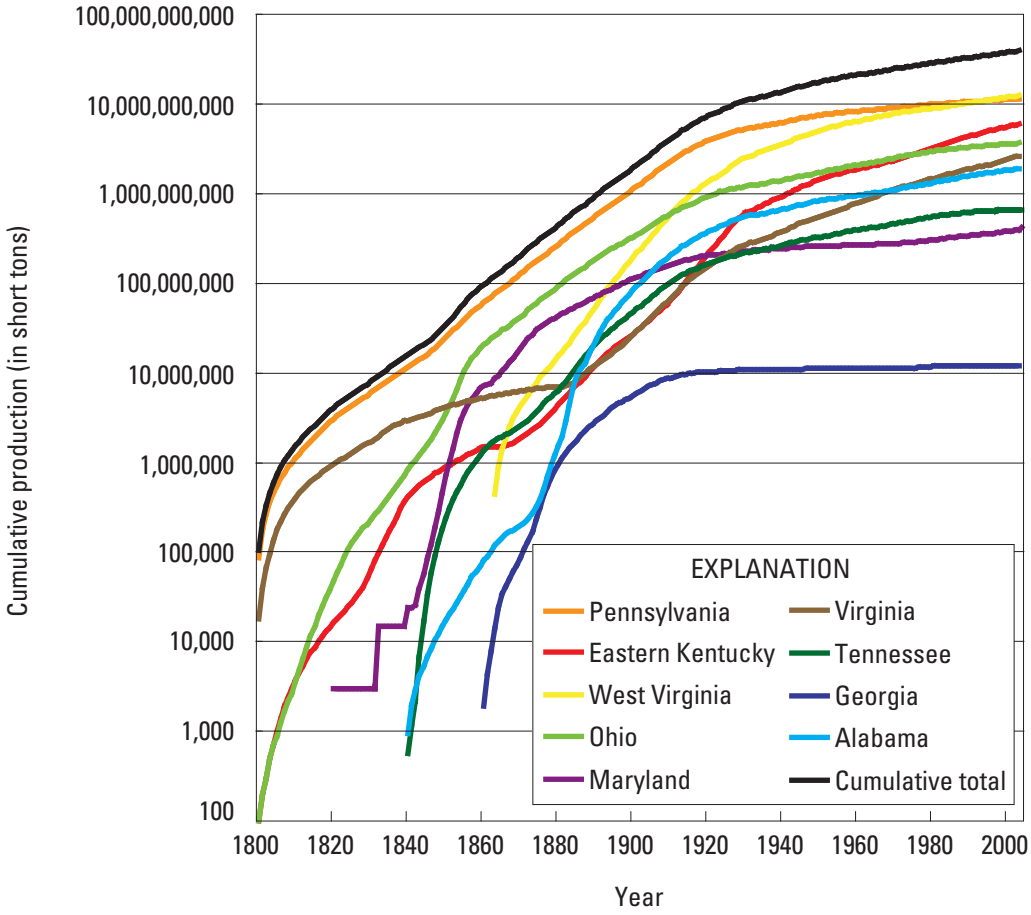

Figure 15. Graph showing cumulative production for the Appalachian basin, by State.

Potential coal reserves for the Appalachian basin (the amount of coal potentially economically recoverable) were obtained by applying coal availability and recoverability factors and current production and reserve decline rates to estimates of original coal resources made by various government agencies (table 2). In general, coal recoverability studies indicate that about 10 percent of the original coal resources in the Appalachian basin are economically recoverable. In addition, approximate reserve estimates may be made by extrapolating current production decline trends into the future. In regions characterized by high-sulfur coal, such as Ohio and western Pennsylvania, declining production trends may provide a better estimate of the amount of economically producible coal in the current production cycle than calculations using availability and recoverability factors. For comparison, the resource assessment of Averitt (1975) was used as a base for calculating potential coal reserves, using both historical production data and availability and recoverability factors. The two estimates of remaining reserves, 22.8 and 27.3 billion tons, respectively, differ by only 5 percent. These estimates ($ECP_{(100)}$) are considered valid only for the current cycle of coal production and utilization. The reserve estimate will change as economic conditions change, as the technology of coal mining and utilization improves, and as societal concerns and limitations evolve. Indeed, the remaining large resources of coal in the northern part of the Appalachian basin, which are currently only marginally economic because of their high sulfur content, eventually may become the coal reserves of the future.

The coal reserve estimate for the Appalachian basin of 54.5 billion tons made by the Energy Information Administration (EIA, 2002) of the U.S. Department of Energy (table 3) is considerably higher than the estimates determined in this report. Of the amount reported by the EIA, approximately 40 percent is classified as high-sulfur coal, which has limited value in today's market; however, installation of flue-gas desulfurization systems (commonly called scrubbers) will allow powerplants to use these high-sulfur coals and to comply with clean air standards. In summary, depending on future trends and uses for the remaining coal in the Appalachian basin, estimated cumulative production ($ECP_{(100)}$) could range from about 60 to 90 billion tons. Scenarios based on declining production trends for 26, 32, and 55 billion tons of potential reserves are plotted for comparison (figs. 16, 17, and 18, respectively). These projections cannot be considered to

Table 2. Coal reserve estimates for the Appalachian basin, in billions of short tons.

State	Estimated original reserves	Cumulative production through 2003	Remaining reserves	Estimated reserves (1994)[1]
Alabama	3.4	1.8	1.6	1.2
Kentucky, eastern	9.9	5.8	4.1	5.4
Virginia	4.2	2.3	1.9	0.8
West Virginia	21.9	12.1	9.8	9.5
Subtotal	39.4	22.0	17.4	16.9
Ohio	5.6	3.4	2.2	4.0
Pennsylvania	14.6	11.6	3.0	6.1
Subtotal	20.2	15.0	5.2	10.1
Georgia	0.0	0.0	0.0	0.0
Maryland	0.4	0.3	0.1	0.1
Tennessee	0.7	0.6	0.1	0.3
Subtotal	1.1	0.9	0.2	0.3
Grand total	60.7	37.9	22.8	27.3

[1]Based on Averitt (1975).

Table 3. Reserve estimates for high-sulfur coal in the Appalachian basin, in billions of tons.

[EIA, Energy Information Administration; lb S/MMBtu, pounds of sulfur per million British thermal units; >, greater than]

State	Total recoverable reserves, 1997 (EIA, 1994–2002)	Total high-sulfur coal as of January 1, 1997 (EIA, 1994–2002)	Recoverable reserves 1.68–2.5 lb S/MMBtu	Recoverable reserves >2.5 lb S/MMBtu	Reserves at active mines (EIA, 2003 data)
Alabama	3.0	0.2	0.2	0.0	0.3
Kentucky, eastern	6.8	1.5	0.8	0.6	0.6
Virginia	1.3	0.0	0.0	0.0	0.2
West Virginia	19.3	5.7	2.5	3.2	1.5
Subtotal	30.3	7.4	3.5	3.8	2.6
Ohio	11.7	10.0	2.6	7.4	0.3
Pennsylvania	11.6	5.6	4.1	1.5	0.5
Subtotal	23.3	15.6	6.7	8.9	0.8
Georgia	0.0	0.0	0.0	0.0	0.0
Maryland	0.4	0.2	0.2	0.0	0.0
Tennessee	0.5	0.1	0.1	0.0	0.0
Subtotal	0.9	0.3	0.3	0.0	0.0
Grand total	54.5	23.5	10.5	12.9	3.4

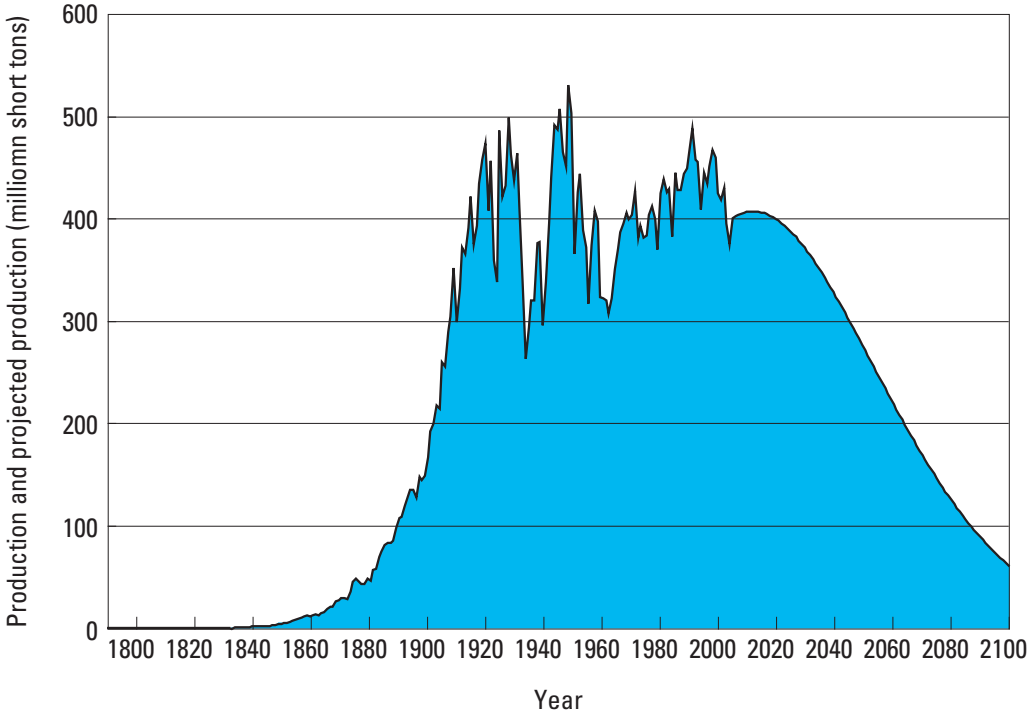

Figure 16. Graph showing Appalachian basin coal production and projected production based on 26 billion tons of potential reserves.

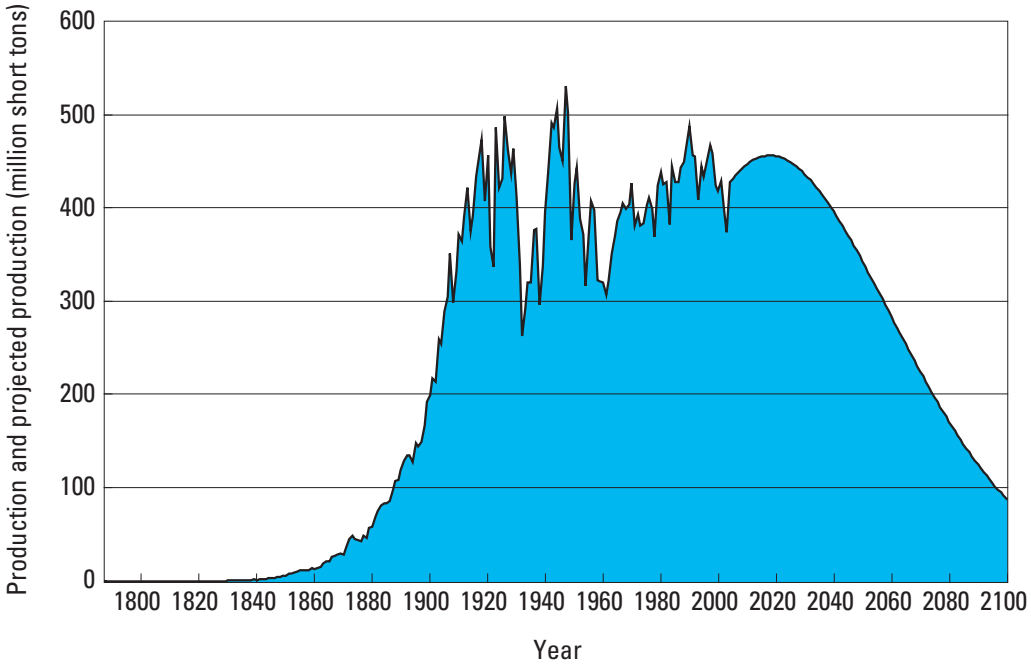

Figure 17. Graph showing Appalachian basin coal production and projected production based on 32 billion tons of potential reserves.

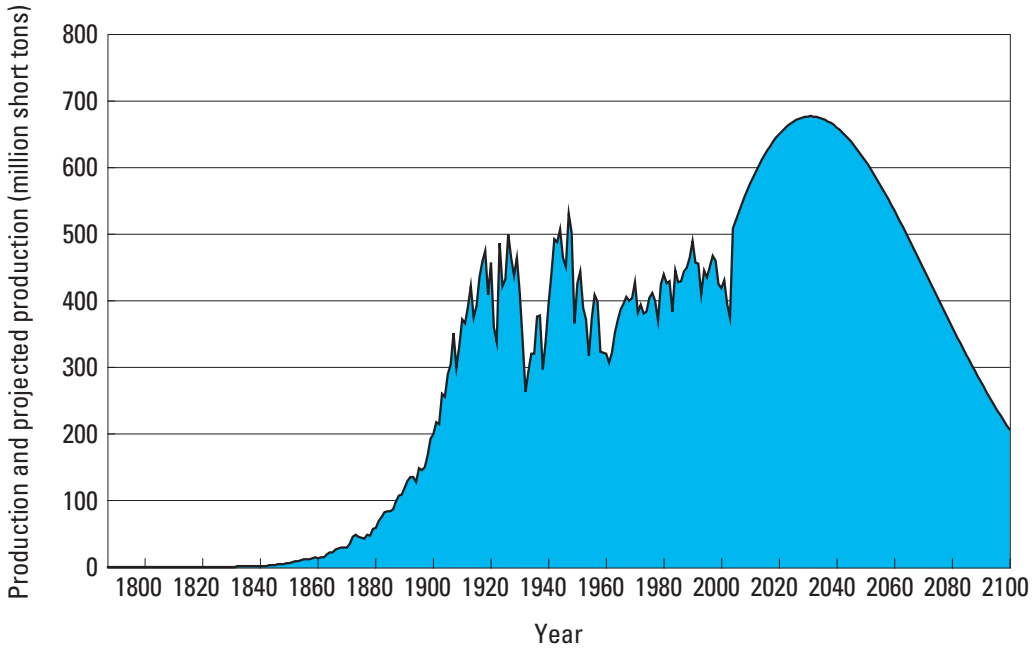

Figure 18. Graph showing Appalachian basin coal production and projected production based on 55 billion tons of potential reserves.

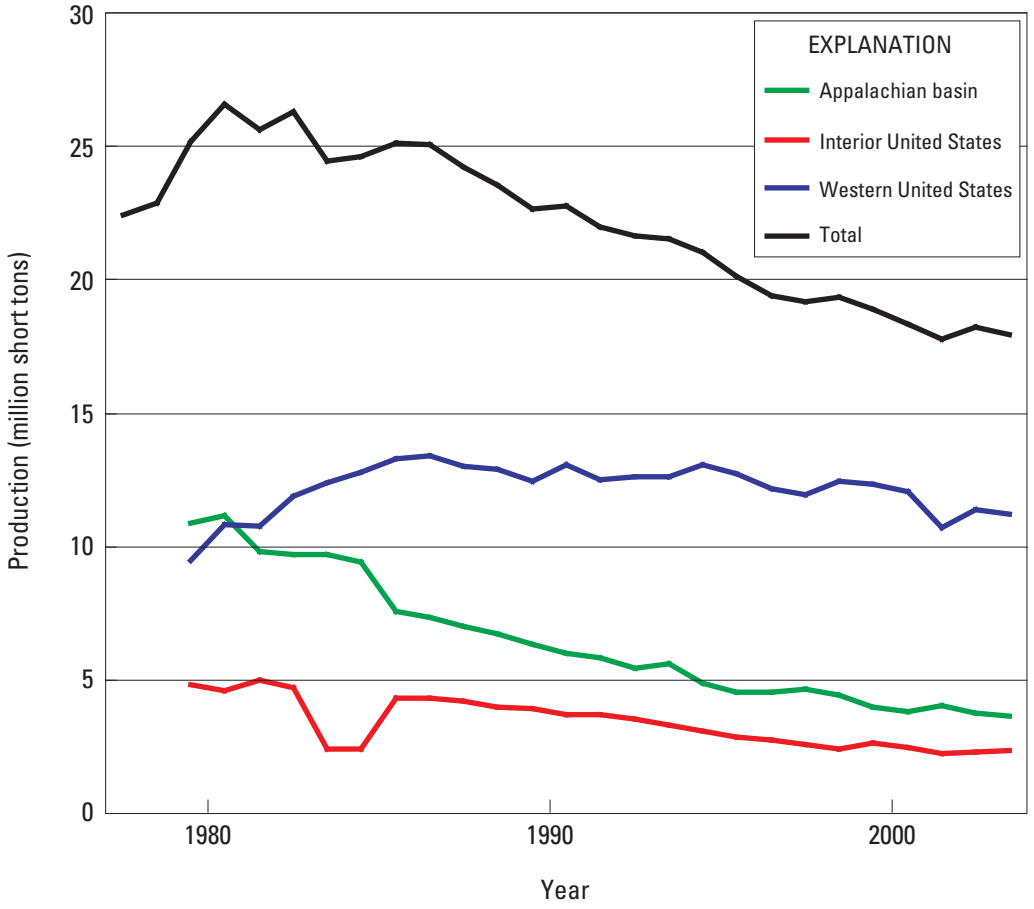

Figure 19. Graph showing coal reserves at mines in the Appalachian basin and in the interior and western parts of the conterminous United States.

reflect accurately the rate of future coal production. Instead, they illustrate only a range of possible production scenarios that might occur, depending on the demand for high-sulfur coal. In general, the projections indicate that annual production from the Appalachian basin will fall below 200 million tons sometime between the middle and end of the 21st century. Supporting this conclusion are the 2003 data on reserves at mines published in the online 2003 coal report of the EIA (2003–2005). In the 25 years between 1978 and 2003, reserves at Appalachian mines declined by about 7 billion tons, from a little more than 10 billion to a little more than 3 billion tons (fig. 19). In contrast, coal reserves at mines in the Western States are not declining as sharply. There, reserves are added almost as fast as coal is produced, so that there is little net change in reserves from year to year (Energy Information Administration, 1982, 1993, 1994–2002, 2003–2005).

Conclusions

The maps illustrate that there are three major groupings of counties, or supply regions, for coal produced from the Appalachian basin. These occur in the northern part of the basin, in Pennsylvania, Ohio, and northern West Virginia; in the central part of the basin, in southern West Virginia, eastern Kentucky, and southwestern Virginia; and in the southern part of the basin, in Alabama. Many of the surrounding counties currently produce coal in low to moderate amounts and these counties commonly have relatively small resources of high-quality coal that can be produced inexpensively.

Most of the counties in the northern supply region are several years past peak production. Although several of the counties in this region have produced about a billion tons each, their current annual production is low. The sulfur content of coal produced in the northern supply region is generally moderate to high (Attanasi and Milici, 1998), which makes these deposits relatively uneconomic because of the restrictions imposed by the Clean Air Act of 1963 as amended (EIA, 1997). Large blocks of coal that can be mined underground with relatively low-cost, longwall mining methods, however, can be produced economically, and this coal can be utilized by powerplants equipped with scrubbers.

In contrast, several counties in the central supply region are at or near peak production; county cumulative production is moderate to high, and the current annual production from these counties commonly is moderate to high. The sulfur content of coal produced from these counties is comparatively low (Attanasi and Milici, 1998), so that coal from this region is valued for consumption in powerplants as well as for other industrial purposes. Because of its relatively low sulfur content, much of the coal in the central supply region can be mined economically by large-scale surface mines as well as underground by longwall mining methods, although there are environmental concerns regarding large-scale mountain-top removal operations. The southern supply region in Alabama is relatively small and consists of three coal-producing counties that are generally above average in terms of current production of good quality coal. The sulfur content of coal in this region is generally moderate.

Without improved technology to facilitate the economic mining of remaining coal resources from thinner and deeper beds, and investment in scrubbers by the electric power industry that will permit the consumption of high-sulfur coal in powerplants, coal production in the Appalachian basin can be expected to enter a period of long decline, thus decreasing future employment in and taxes from the coal industry.

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