Coal Market Module

The NEMS Coal Market Module (CMM) provides forecasts of U.S. coal production, consumption, exports, imports, distribution, and prices. The CMM comprises three functional areas: coal production, coal distribution, and coal exports. A detailed description of the CMM is provided in the EIA publication, *Coal Market Module of the National Energy Modeling System 2004,* DOE/EIA-M060(2004) (Washington, DC, 2004*).*

Key Assumptions

Coal Production

The coal production submodule of the CMM generates a different set of supply curves for the CMM for each year of the forecast. Separate supply curves are developed for each of 11 supply regions and 12 coal types (unique combinations of thermal grade, sulfur content, and mine type). The modeling approach used to construct regional coal supply curves addresses the relationship between the minemouth price of coal and corresponding levels of capacity utilization of mines, mining capacity, labor productivity, and the cost of factor inputs (mining equipment, mine labor, and fuel requirements).

The key assumptions underlying the coal production modeling are:

- Mining costs are assumed to vary with changes in capacity utilization of mines, mining capacity, labor productivity, and factor input costs. Factor input costs are represented by projections of electricity prices from the Electricity Market Module (EMM) and estimates of future coal mine labor and mining equipment costs.

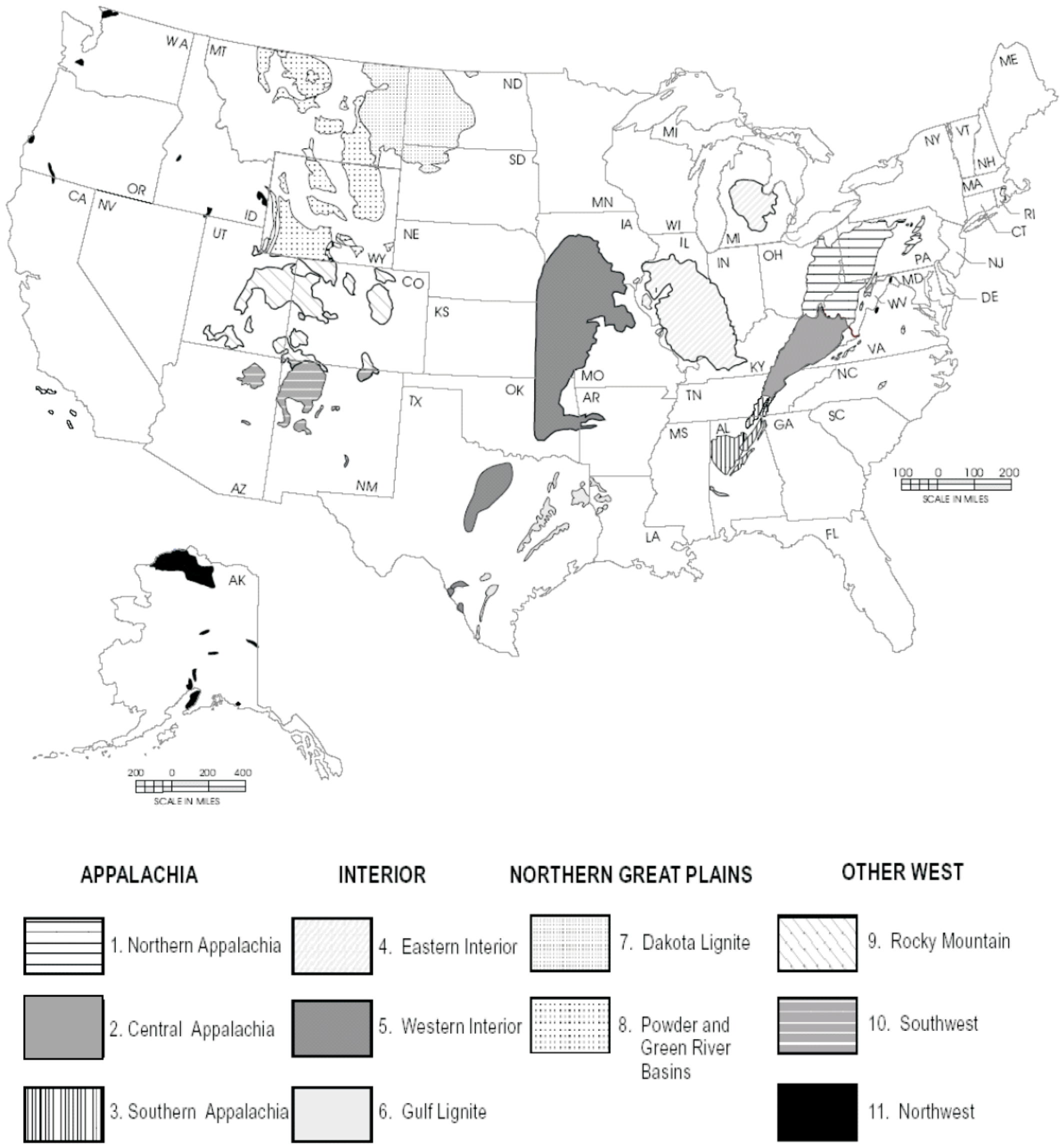
- Between 1979 and 2002, U.S. coal mining productivity (measured in short tons of coal produced per miner per hour) increased at an estimated average rate of 5.9 percent per year. The major factors underlying these gains were interfuel price competition, structural change in the industry, and technological improvements in coal mining.[104] Based on the expectation that further penetration of certain more productive mining technologies, such as longwall methods and large capacity surface mining equipment, will gradually level off, productivity improvements are assumed to continue, but to decline in magnitude. Different rates of improvement are assumed by region and by mine type, surface and underground. On a national basis, labor productivity increases on average at a rate of 1.3 percent a year over the entire forecast, declining from an estimated annual rate of 1.4 percent between 2002 and 2010 to approximately 1.3 percent over the 2010 to 2025 period. These estimates are based on recent historical data reported on Form EIA-7A, *Coal Production Report*, and expectations regarding the penetration and impact of new coal mining technologies.[105]

- Between 1985 and 1993, the average hourly wage for U.S. coal miners (in 2002 dollars) declined at an average rate of 1.5 percent per year, falling from $22.89 to $20.32.[106] During this same time period the producer price index (PPI) for mining machinery and equipment (in 2002 dollars) declined by 0.6 percent per year, falling from 168.5 to 161.2.[107] In the reference case, both the wage rate for U.S. coal miners and mine equipment costs are assumed to remain constant in 2002 dollars (i.e., increase at the general rate of inflation) over the forecast. This assumption reflects the more recent trend in wages and mine equipment costs that has prevailed since 1993. In 2002, the average hourly wage rate for coal miners was $19.04, and the PPI for mining machinery and equipment was 161.2.

Coal Distribution

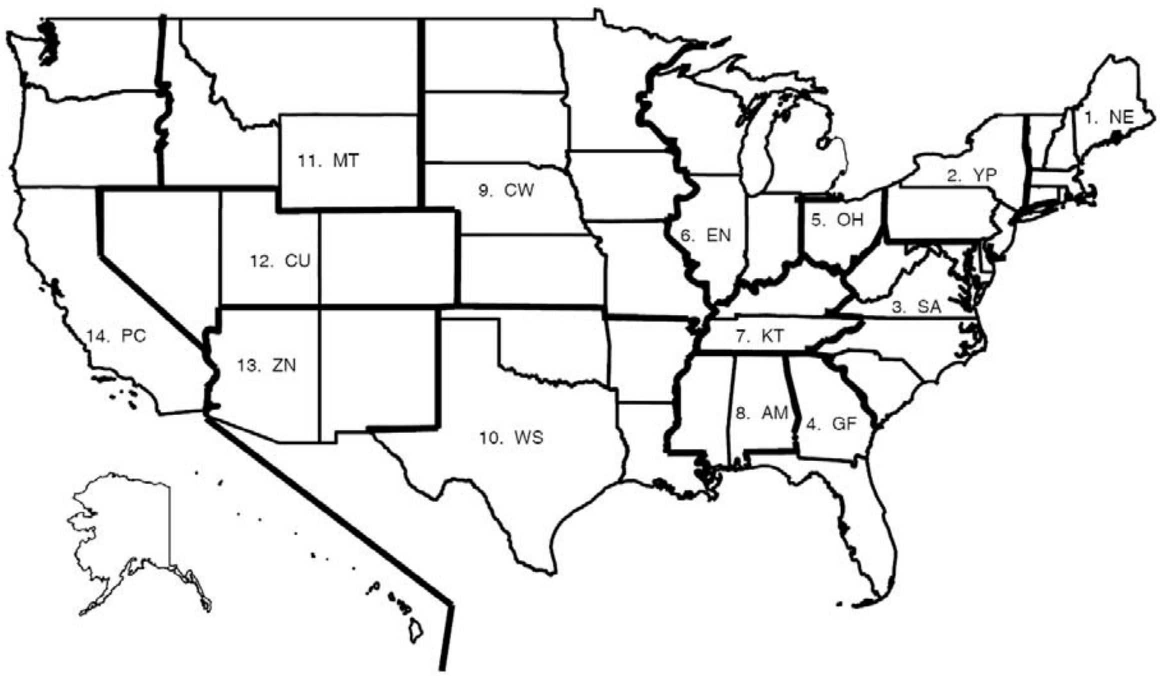
The coal distribution submodule of the CMM determines the least-cost (minemouth price plus transportation cost) supplies of coal by supply region for a given set of coal demands in each demand sector using a linear programming algorithm. Production and distribution are computed for 11 supply (Figure 10) and 14 demand regions (Figure 11) for 49 demand subsectors.

Figure 10. Coal Supply Regions



Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Figure 11. Coal Demand Regions



Region Code	Region Content
1. NE	CT,MA,ME,NH,RI,VT
2. YP	NY,PA,NJ
3. SA	WV,MD,DC,DE,VA,NC,SC
4. GF	GA,FL
5. OH	OH
6. EN	IN,IL,MI,WI
7. KT	KY,TN

Region Code	Region Content
8. AM	AL,MS
9. CW	MN,IA,ND,SD,NE,MO,KS
10. WS	TX,LA,OK,AR
11. MT	MT,WY,ID
12. CU	CO,UT,NV
13. ZN	AZ,NM
14. PC	AK,HI,WA,OR,CA

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

The projected levels of industrial, coking, and residential/commercial coal demand are provided by the industrial, commercial, and residential demand modules; electricity coal demands are provided by the EMM; coal imports are determined exogeneously, and coal export demands are provided from the CMM itself.

The key assumptions underlying the coal distribution modeling are:

- Base-year transportation costs are estimates of average transportation costs for each origin-destination pair. These costs are computed as the difference between the average delivered price for a demand region (by sector and for export) and the average minemouth price for a supply curve. Delivered price data are from Form EIA-3, *Quarterly Coal Consumption Report-Manufacturing Plants*, Form EIA-5, *Quarterly Coke Consumption* and *Quality Report, Coke Plants*, Form EIA-423, *Monthly Cost and Quality of Fuels for Electric Plants Report*, Federal Energy Regulatory Commission (FERC) Form 423, *Monthly Report of Cost and Quality of Fuels for Electric Plants*, and the U.S. Bureau of the Census' Monthly Report EM-545. Minemouth price data are from Form EIA-7A, *Coal Production Report*.

- A two-tier transportation rate structure is used for those regions which, in response to rising demands or changes in demands, may expand their market share beyond historical levels. The first-tier rate is representative of the historical average transportation rate. The second-tier transportation rate is used to capture the higher cost of expanded shipping distances in large demand regions. The second tier is also used to capture costs associated with the use of subbituminous coal at units that were not originally designed for its use.

  Coal transportation costs are modified over time in response to projected variations in reference case fuel costs (No. 2 diesel fuel in the industrial sector), labor costs, the user cost of capital for transportation equipment, and a time trend. The transportation rate multipliers used for all five *AEO2004* cases are shown in Table 68.

Table 68. Transportation Rate Multipliers
(Constant Dollar Index, 2002=1.000)

Year	Reference Case	High Oil Price	Low Oil Price	High Economic Growth	Low Economic Growth
2002	1.0000	1.0000	1.0000	1.0000	1.0000
2005	0.9353	0.9507	0.9197	0.9532	0.9273
2010	0.9239	0.9359	0.9125	0.9759	0.8928
2015	0.8756	0.8841	0.8672	0.9390	0.8208
2020	0.8216	0.8239	0.8149	0.8984	0.7495
2025	0.7581	0.7588	0.7547	0.8560	0.6804

Source: Energy Information Administration. Based on methodology described in "Forecasting Annual Energy Outlook Coal Transportation Rates", *Issues in Midterm Analysis and Forecasting 1997*, DOE/EIA-0607(97), (Washington, DC, July 1997).

- Coal contracts in the CMM represent a minimum quantity of a specific electricity coal demand that must be met by a unique coal supply source prior to consideration of any alternative sources of supply. Base-year coal contracts between coal producers and electricity generators are estimated on the basis of receipts data reported by electric utilities on FERC Form 423, *Monthly Report of Cost and Quality of Fuels for Electric Plants*, and by nonutility generators on Form EIA-423, *Monthly Cost and Quality of Fuels for Electric Plants Report*. Coal contracts are specified by CMM supply region, coal type, demand region, and whether or not a unit has flue gas desulfurization equipment. Coal contract quantities are reduced over time on the basis of contract duration data reported by electric utilities on FERC Form 580, "Interrogatory on Fuel and Energy Purchase Practices" and information obtained from various coal and electric power industry publications and reports.

- Electric generation demand received by the CMM is subdivided into "coal groups" representing demands for different sulfur and thermal heat content categories. This process allows the CMM to determine the economically optimal blend of different coals to minimize delivered cost, while meeting the sulfur emissions requirements of the Clean Air Act Amendments of 1990. Similarly, nongeneration demands are subdivided into subsectors with their own coal groups to ensure that, for example, lignite is not used to meet a coking coal demand.

- Projections of annual U.S. coal imports, specified by demand region and economic sector, are developed exogenously. The forecast is based primarily on the capability and plans of existing coal-fired generating plants to import coal and announced plans to expand the coal import infrastructure. Projections of coal imports do not vary across the alternative *AEO2004* forecast scenarios. Total sulfur dioxide emissions from imports and domestically produced coal are subject to the restrictions on emissions specified in the CAAA90.

Coal Exports

Coal exports are modeled as part of the CMM's linear program that provides annual forecasts of U.S. steam and metallurgical coal exports, in the context of world coal trade. The linear program determines the pattern of world coal trade flows that minimize the production and transportation costs of meeting a prespecified set of regional world coal import demands. It does this subject to constraints on export capacity and trade flows.

The CMM projects steam and metallurgical coal trade flows from 16 coal-exporting regions of the world to 20 import regions for three coal types (coking, bituminous steam, and subbituminous). It includes five U.S. export regions and four U.S. import regions.

The key assumptions underlying coal export modeling are:

- The coal market is competitive. In other words, no large suppliers or groups of producers are able to influence the price through adjusting their output. Producers' decisions on how much and who they supply are driven by their costs, rather than prices being set by perceptions of what the market can bear. In this situation, the buyer gains the full consumer surplus.

- Coal buyers (importing regions) tend to spread their purchases among several suppliers in order to reduce the impact of potential supply disruptions, even though this may add to their purchase costs. Similarly, producers choose not to rely on any one buyer and instead endeavor to diversify their sales.

- Coking coal is treated as homogeneous. The model does not address quality parameters that define coking coals. The values of these quality parameters are defined within small ranges and affect world coking coal flows very little.

Data inputs for coal export modeling:

- U.S. coal exports are determined, in part, by the projected level of world coal import demand. World steam and metallurgical coal import demands for the *AEO2004* forecast cases are shown in Tables 69 and 70.

- Step-function coal export supply curves for all non-U.S. supply regions. The curves provide estimates of export prices per metric ton, inclusive of minemouth and inland freight costs, as well as the capacities for each of the supply steps.

- Ocean transportation rates (in dollars per metric ton) for feasible coal shipments between international supply regions and international demand regions. The rates take into account maximum vessel sizes that can be handled at export and import piers and through canals and reflect route distances in thousands of nautical miles.

Table 69. World Steam Coal Import Demand by Import Region, 2001-2025
(Million metric tons of coal equivalent)

Import Regions[1]	2001[2]	2005	2010	2015	2020	2025
The Americas	38.5	45.0	50.3	56.1	59.7	60.5
United States	15.7	20.6	27.6	31.6	35.2	38.8
Canada	15.0	12.4	11.0	10.2	9.8	6.3
Mexico	2.1	6.0	6.4	6.6	7.0	7.7
South America	5.7	6.0	5.3	7.7	7.7	7.7
Europe	132.5	135.7	145.1	138.8	134.5	132.0
Scandinavia	11.7	8.4	5.6	4.3	3.6	2.9
U.K/Ireland	25.1	24.1	26.1	25.0	24.1	23.5
Germany/Austria	15.4	17.9	21.5	22.4	24.2	26.0
Other NW Europe	24.1	22.5	21.2	14.5	11.0	9.3
Iberia	19.4	25.3	27.4	26.5	24.7	22.9
Italy	11.4	11.3	11.3	11.3	9.7	9.3
Med/E Europe	25.4	26.2	32.0	34.8	37.2	38.1
Asia	195.0	226.1	261.6	279.0	304.4	320.1
Japan	72.2	83.3	96.0	101.5	106.9	112.3
East Asia	84.3	94.3	106.1	109.7	121.6	126.1
China/Hong Kong	9.8	9.7	14.5	19.0	23.6	25.4
ASEAN	15.5	23.9	28.5	30.5	32.2	33.5
Indian Sub	10.2	14.9	16.5	18.3	20.1	22.8
Total	366.0	406.8	457.0	473.9	498.6	512.6

[1]Import Regions: **South America:** Argentina, Brazil, Chile; **Scandinavia:** Denmark, Finland, Norway, Sweden; **Other NW Europe:** Belgium, France, Luxembourg, Netherlands; **Iberia:** Portugal, Spain; **Med/E Europe:** Algeria, Bulgaria, Croatia, Egypt, Greece, Israel, Malta, Morocco, Romania, Tunisia, Turkey; **East Asia:** North Korea, South Korea, Taiwan; **ASEAN:** Malaysia, Philippines, Thailand; **Indian Sub:** Bangladesh, India, Iran, Pakistan, Sri Lanka.

[2] The base year of the world trade forecast for coal is 2001.

Notes: One “metric ton of coal equivalent” contains 27.78 million Btu. Totals may not equal sum of components due to independent rounding.

Source: Projections: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Table 70. World Metallurgical Coal Import Demand by Import Region, 2001-2025
(Million metric tons of coal equivalent)

Import Regions[1]	2001[2]	2005	2010	2015	2020	2025
The Americas	20.6	23.3	25.9	27.7	29.3	29.4
United States	2.1	2.3	2.3	2.3	2.3	2.3
Canada	3.9	4.7	4.6	4.4	4.2	4.0
Mexico	1.1	1.3	2.3	2.9	3.8	4.0
South America	13.5	15.0	16.7	18.1	19.0	19.1
Europe	53.4	53.3	52.9	51.4	49.6	49.1
Scandinavia	3.3	2.8	2.8	2.8	1.8	1.6
U.K/Ireland	10.4	7.7	7.7	7.2	7.2	7.2
Germany/Austria	3.6	6.4	7.0	7.0	7.0	7.0
Other NW Europe	16.6	15.2	13.4	12.4	11.4	10.9
Iberia	4.4	4.5	3.9	3.9	3.9	3.9
Italy	8.6	7.3	7.2	6.4	6.4	6.4
Med/E Europe	6.5	9.4	10.9	11.7	11.9	12.1
Asia	109.0	109.4	109.4	111.7	113.5	116.3
Japan	69.2	63.5	59.6	58.2	56.7	54.8
East Asia	25.6	28.1	31.4	33.4	35.7	37.6
China/Hong Kong	0.0	0.6	0.6	0.6	0.6	0.6
ASEAN	0.0	0.0	0.0	0.0	0.0	0.0
Indian Sub	14.2	17.2	17.8	19.5	20.5	23.3
Total	183.0	186.0	188.2	190.8	192.4	194.8

[1]Import Regions: **South America:** Argentina, Brazil, Chile; **Scandinavia:** Denmark, Finland, Norway, Sweden; **Other NW Europe:** Belgium, France, Luxembourg, Netherlands; **Iberia:** Portugal, Spain; **Med/E Europe:** Algeria, Bulgaria, Croatia, Egypt, Greece, Israel, Malta, Morocco, Romania, Tunisia, Turkey; **East Asia:** North Korea, South Korea, Taiwan; **ASEAN:** Malaysia, Philippines, Thailand; **Indian Sub:** Bangladesh, India, Iran, Pakistan, Sri Lanka.

2 The base year of the world trade forecast for coal is 2001.

Notes: One "metric ton of coal equivalent" contains 27.78 million Btu. Totals may not equal sum of components due to independent rounding.

Source: Projections: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Coal Quality

Each year the values of base year coal production, heat, sulfur and mercury (Hg) content and carbon dioxide emissions for each coal source in CMM are calibrated to survey data. Surveys used for this purpose are the FERC Form 423, a survey of the origin, cost and quality of fossil fuels delivered to electric utilities, the Form EIA–423, a survey of the origin, cost and quality of fossil fuels delivered to non-utility generating facilities, the Form EIA-5 which records the origin, cost, and quality of coal receipts at domestic coke plants, and the Form EIA–3, which records the origin, cost and quality of coal delivered to domestic industrial consumers. Estimates of coal quality for the export and residential/commercial sectors are made using the survey data for coal delivered to coking coal and industrial steam coal consumers. Hg content data for coal by supply region and coal type, in units of pounds of Hg per trillion Btu, shown in Table 71, were derived from shipment-level data reported by electricity generators to the Environmental Protection Agency in its 1999 Information Collection Request. The database included approximately 40,500 Hg samples reported for 1,143 generating units located at 464 coal-fired facilities. Carbon dioxide emission factors for each coal type are shown in Table 71 in pounds of carbon dioxide emitted per million Btu.[108]

Table 71. Production, Heat Content, and Sulfur, Mercury and Carbon Dioxide Emission Factors by Coal Type and Region

Coal Supply Region	States	Coal Rank and Sulfur Level	Mine Type	2002 Production (Million Short tons)	Heat Content (Million Btu per Short Ton)	Sulfur (Pounds Per Million Btu)	Mercury (Pounds Per Trillion Btu)	CO_2 (Pounds Per Million Btu)
Northern Appalachia	PA, OH, MD, WV(North)	Metallurgical	Underground	2.8	27.43	0.77	N/A	205.4
		Mid-Sulfur Bituminous	All	66.6	25.37	1.25	11.16	205.4
		High-Sulfur Bituminous	All	59.4	24.75	2.48	11.67	203.6
		Waste Coal (Gob and Culm)	All	11.1	12.31	1.88	63.9	203.6
Central Appalachia	KY(East), WV(South), TN(North)	Metallurgical	Underground	34.0	27.43	0.60	N/A	203.8
		Low-Sulfur Bituminous	All	63.9	25.26	0.54	5.61	203.8
		Mid-Sulfur Bituminous	All	151.2	24.93	0.84	7.58	203.3
Southern Appalachia	AL,TN(South)	Metallurgical	Underground	4.6	27.43	0.48	N/A	203.3
		Low-Sulfur Bituminous	All	3.1	24.66	0.57	3.87	203.3
		Mid-Sulfur Bituminous	All	11.4	24.53	1.06	10.15	203.3
East Interior	IL, IN, KY(West), MS	Mid-Sulfur Bituminous	All	32.0	22.68	1.13	5.60	202.7
		High-Sulfur Bituminous	All	60.7	22.85	2.74	6.35	202.5
		Mid-Sulfur Lignite	Surface	2.3	11.26	0.98	14.11	211.4
West Interior	IA, MO, KS, AR, OK, TX(Bit)	High-Sulfur Bituminous	Surface	1.9	23.58	2.28	21.55	202.4
Gulf Lignite	TX(Lig), LA	Mid-Sulfur Lignite	Surface	26.7	13.11	1.24	14.11	211.4
		High-Sulfur Lignite	Surface	22.3	13.08	2.07	15.28	211.4
Dakota Lignite	ND, MT(Lig)	Mid-Sulfur Lignite	Surface	31.1	13.24	1.15	8.38	216.6
Powder River, Green River, and Hannah Basins	WY, MT(Sub)	Low-Sulfur Subbituminous	Surface	372.1	17.44	0.35	5.68	210.7
		Mid-Sulfur Subbituminous	Surface	38.2	17.57	0.76	5.82	210.7
		Low-Sulfur Bituminous	Underground	0.0	21.93	0.51	2.08	204.4
Rocky Mountain	CO, UT	Low-Sulfur Bituminous	Underground	50.4	23.25	0.40	3.82	203.0
		Low-Sulfur Subbituminous	Surface	10.0	20.61	0.39	2.04	210.6
Southwest	AZ, NM	Low-Sulfur Bituminous	Surface	23.0	21.40	0.47	4.66	205.4
		Mid-Sulfur Subbituminous	Surface	16.9	18.69	0.85	7.18	206.7
		Mid-Sulfur Bituminous	Underground	1.8	19.52	0.72	7.18	206.7
Northwest	WA, AK	Mid-Sulfur Subbituminous	Surface	7.0	15.63	1.13	6.99	207.9

*Indicates that quantity is less than 50,000 short tons.

N/A = not available.

Source: Energy Information Administration, Form EIA-3, “Quarterly Coal Consumption Report—Manufacturing Plants”; Form EIA-5, “Quarterly Coal Consumption and Quality Report, Coke Plants; Form EIA-6A, “Coal Distribution Report—Annual”; Form EIA-7A, “Coal Production Report, and Form EIA-423, "Monthly Cost and Quality of Fuels for Electric Plants Report.” Federal Energy Regulatory Commission, Form 423, “Monthly Report of Cost and Quality of Fuels for Electric Plants.” U.S. Department of Commerce, Bureau of the Census, “Monthly Report EM-545.” U.S. Environmental Protection Agency, Emission Standards Division, *Information Collection Request for Electric Utility Steam Generating Unit, Mercury Emissions Information Collection Effort* (Research Triangle Park, NC, 1999). B.D. Hong and E.R. Slatick, “Carbon Dioxide Emission Factors for Coal,” in Energy Information Administration, *Quarterly Coal Report*, January-March 1994, DOE/EIA-0121 (94/Q1) (Washington, DC, August 1995).

Legislation

It is assumed that provisions of the Energy Policy Act of 1992 that relate to the future funding of the Health and Benefits Fund of the United Mine Workers of America will have no significant effect on estimated production costs, although liabilities of company's contributions will be redistributed. Electricity sector demand for coal, which represented 92 percent of domestic coal demand in 2002, incorporates the provisions of the Clean Air Act Amendments of 1990. It is assumed that electricity producers will be granted full flexibility to meet the specified reductions in sulfur dioxide emissions. The reference case excludes any potential environmental actions not currently mandated such as mercury reductions or other rules or regulations not finalized.

Mining Cost Cases

In the reference case, labor productivity is assumed to increase at an average rate of 1.3 percent per year through 2025, while wage rates and mine equipment costs remain constant in 2002 dollars. Two alternative cases were modeled in the NEMS CMM, assuming different growth rates for both labor productivity and miner wages. In a low mining cost sensitivity case, productivity increases at 2.9 percent per year, and real wages and mine equipment costs decline by 0.5 percent per year. In a high mining cost sensitivity case, productivity decreases by 0.6 percent per year, and real wages and mine equipment costs increase by 0.5 percent per year. In the alternative cases, the annual growth rates for productivity were increased and decreased based on historical variations in national average labor productivity. Both cases were run as fully integrated NEMS runs.

Notes and Sources

[104] Energy Information Administration, The U.S. Coal Industry, 1970-1990: Two Decades of Change, DOE/EIA-0559, (Washington, DC, November 1992).

[105] Stanley C. Suboleski, et.al., Central Appalachia: Coal Mine Productivity and Expansion, Electric Power Research Institute, EPRI IE-7117, (September 1991).

[106] U.S. Department of Labor, Bureau of Labor Statistics, Series ID: EEU10120006.

[107] U.S. Department of Labor, Bureau of Labor Statistics, Series ID: PCU3532#.

[108] Hong, B.D. and Slatick, E.R. “Carbon Dioxide Emission Factors for Coal,” Energy Information Administration, Quarterly Coal Report, January-March 1994, DOE/EIA-121 (94/Q1) (Washington, DC, August 1995).