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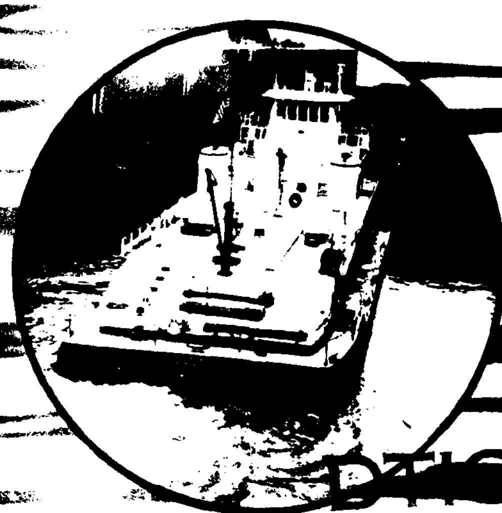
# Projections Of Demand For Waterborne Transportation

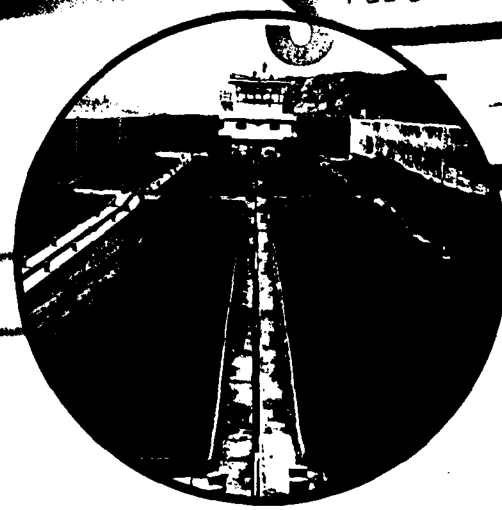
Ohio River Basin
1980 - 2040

## Volume 3

## Coal and Coke









U. S. Army Corps of Engineers
Ohio River Division
Cincinnati, Ohio



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River Basin Navigation System. Each of the studies considers existing waterborne commerce and develops a consistent set of projects of future traffic demands for all of the navigable waterways of the Basin. Each report contains information on past and present waterborne commerce in the Basin and projections by commodity groups and origin-destination areas from 1976 to at least 1990.

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(Continued from #20)
The three study projections, in conjunction with other analytical tools and system information, will be used to evaluate specific waterway improvements to meet short and long-term navigation needs. The output from these studies will serve as input to Corps' Inland Navigation Simulation Models to help analyze the performance and opportunities for improvement of the Ohio River Basin Navigation System. These data will be used in current studies relating to improvement of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, the Cumberland River and the Tennessee River, as well as other improvements.

This document is volume 3 of the 17 volume report shown below.

The study included a Commodity Resource Inventory, a Modal Split Analysis and a Market Demand Analysis. The work included investigation and analyses of the production, transportation and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of and within the Ohio River Basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A study summary aggregates the commodity group totals for each of the several projections periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin. The study results are presented in the following 17 documents:

| Volume | Subject Title | |
|---|---|---|
| 1 | Study summary | |
| 2 | Methodology | |
| 3 | Group I: | Coal and coke |
| 4 | Group II: | Petroleum fuels |
| 5 | Group III: | Crude Petrol. |
| 6 | Group IV: | Aggregates |
| 7 | Group V: | Grains |
| 8 | Group VI: | Chemicals and chemical fertilizers |
| 9 | Group VII: | Ores and Minerals |
| 10 | Group VIII: | Iron ore, steel and iron |
| 11 | Group IX: | Feed and food products, nec. |
| 12 | Group X: | Wood and paper products |
| 13 | Group XI: | Petroleum products, nec. |
| 14 | Group XII: | Rubber, plastics, nonmetallic, mineral, products, nec. |
| 15 | Group XIII: | Nonferrous, metals and alloys, nec. |
| 16 | Group XIV: | Manufactured products, nec. |
| 17 | Group XV: | Other, nec. |

Additionally, an Executive Summary is available as a separate document.

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# GROUP I. COAL & COKE.

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# PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION OHIO RIVER BASIN 1980, 1990, 2000, 2020, 2040.

Volume 3.

Prepared for

**U.S. ARMY CORPS OF ENGINEERS**
**OHIO RIVER DIVISION, HUNTINGTON DISTRICT**

15
Contract No. DACW69-78-C-0136

by

Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

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DECEMBER 1980

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CONTENTS: v.1. Study summary.--v.2. Methodology.--v.3. Commodity groups .

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## PREFACE

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River basin navigation system. Each of the studies considers existing waterborne commerce and develops a consistent set of projections of future traffic demands for all of the navigable waterways of the basin. Each report contains information on past and present waterborne commerce in the basin with projections by commodity group and origin-destination areas from 1976 to either 1990 or 2040.

The three projections, in conjunction with other analytical tools and waterway system information, will be used to evaluate specific waterway improvements required to meet short and long-term navigation needs. The output from these studies will serve as input to Corps inland navigation simulation models to help analyze the performance and requirements for improvements of the Ohio River basin navigation system. These data will be used in current studies relating to improvements of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, and the Tennessee River, as well as for other improvements.

The reports on the three studies are referred to as the "CONSAD," the "BATTELLE," and the "NATHAN" reports. The latter and final report was completed in November 1980. It was prepared for the Corps of Engineers by Robert R. Nathan Associates, Inc., Consulting Economists, Washington D.C. This study encompasses the period 1976-2040, and is by far the most detailed of the three.

The "CONSAD" report, completed in January 1979, was prepared for the Corps by the CONSAD Research Corporation of Pittsburgh, Pennsylvania. The study and the 1976-1990 projected traffic demands discussed in that report were developed by correlating the historic waterborne commodity flows on the Ohio River navigation system, with various indicators of regional and national demands for the commodities. The demand variables which appeared to best describe the historic traffic pattern for each of the commodity groups was selected for projection purposes. The projected values for the demand variables are based upon the 1972 OBERS Series E Projections of National and Regional Economic Activity. The OBERS projections serve as national standards and were developed by the Bureau of Economic Analysis of the U.S. Department of Commerce, in conjunction with the Economic Research Service of the Department of Agriculture.

The "BATTELLE" report was completed in June 1979, and was prepared for the Corps by the Battelle Columbus Laboratories, Columbus, Ohio. The study and the 1976-1990 traffic projections discussed in that report were developed by surveying all waterway users in the Ohio River Basin through a combined mail survey and personal interview approach. The purpose of the survey was to obtain an estimate from each individual shipper of his future commodity movements, by specific origins and destinations, as well as other associated traffic information. All identifiable waterway users were contacted and requested to provide the survey information. In addition, personal interviews were held with the major shippers. The responses were then aggregated to yield projected traffic demands for the Ohio River navigation system.

The "NATHAN" report presents the findings of a commodity resource inventory, a modal split analysis and a market demand analysis. The work included investigation and analyses of the production, transportation, and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of, and within the Ohio River basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A Study Summary and an Executive Summary present appropriately abbreviated discussion and findings resulting from these analyses. The Study Summary aggregates the commodity group totals for each of the several projection periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin.

The "NATHAN" report, "Projections of Demand for Waterborne Transportation, Ohio River Basin, 1980, 1990, 2000, 2020, 2040" consists of the following volumes:

| Subject Title | Number of Pages | Volume Number |
|---|---|---|
| Study Summary | 220 | 1 |
| Methodology | 118 | 2 |
| Group I: Coal and Coke | 134 | 3 |
| Group II: Petroleum Fuels | 66 | 4 |
| Group III: Crude Petroleum | 42 | 5 |
| Group IV: Aggregates | 64 | 6 |
| Group V: Grains | 131 | 7 |
| Group VI: Chemicals and Chemical Fertilizers | 90 | 8 |
| Group VII: Ores and Minerals | 61 | 9 |
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| Group IX: Feed and Food Products, Nec. | 44 | 11 |
| Group X: Wood and Paper Products | 61 | 12 |
| Group XI: Petroleum Products, Nec. | 38 | 13 |
| Group XII: Rubber, Plastic, Nonmetallic Mineral Products, Nec. | 41 | 14 |
| Group XIII: Nonferrous Metals and Alloys, Nec. | 57 | 15 |
| Group XIV: Manufactured Products Nec. | 35 | 16 |
| Group XV: Others, Nec. | 48 | 17 |

Additionally, an Executive Summary is available as a separate document.

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# PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION OHIO RIVER BASIN 1980, 1990, 2000, 2020, 2040

## Group I: Coal and Coke

Prepared for
U.S. Army Corps of Engineers
Huntington District
Contract No. DACW69-78-C-0136

by

Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

November 1980

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# I. INTRODUCTION

Group I, coal and coke, consists of the various grades and types of coal produced in the United States, as well as coke, a semi-refined product made from coal. During 1976, this group of commodities and products accounted for 58.0 percent of all waterborne traffic in the Ohio River System (ORS).

The areas within the Ohio River Basin (ORB) for which projections of Group I consumption, production and movements have been made are designated as Primary Study Areas (PSAs). The PSAs for Group I are those U.S. Department of Commerce Bureau of Economic Analysis Areas (BEAs) and area segments (aggregations of counties within a BEA) which are origins or destinations of Group I waterborne movements. A map showing Group I PSAs is presented in the appendix to this report.

In addition to the PSAs, external areas linked to the ORB through waterborne commerce have been identified. Areas (BEAs) outside the ORB which are destinations of waterborne Group I movements originating in the ORB are designated as Secondary Consumption Areas (SCAs). Areas (BEAs) outside the ORB which are origins of Group I waterborne movements destined to the ORB are designated as Secondary Production Areas (SPAs).

## A. Description of Group I

The individual commodities and products included in Group I are:

| Waterborne Commerce Statistics Code (WCSC) | Commodity/Product |
|---|---|
| 1121 | Coal and lignite |
| 2920 | Coke, including petroleum coke |

| | |
|---|---|
| 3313 | Coke (coal and petroleum), petroleum pitches and asphalts, naphtha and solvents |

Historical data and discussions with industry authorities indicate that coal and lignite account largely for Group I waterborne traffic in the ORS. Coke produced in the Ohio River System hinterland generally is used at the site of production, or it is transported via rail to its location of use. As shown in Table 1, waterborne shipments of coke accounted for only 477.5 thousand tons in 1976. The products in WCSC category 3313 are foreign trade elements of coal and coke. There was no recorded movement of these products in the ORS during the period 1969-76, and it was ascertained that there probably will be no movements of these products in the future. Accordingly, future waterway movements of Group I commodities and products are expected to be dominated by coal and lignite (WCSC 1121), with only trace movements of coke and petroleum coke (WCSC 2920).

B. Existing Waterway Traffic Flows

Coal and coke contribute substantial volumes to ORB waterborne traffic. In 1976, 58 percent of total Ohio River System shipments were coal and coke movements (Table 2). In regard to total coal and coke waterborne movements, local shipments constitute a higher portion than most commodities transported in the System. In fact, coal and coke accounted for 70.1 percent of all local ORS movements in 1976.

Total inbound, outbound, and local coal and coke waterway traffic amounted to 116.5 million tons in 1976, an increase from 86.9 millon tons in 1969 (Table 1). Thus, the waterway movements of coal and coke increased by an average annual rate of 4.3 percent between 1969 and 1976.

In 1976, local movements of coal and coke accounted for 87 percent of all Group I waterway traffic in the ORS. This was the general pattern of Group I movements throughout the period, from 1969 to 1976. Local traffic increased at an average annual rate of 4.0 percent during the period. Inbound and outbound movements of Group I shipments exhibited a slightly different pattern. Inbound shipments increased dramatically, growing from 7.8 thousand tons in

Table 1. Ohio River System: Waterborne Shipments of Coal and Coke by Commodity
Inbound, Outbound, and Local Movements, 1969-76

(Thousands of tons unless otherwise specified)

| Commodity and type of movement | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | Average annual percentage change, 1969-76 |
|---|---|---|---|---|---|---|---|---|---|
| Total[a] | 86,957.5 | 89,700.1 | 84,716.0 | 94,177.1 | 91,566.8 | 92,561.3 | 99,655.8 | 116,532.9 | 4.3 |
| Inbound | 7.8 | 98.9 | 246.6 | 835.4 | 1,279.2 | 1,943.4 | 2,774.1 | 2,632.2 | 129.7 |
| Outbound | 9,872.2 | 11,228.6 | 10,431.2 | 12,173.1 | 11,195.7 | 12,164.1 | 11,622.3 | 12,552.7 | 3.5 |
| Local | 77,077.5 | 78,372.6 | 74,038.2 | 81,168.6 | 79,091.9 | 78,453.8 | 85,259.4 | 101,348.0 | 4.0 |
| Coal and lignite | 86,573.0 | 89,260.2 | 84,366.7 | 93,875.9 | 91,139.3 | 92,095.2 | 99,313.0 | 116,055.5 | 4.3 |
| Inbound | 2.4 | 10.8 | 111.0 | 685.3 | 1,127.5 | 1,696.6 | 2,621.7 | 2,374.8 | 167.9 |
| Outbound | 9,843.1 | 11,186.9 | 10,425.5 | 12,166.6 | 11,174.7 | 12,141.8 | 11,611.9 | 12,503.6 | 3.5 |
| Local | 76,727.5 | 78,062.5 | 73,830.2 | 81,024.0 | 78,837.1 | 78,256.8 | 85,079.4 | 101,177.1 | 4.0 |
| Coke | 384.5 | 439.9 | 349.3 | 301.2 | 427.5 | 466.1 | 342.8 | 477.5 | 3.1 |
| Inbound | 5.4 | 88.1 | 135.6 | 150.1 | 151.7 | 246.8 | 152.4 | 257.6 | 73.7 |
| Outbound | 29.1 | 41.7 | 5.7 | 6.5 | 21.0 | 22.3 | 10.4 | 48.9 | 7.7 |
| Local | 350.0 | 310.1 | 208.0 | 144.6 | 254.8 | 197.0 | 180.0 | 171.0 | (9.7) |

Note: Individual items may not add to totals due to rounding.
a. Excludes waterborne commodity code no. 3313 (coke, petroleum pitches and asphalts, and naphtha and solvents) for which no movements were reported.
Source: Compiled by RRNA from Waterborne Commerce by Port Equivalents, 1969-76, supplied by the U.S. Army Corps of Engineers.

Table 2. Ohio River System: Waterborne Shipments of All Commodities and of Coal and Coke, 1976

(Thousands of tons unless otherwise specified)

| | Total | Inbound | Outbound | Local[a] |
|---|---|---|---|---|
| All commodities | 200,770.5 | 29,439.5 | 26,854.0 | 144,477.0 |
| Coal and coke | 116,532.9 | 2,632.2 | 12,552.7 | 101,348.0 |
| As a percentage of all commodities | 58.0 | 8.9 | 46.7 | 70.1 |

a. Local shipments include 246.0 thousand tons which were shipped from BEAs outside the Ohio River Basin via rail and were transloaded onto barges at points in the Ohio River System for shipment within the ORS. Thus, the waterway component of these movements is local to the Ohio River System, although the total movement is inbound.

Source: Compiled by RRNA from Waterborne Commerce by Port Equivalents, revised 1976, supplied by the U.S. Army Corps of Engineers.

1969 to 2.6 million tons in 1976. Most of this growth was due to two factors:

- The movements of western coal into areas in the middle part of the ORB.
- Increasing imports of coke moving up the Mississippi River into the ORS and destined for steel producing centers.

Outbound movements of coal and coke increased at a rate of 3.5 percent annually during the period to supply increased demands for coal by electric utilities along the Mississippi River and on the Gulf Coast.

B-1. BEA-to-BEA Traffic Flows

The largest shippers of waterborne coal movements in the ORS hinterland in 1976 were BEAs 66 (Pittsburgh), 65 (Clarksburg), 55 (Evansville) and 52 (Huntington). Together, these BEAs accounted for 88 percent of all Group I waterborne shipments. The distribution of waterborne coal and coke movements is shown in Table 3.

B-2. Highlights of Important Links

Most shipments were made to destination points close to, or actually in, the BEAs of their origination. For instance, BEA 55 (Evansville) shipped coal to nearby destinations at the lower end of the ORS, with only trace movements flowing as far up the system as BEA 66 (Pittsburgh). Of the waterborne shipments originating in BEA 66 (Pittsburgh), over 80 percent were to port equivalents (PEs) within BEA 66. A third of the coal shipments from BEA 52 (Huntington), which is located in the central portion of the ORB, was between PEs in BEA 52.

Besides having origins in three major areas, [BEAs 55 (Evansville) 52 (Huntington), 66 (Pittsburgh)], coal originates in other PSAs as well. BEA 65 (Clarksburg) is the fourth largest originating point of waterborne coal shipments. Most of these shipments are destined for BEA 66 (Pittsburgh). BEA 51 (Bristol) is also an important origin of waterborne coal shipments. It is not a waterside PSA, but it ships coal by rail and truck to 52 (Huntington) and 62 (Cincinnati) where the coal is then loaded onto barges.

Table 3. Ohio River Basin: Waterborne Commerce by BEA, 1976
Group 1: Coal and Coke

(Thousands of tons)

| Origins | Total | ORB BEAs | BEA 47 | BEA 48 | BEA 49 | BEA 52 | BEA 54 | BEA 55 | BEA 62 | BEA 64 | BEA 65 | BEA 66 | BEA 115 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Destinations | | | | | | | | | | | | |
| Total | 116,532.9 | 103,980.2 | 3,371.0 | 834.7 | 7,500.9 | 14,946.3 | 8,280.8 | 1,099.2 | 15,982.4 | 396.2 | 2,418.8 | 46,788.9 | 2,461.0 |
| ORB BEAs | 113,654.7 | 101,102.0[c] | 3,352.1 | 684.2 | 7,218.9 | 13,203.6 | 8,280.8 | 1,017.9 | 15,805.7 | 396.2 | 2,418.8 | 46,618.8 | 2,105.0 |
| BEA 48 | 1,574.7 | 570.6 | -- | 566.1 | -- | 4.5 | -- | -- | -- | -- | -- | -- | -- |
| BEA 49 | 146.1 | 146.1 | -- | -- | -- | 79.4 | -- | -- | 66.7 | -- | -- | -- | -- |
| BEA 50[a] | 512.6 | 463.8 | -- | 31.5 | -- | 23.6 | -- | -- | 268.3 | -- | -- | 72.2 | 68.2 |
| BEA 51[a] | 1,269.6 | 1,168.6 | -- | 31.5 | -- | 329.9 | -- | 3.9 | 253.3 | -- | 37.8 | 506.8 | 5.4 |
| BEA 52 | 28,724.5 | 27,283.4 | 240.8 | -- | 88.0 | 9,254.9 | 19.2 | 114.4 | 5,212.5 | 383.8 | 718.2 | 10,901.0 | 350.6 |
| BEA 53[a] | 1,292.2 | 1,249.0 | 60.2 | -- | -- | 297.8 | 4.8 | 9.6 | 633.4 | 2.6 | -- | 138.3 | 102.3 |
| BEA 55 | 37,747.7 | 27,886.0 | 3,051.1 | 52.9 | 6,563.9 | 1,350.6 | 8,256.8 | 884.0 | 6,170.0 | -- | -- | 98.2 | 1,458.5 |
| BEA 65 | 10,879.9 | 10,871.0 | -- | -- | -- | -- | -- | -- | 29.4 | -- | 1,250.8 | 9,590.8 | -- |
| BEA 66 | 31,257.4 | 31,220.2 | -- | 2.2 | 567.0 | 1,783.4 | -- | 6.0 | 3,095.5 | 9.8 | 412.0 | 25,309.3 | 35.0 |
| BEA 68 | 4.4 | 2.2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2.2 | -- |
| BEA 115 | 245.6 | 241.1 | -- | -- | -- | 79.5 | -- | -- | 76.6 | -- | -- | -- | 85.0 |
| Non-ORB BEAs | 2,878.2 | 2,878.2[c] | 18.9 | 150.5 | 282.0 | 1,742.7 | -- | 81.3 | 76.7 | -- | -- | 170.1 | 356.0 |
| BEA 11 | 102.1 | 102.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 102.1 | -- |
| BEA 77 | 44.3 | 44.3 | 4.3 | 5.5 | -- | -- | -- | 34.5 | -- | -- | -- | -- | -- |
| BEA 114 | 1,448.1 | 1,448.1 | -- | -- | 282.0 | 1,099.4 | -- | -- | 66.7 | -- | -- | -- | -- |
| BEA 115[b] | 1,012.0 | 1,012.0 | -- | 145.0 | -- | 494.0 | -- | -- | 10.0 | -- | -- | 9.0 | 354.0 |
| BEA 118 | 53.4 | 53.4 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 53.4 | -- |
| BEA 137 | 22.3 | 22.3 | -- | -- | -- | -- | -- | 22.3 | -- | -- | -- | -- | -- |
| BEA 138 | 37.4 | 37.4 | 4.0 | -- | -- | 3.3 | -- | 24.5 | -- | -- | -- | 5.6 | -- |
| BEA 141 | 138.0 | 138.0 | -- | -- | -- | 138.0 | -- | -- | -- | -- | -- | -- | -- |
| BEA 143 | 15.0 | 15.0 | 5.0 | -- | -- | 8.0 | -- | -- | -- | -- | -- | -- | 2.0 |
| BEA 144 | 5.6 | 5.6 | 5.6 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(Continued)

Table 3. (Continued)

| Origins | Destinations: Non-ORB BEAs | BEA 38 | BEA 39 | BEA 46 | BEA 57 | BEA 77 | BEA 79 | BEA 81 | BEA 89 | BEA 91 | BEA 113 | BEA 114 | BEA 115[b] | BEA 135 | BEA 137 | BEA 138 | BEA 141 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 12,552.7 | 1,501.9 | 442.5 | 1,559.7 | 3.3 | 831.3 | 82.0 | 256.0 | 202.7 | 162.9 | 16.7 | 1,192.6 | 645.8 | 6.7 | 1,382.6 | 3,929.8 | 336.2 |
| ORB BEAs | 12,552.7 | 1,501.9 | 442.5 | 1,559.7 | 3.3 | 831.3 | 82.0 | 256.0 | 202.7 | 162.9 | 16.7 | 1,192.6 | 645.8 | 6.7 | 1,382.6 | 3,929.8 | 336.2 |
| BEA 48 | 1,004.1 | -- | -- | -- | -- | 183.6 | -- | -- | 18.9 | -- | -- | -- | -- | -- | 23.4 | 778.2 | -- |
| BEA 49 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| BEA 50[a] | 48.8 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 5.6 | -- | -- | -- | 43.2 | -- |
| BEA 51[a] | 101.0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 21.0 | -- | -- | 18.6 | 44.6 | 16.8 |
| BEA 52 | 1,441.1 | -- | -- | -- | -- | 9.6 | -- | -- | -- | 10.5 | -- | 450.8 | -- | -- | 606.4 | 44.4 | 319.4 |
| BEA 53[a] | 43.2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 15.0 | -- | -- | 28.2 | -- | -- |
| BEA 55 | 9,861.7 | 1,494.1 | 442.5 | 1,559.7 | 3.3 | 638.1 | 82.0 | 256.0 | 179.3 | 152.4 | 16.7 | 692.0 | 645.8 | 6.7 | 700.3 | 2,992.8 | -- |
| BEA 65 | 8.9 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 8.9 | -- |
| BEA 66 | 37.2 | 7.8 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 6.0 | -- | -- | 5.7 | 17.7 | -- |
| BEA 68 | 2.2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2.2 | -- | -- | -- | -- | -- |
| BEA 115 | 4.5 | -- | -- | -- | -- | -- | -- | -- | 4.5 | -- | -- | -- | -- | -- | -- | -- | -- |
| Non-ORB BEAs | | | | | | | | | | | | | | | | | |
| BEA 11 | | | | | | | | | | | | | | | | | |
| BEA 77 | | | | | | | | | | | | | | | | | |
| BEA 114 | | | | | | | | | | | | | | | | | |
| BEA 115[b] | | | | | | | | | | | | | | | | | |
| BEA 118 | ** Traffic external to the Ohio River System ** | | | | | | | | | | | | | | | | |
| BEA 137 | | | | | | | | | | | | | | | | | |
| BEA 138 | | | | | | | | | | | | | | | | | |
| BEA 141 | | | | | | | | | | | | | | | | | |
| BEA 143 | | | | | | | | | | | | | | | | | |
| BEA 144 | | | | | | | | | | | | | | | | | |

a. A non-waterside BEA origin for waterborne traffic originating from port equivalents in the Ohio River System.
b. Waterborne traffic originating from or destined to port equivalents not located in the Ohio River System.
c. Inbound (non-ORB to ORB) shipment data include coal shipments which originated from BEAs outside the ORB via rail and were transloaded onto barges within the ORS. The water component is local to the Ohio River System; however, the total movement is inbound to the ORB and will henceforth be treated as an inbound movement.
Source: U.S. Army Corps of Engineers, Waterborne Commerce by Port Equivalents, revised 1976.

a. Inbound Movements

BEA 114 (St. Louis) was the major source of inbound ORS waterway shipments of coal in 1976, with nearly 1.5 million tons shipped to the ORS. Coal coming into the ORS from this BEA was shipped from the western states of Montana and Wyoming into St. Louis (BEA 114) via rail. It was then transferred to barges and transported to electric utilities in BEA 52. In the future, using new major transloading points near Paducah, KY, this inflow of western coal is expected to continue. Major new destination points are expected to be in BEA 55 (Evansville) by 1990. It is unlikely, however, that the 129.7 percent average annual increase in inbound movements, which occurred between 1969 and 1976, will continue. Some inbound movements of imported coke from Germany and Japan will occur. These shipments will be transferred from ocean-going vessels in Gulf ports for movement by barge up the Mississippi and Ohio Rivers to steel centers in the ORB.

b. Outbound Movements

Outbound waterborne shipments of coal and coke from the ORB totalled more than 12 million tons of coal in 1976 (Table 2). Between 1969 and 1976, outbound shipments increased at an annual average rate of 3.5 percent. Most of these shipments consisted of coal. They were generally destined for electric utilities located along the Mississippi River, north of its junction with the Ohio River, and to points along the Gulf Coast. The destinations north of the confluence of the Mississippi and Ohio Rivers included points in Illinois, Wisconsin, Minnesota and Missouri. Destinations on the Gulf Coast, however, were more important in terms of the quantities they received. These destinations included electric utility steam plants in Florida, Mississippi, Alabama, Georgia, Louisiana and Texas. In 1976, nearly 4 million tons of coal were sent to BEA 138 (New Orleans) (Table 3). This was the largest single destination of ORB coal outside of the PSAs. The major shipping PSAs serving areas outside the ORB are BEAs 55 (Evansville) and 52 (Huntington).

c. Intermodal Transfers

The transportation of coal is generally multimodal in the ORB. Movements of coal often involve the use of two or three modes between origin and destination points. The most common mode of initial transport from coal mines is truck. This mode is utilized for short hauls and for delivery of coal to transshipment points. Rail cars are used for short hauls only if the mines have rail spurs at the mine sites.

For long hauls, coal moves mostly by rail, barge, or a combination of the two modes. While rail-to-barge transfers are of lesser importance than truck-to-rail and truck-to-barge transfers, a survey of shippers and available data indicated that substantial rail-to-barge transfers occur along the Ohio River in BEAs 52 (Huntington), 62 (Cincinnati), and 66 (Pittsburgh). The transfers in BEAs 52 and 62 are for shipments which originate in BEAs 51 (Bristol), 52 (Huntington), and 53 (Lexington), as well as the southerly BEA 50 (Knoxville). Most of the transfers in BEA 66 (Pittsburgh) consist of coal produced in BEA 66 itself.

## C. Summary of Findings

The consumption of coal in the PSAs increased at an average annual rate of 6.3 percent during the period 1969-76, from 127.1 million tons in 1969 to 194.6 million tons in 1976. Most of the growth was due to increases in consumption by electric utilities, and by general industrial users. The market for metallurgical coal declined slightly during the period due to a depressed steel industry. The consumption of coke followed the pattern of metallurgical coal consumption. Total consumption of coke fell slightly during the period, from 14.7 million tons in 1969 to 11.9 million tons in 1976.

In the future, coal consumption is expected to grow at a slower rate than during 1969-76. Consumption during the period 1976-90 is projected to increase at a rate of 1.8 percent per year. Coke plant consumption is actually expected to decrease. Total consumption of coal will be 268.9 million tons in 1990, up from 194.6 million tons in 1976. Beyond 1990, coal consumption will increase at an average annual rate of 1.64 percent, lower than in the earlier period.

Production of coal and coke increased at an average annual rate of 0.6 percent per year during the period 1969-76. Underground coal production decreased somewhat, while surface production increased at an average rate of 5.4 percent per year. The production mix of surface and underground mining changed during 1969-76, shifting in favor of surface mining.

Coal production in the PSAs, driven by large increases in demand, is projected to increase at an average annual rate of 2.6 percent during the period 1976-90. Thereafter, production is projected to increase at the slower rate of 1.2 percent a year. Most of the PSAs in the central portion of the ORB, such as BEAs 51 (Bristol), 52 (Huntington), and 50 (Knoxville), are expected to increase production at rates faster than the PSAs in the northeastern section of the ORB.

In 1976, waterway movements of coal totalled 116.5 million tons. Of this total, 101.1 million tons were local, 12.6 million tons were outbound, and 2.9 million tons were inbound movements. In the future, the difference between PSA production and consumption will be greater, and will yield more coal for outbound shipments. Between 1976 and 2000, waterway flows are projected to increase 75 percent over the 1976 levels, reaching 204 million tons of coal in the year 2000. The growth rate of waterway coal shipments is expected to decrease slightly in the following decades as alternative sources of energy are developed, and as pipeline transmission of liquefied or gasified coal replaces some waterway transport. The projected waterway movements of coal in the ORS are 228 million tons and 254 million tons in 2020 and 2040, respectively.

During the projection period, inbound shipments of coal are expected to increase rapidly as western coal begins to move into the PSAs. However, most of this increase probably will not begin until the mid 1980s. Outbound waterborne movements of coal are expected to fluctuate while local movements are projected to increase steadily from 101 million tons in 1976 to 193 million tons in 2040.

## II. MARKET DEMAND ANALYSIS

Consumption of coal and coke in the Primary Study Areas has increased substantially during the last decade. Large increases in electrical generating capacity resulted from growth in both population and income levels in the PSAs. This growth, along with rising prices of fuel oil, led to increases in the volume of coal consumed.

Primarily because of stagnation in the steel industry, the consumption of coal used in the production of coke did not exhibit the growth that the consumption of steam coal demonstrated. Low capacity utilization rates in the steel industry were not peculiar to the PSAs. The entire U.S. steel industry was characterized by these low rates.

Relatively high growth rates for coal used by other consumers offset low growth rates for coal used in the production of coke. In fact, these other consumers, which include private electric generation facilities and miscellaneous industrial users, recently have been increasing their usage of coal. This increased usage has been a result of general increases in economic activity within the PSAs, and of high oil prices which have induced the substitution of coal for fuel oil.

### A. Market Areas

In addition to local demand for Group 1 commodities produced in the PSAs, demand also is generated by Secondary Consumption Areas (SCAs) located outside the ORB. These SCAs are defined as BEAs which are the destinations of waterborne coal and coke movements originating in the Ohio River Basin.

A-1. Primary Study Areas (PSAs)

This study has identified 15 BEAs and BEA segments in the ORB which either have been or will be the ultimate origins or destinations of waterborne coal and coke movements.[1] Appendix Table A-1 presents the BEAs and BEA segments which constitute the Primary Study Areas (PSAs) for coal and coke, and for which coal and coke consumption has been analyzed and projected.

Due to the widespread distribution of waterborne coal and coke movements, virtually all of the counties in 11 BEAs stimulate waterway traffic. In four BEAs, however, waterway traffic on the Ohio River System is stimulated by a limited number of counties. Thus, for BEAs 48 (Chattanooga), 51 (Bristol), 68 (Cleveland) and 115 (Paducah), only BEA segments consisting of relevant counties are treated as PSAs.

A-2. Secondary Consumption Areas (SCAs)

The Secondary Consumption Areas (SCAs) which are destinations of waterborne shipments from the Ohio River Basin were not segmented. These BEAs may or may not be the ultimate points of consumption. In some cases, they are distribution centers for large consumption areas (i.e., water ports from which coal is distributed).

Ohio River Basin coal serves five broad external markets. These include the New England states, the Mid-Atlantic states, the Southeastern states and the North Central states. The fifth market is the export market, mostly consisting of Canada (steam and metallurgical coal), Japan and Europe (metallurgical coal). Domestic markets generally are served by rail transport, while export markets in Europe are served by rail transport to marine ports (Baltimore and Hampton Roads). Shipments to Canada move via rail to the Great Lakes where they are transferred to special bulk carriers. Waterway shipments to external markets are mostly to points on the upper and lower Mississippi River and on the Gulf Coast.

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1. An exception is noted in the case of western coal which is shipped from Montana and Wyoming to BEA 114 (St. Louis) by rail, and is transferred to barges at points near St. Louis and Paducah. No attempt was made to include the states of Montana and Wyoming in the PSAs. Instead, western coal shipments are treated as inbound shipments originating from BEA 114.

## B. Commodity and Product Uses

Coal and lignite have three major uses as inputs into the production of other products. The primary use of coal, accounting for 76 percent of domestic coal consumption in 1976 (Tables 4 and 5), is as an input into the production of electricity. Metallurgical usages of coal include the production of coke for pig iron production and other metal processes. These usages comprised 14 percent of total domestic coal consumption in 1976. The remaining 10 percent of coal consumption was by a miscellaneous group of users. Miscellaneous uses include: coal for private electricity-generation and various industrial processes; coal for railroad and bunker fuel (a declining usage); and coke for space heating. Industrial electricity generation and other industrial uses of coal have become more important recently. They are expected to continue to increase in importance as industrial users convert from natural gas and fuel oil to coal as their primary or secondary source of energy.

### B-1. Past and Current Electricity Generation

The historical pattern of coal consumption for electricity generation in the United States has been marked by two distinct trends. First, the relative importance of coal as the the principal fuel for electricity generation has declined steadily in the post-World War II years. Second, the absolute amount of electricity generation provided by coal has been increasing since 1951. In 1951, coal was used for 68.5 percent of the electricity generated, but by 1976 this percentage had declined to 54.0 percent. However, coal provided only 185,204 million kilowatts hours in 1951.[1] In 1976, 943,877 million kilowatt hours were produced.[2] This effected an increase of 510 percent in absolute electricity generation between 1951 and 1976. During the same period, however, electricity generation by all fuels increased nearly 650 percent. Thus, the increased use of coal for electricity generation did not match the growth in the use of other fuels.

Historical and current regional patterns of electricity generation by type of fuel vary widely and have changed dramatically

1. Richard L. Gordon, U.S. Coal and the Electric Power Industry. (Washington, D.C.: Johns Hopkins Press, 1975).
2. Edison Electric Institute, Statistical Yearbook, 1976 ed. (Washington, D.C.: EEI, 1977).

Table 4. United States: Consumption of Bituminous Coal and Lignite by Consumer Use, 1969-76

(Thousands of tons unless otherwise specified)

| Consumer use | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 |
|---|---|---|---|---|---|---|---|---|
| All uses | 507,275 | 515,619 | 494,862 | 516,776 | 556,022 | 552,709 | 556,301 | 612,742 |
| Electric utilities | 308,461 | 318,921 | 326,280 | 348,612 | 386,879 | 390,068 | 403,249 | 463,058 |
| as a percent of all uses | 60.81 | 61.85 | 65.93 | 67.46 | 69.58 | 70.57 | 72.49 | 75.57 |
| Coke plants | 92,901 | 96,009 | 82,809 | 87,272 | 93,634 | 89,747 | 83,272 | 92,678 |
| as a percent of all uses | 18.31 | 18.62 | 16.73 | 16.89 | 16.84 | 16.24 | 14.97 | 15.13 |
| Other uses | 105,913 | 100,689 | 85,773 | 80,892 | 75,509 | 72,894 | 69,780 | 57,006 |
| as a percent of all uses | 20.88 | 19.53 | 17.33 | 15.65 | 13.58 | 13.19 | 12.54 | 9.30 |

Sources: U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1969-75 eds., and Bituminous Coal and Lignite Distribution, 1976 ed.

Table 5. United States and Selected States: Consumption of Bituminous Coal and Lignite by Consumer Use, Estimated 1976

(Thousands of tons unless otherwise specified)

| | Amount | Consumer use (percent) | | |
|---|---|---|---|---|
| | | Electric utilities | Coke and gas plants | Others |
| United States | 612,742 | 75.57 | 15.13 | 9.30 |
| Alabama | 25,982 | 68.72 | 25.75 | 5.53 |
| Georgia | 15,072 | 96.71 | -- | 3.29 |
| Illinois | 41,455 | 84.46 | 6.60 | 8.94 |
| Indiana | 45,837 | 63.79 | 27.16 | 9.05 |
| Kentucky | 27,320 | 91.39 | 2.97 | 5.64 |
| Maryland | 9,190 | 51.07 | 46.89 | 2.04 |
| Ohio | 70,964 | 70.64 | 17.62 | 11.74 |
| Pennsylvania | 64,592 | 57.67 | 36.04 | 6.29 |
| Tennessee | 23,091 | 91.09 | 0.74 | 8.17 |
| Virginia | 7,470 | 71.04 | 0.11 | 28.85 |
| West Virginia | 36,480 | 77.07 | 14.51 | 8.42 |

Source: U.S. Department of the Interior, Bureau of Mines, Bituminous Coal and Lignite Distribution, 1976 ed.

since World War II. Table 6 illustrates the change in the percent distribution of electricity generation by fossil-fuel type and by region.

U.S. regional consumption of fuels used in generating electricity has been characterized either by competition between two fuels or by dependence on a single fuel. In the North Atlantic states there has been competition between coal and fuel oil. In 1946, more than 75 percent of fossil-fuel plant electricity generation in New England was by coal. After oil import quotas were relaxed in 1966, oil made inroads into coal's traditional dominance of the market. By 1976, coal provided only 4 percent of the electricity generated by fossil-fuel in New England (Table 6).

Within the Mid-Atlantic region, coal provided 92.6 percent of fuel used for electricity generation in 1945. This area was also a region of coal and fuel oil competition. By 1976, coal's share of fossil-fuel generation had dropped to 60 percent of the market. In the region, after the repeal of the oil import quota, Pennsylvania remained dominantly a coal user, while New Jersey and New York utilities switched to fuel oil.

Due to their proximity to major coal production regions, the East North Central states have been predominately coal users for electricity generation. This proximity has given coal a distinct cost advantage over fuel oil. Natural gas has made some inroads into the region, but coal remains dominant. In 1946, coal had 98.1 percent of the market, but this slipped slightly (to 94 percent) by 1976 (Table 6).

Some of the South Atlantic states and the bulk of the East South Central states have relied heavily on hydroelectric power for their electric utility generation. These states, particularly the South Central states, have been dominated by TVA's policies which have advocated the development of hydroelectric facilities for base load accomodation, with augmentation by coal-fuel plants. However, some exceptions have existed. In 1946, Florida relied on fuel oil, which held a 93.3 percent share of the electricity generation market. Coal has since obtained 20 percent of this market. For the South Atlantic region, coal use for electricity generation slipped from a 79.8 percent share in 1946 to a 68 percent share in 1976. Oil and gas provided the balance. Mississippi and Tennessee, in the East South Central region, shifted from gas to coal between 1946 and 1976, and coal increased its share of fossil-fuel electricity generation in these two states from 67.5 percent to 89 percent.

Table 6. United States: Percent Distribution of Fuels in Fossil-Fired Electric Utility Plants, by Type of Fuel and State, 1946 and 1976

| Area or state | 1946 Coal | 1946 Oil | 1946 Gas | 1976 Coal | 1976 Oil | 1976 Gas |
|---|---|---|---|---|---|---|
| United States | 77.1 | 9.7 | 13.0 | 62.0 | 19.0 | 19.0 |
| New England | 75.7 | 24.3 | -- | 4.0 | 95.0 | 1.0 |
| Connecticut | 68.5 | 31.5 | -- | -- | 100.0 | -- |
| Maine | 12.7 | 87.0 | -- | -- | 100.0 | -- |
| Massachusetts | 93.7 | 6.3 | -- | -- | 99.0 | 1.0 |
| New Hampshire | 82.6 | 17.4 | -- | 52.0 | 48.0 | -- |
| Rhode Island | 31.1 | 68.9 | -- | -- | 90.0 | 10.0 |
| Vermont | 39.0 | 59.4 | -- | 78.0 | -- | 22.0 |
| Middle Atlantic | 92.6 | 7.3 | 0.1 | 60.0 | 39.0 | 1.0 |
| New Jersey | 84.3 | 15.7 | 0.2 | 31.0 | 64.0 | 5.0 |
| New York | 94.2 | 4.9 | -- | 22.0 | 77.0 | 1.0 |
| Pennsylvania | 95.1 | 7.3 | 0.1 | 91.0 | 9.0 | -- |
| East North Central | 98.1 | 1.4 | 0.5 | 94.0 | 4.0 | 2.0 |
| Illinois | 97.9 | 1.6 | 0.5 | 91.0 | 6.0 | 3.0 |
| Indiana | 96.7 | 1.6 | 1.7 | 98.0 | 1.0 | 1.0 |
| Michigan | 98.4 | 1.6 | -- | 82.0 | 15.0 | 3.0 |
| Ohio | 98.8 | 0.7 | 0.5 | 99.0 | 1.0 | -- |
| Wisconsin | 97.6 | 2.3 | -- | 95.0 | 2.0 | 3.3 |
| West North Central | 52.7 | 10.8 | 36.4 | 82.0 | 4.0 | 14.0 |
| Iowa | 67.2 | 12.6 | 19.9 | 86.0 | 1.0 | 13.0 |
| Kansas | 24.1 | 10.6 | 65.3 | 36.0 | 12.0 | 52.0 |
| Minnesota | 68.7 | 7.4 | 23.6 | 93.0 | 3.0 | 4.0 |
| Missouri | 53.0 | 10.9 | 36.1 | 95.0 | 1.0 | 4.0 |
| Nebraska | 43.7 | 11.0 | 45.3 | 67.0 | 9.0 | 24.0 |
| North Dakota | 91.0 | 7.2 | 1.8 | 100.0 | -- | -- |
| South Dakota | 35.6 | 25.7 | 38.7 | 95.0 | 3.0 | 2.0 |

(Continued)

Table 6. (Continued)

| Area or state | 1946 Coal | 1946 Oil | 1946 Gas | 1976 Coal | 1976 Oil | 1976 Gas |
|---|---|---|---|---|---|---|
| South Atlantic | 79.8 | 14.3 | 5.9 | 68.0 | 28.0 | 4.0 |
| Delaware | 72.3 | 27.7 | -- | 32.0 | 64.0 | 4.0 |
| District of Columbia | 98.9 | 1.1 | -- | -- | 100.0 | -- |
| Florida | -- | 93.3 | 6.7 | 20.0 | 64.0 | 16.0 |
| Georgia | 33.1 | 6.9 | 60.0 | 88.0 | 11.0 | 1.0 |
| Maryland | 97.9 | 2.1 | -- | 54.0 | 46.0 | -- |
| North Carolina | 98.8 | 1.2 | -- | 99.0 | 1.0 | -- |
| South Carolina | 95.7 | 4.3 | -- | 82.0 | 16.0 | 2.0 |
| Virginia | 95.9 | 4.1 | -- | 48.0 | 52.0 | -- |
| West Virginia | 99.5 | -- | 0.5 | 99.0 | 1.0 | -- |
| East South Central | 67.5 | 1.1 | 31.4 | 93.0 | 5.0 | 2.0 |
| Alabama | 58.5 | 0.3 | 41.3 | 99.0 | -- | 1.0 |
| Kentucky | 99.2 | 0.8 | -- | 100.0 | -- | -- |
| Mississippi | 1.3 | 7.1 | 91.6 | 27.0 | 53.0 | 20.0 |
| Tennessee | 64.9 | 1.0 | 34.1 | 100.0 | -- | -- |
| West South Central | 2.6 | 3.7 | 93.7 | 7.0 | 7.0 | 86.0 |
| Arkansas | 4.6 | 8.8 | 86.6 | -- | 77.0 | 23.0 |
| Louisiana | -- | 4.4 | 95.6 | -- | 18.0 | 82.0 |
| Oklahoma | 15.8 | 6.3 | 77.9 | -- | -- | 100.0 |
| Texas | -- | 2.4 | 97.6 | 10.0 | 2.0 | 88.0 |
| Mountain | 35.6 | 15.9 | 48.1 | 79.0 | 5.0 | 16.0 |
| Arizona | 0.1 | 39.1 | 60.6 | 71.0 | 17.0 | 12.0 |
| Colorado | 62.2 | 7.5 | 30.3 | 78.0 | 2.0 | 20.0 |
| Montana | -- | 8.0 | 92.0 | 98.0 | 1.0 | 1.0 |
| Nevada | -- | 100.0 | -- | 78.0 | 3.0 | 19.0 |
| New Mexico | 8.8 | 10.8 | 78.7 | 65.0 | 3.0 | 32.0 |
| Utah | 81.8 | 17.3 | 0.9 | 92.0 | 1.0 | 7.0 |
| Wyoming | 62.4 | 17.7 | 19.9 | 100.0 | -- | -- |
| Pacific | 0.1 | 77.3 | 18.9 | 7.0 | 61.0 | 32.0 |
| California | -- | 78.9 | 20.2 | -- | 66.0 | 34.0 |
| Oregon | -- | 26.0 | -- | -- | -- | 100.0 |
| Washington | 1.4 | 78.9 | -- | 100.0 | -- | -- |

Sources: Data for 1976 from Keystone Coal Industry Manual, 1977 ed. Data for 1946 from Richard Gordon, Coal and the U.S. Electric Utility Industry, 1975.

The West North Central states vary greatly in their use of fossil-fuels for steam plants. However, due to notable shifts to coal in Iowa, Missouri, Minnesota, and South Dakota, coal increased its overall share in this market from 52.7 percent in 1946 to 82 percent in 1976. The diversity of the region is mainly due to the geographic locations of the states relative to the sources of the various types of fuel; states located advantageously close to coal fields use coal, while those closer to the natural gas fields and pipeline networks use gas. Proximity to natural gas is the reason why the West South Central states have relied predominantly on natural gas as fossil-fuel for electricity generation. The area obtained 93.7 percent of its fossil-fuel for electricity from natural gas sources in 1946. In 1976, this use of natural gas was still high; natural gas accounted for 86.0 percent of electricity generation at fossil-fuel utility plants.

As Table 6 shows, the mix of fuels used in the Pacific and Mountain states is rather varied. Oil dominates in California, while gas is prevalent in Oregon. Coal supplies 79 percent of the fossil-fuel generation in the Mountain states as a group. Although the vast coal resources in the West probably will supply much of the fossil-fuel for future electricity generation growth, hydro-electricity has been, and still is, important in these states.

B-2. Future Electricity Generation

The choice of fuel for the generation of electricity is one of the most debated issues in the United States today. There has been much discussion concerning nuclear power, western coal development, solar and geothermal sources of energy, Mexican oil reserves, and many other topics related to electricity generation. However, there appears to be a consensus that in the short run no major changes in the means of electricity generation will occur, while in the long run, after 1990, significant changes undoubtedly will occur.

In the short run, electric utilities are dependent on the technology inherent in their existing capital stock. Thus, between 1976 and 1990, only marginal changes can be made in the kinds of fuel used to provide electricity. Two such marginal changes could impact on coal usage during this period, however. The first, increasing generating capacity by constructing nuclear plants, would have a negative impact on coal usage. The second, conversion from fuel oil and natural gas to coal in generating plants, would increase the amount of coal used by electric utilities. The net effect of these two changes would differ among the various regions of the country. For instance, the East South Central and South

Atlantic states have been planning large increases in nuclear generating capacity. This could cause coal demand in these regions to level off and possibly to decrease. In the states which have the large western coal reserves, the development of mine-mouth generating facilities could generate electricity for long distance transmission to population centers, and, thereby, increase the demand for coal. The degree to which these changes actually occur will depend, of course, on the changing economics (costs) of electricity generation.

Beyond 1990, it is almost certain that the nation will still be demanding energy in electrical form, but the means of electricity generation are uncertain. Nuclear power, with the development of fusion-type generation facilities as the most probable new technology, will probably experience cautious and moderate growth through the post-1990 era. The impact of this kind of development has been projected to be unimportant prior to the year 2000. Solar and geothermal technologies also will play a role in future electricity generation, but probably not before the turn of the century. Most published works considering these issues present contradictory conclusions as to the extent to which new technologies will be developed and as to the timing of new technology implementation.

Coal gasification (or liquefaction) is one new technology which will certainly become important. Coal can be gasified into high Btu gas as a substitute for natural gas. A low Btu gas, also derivable from coal, could be used to generate electricity.

Currently, there is debate within the Federal government, particularly in the Department of Energy (DOE), concerning the exact siting of coal conversion facilities. Potential sites within the Ohio River System hinterland include western and eastern Kentucky and certain areas in West Virginia. Presently, the cost of gasified or liquefied products from coal is above a level which would make these products economically viable.

As the technology becomes more efficient and the prices of competing fuels increase, coal conversion will become commercially attractive. Estimates by DOE suggest that 0.7 quadrillion Btus of synthetic fuels will be produced by 1990. This is approximately equal to 30 million tons of high Btu coal. Some studies project synthetic fuel production to total the equivalent of 215 million tons of coal a year by 2000.

The liquefaction or gasification of coal will likely have significant impacts on the transportation of coal. Once coal is transformed from solid matter into a liquid or a gas, it can be transported via pipeline to the ultimate users. Pipelines are very efficient and have resulted in drastic reductions in barge and rail transportation of petroleum fuels in the past. Therefore, with gasified and liquefied coal, it is expected that the growth rate, at least, of rail and barge transportation of coal will be reduced.

### B-3. Metallurgical Coal

Second to its use for electricity generation is the use of coal in the production of coke. In 1976, this use accounted for 84.8 million tons of coal, or 14 percent of domestic consumption (Table 7). In absolute quantities, however, the consumption of metallurgical coal has been declining since 1950. This decrease is due mostly to the technological changes in the manufacture of iron and steel which have reduced the amount of coke needed per ton of pig iron production.

Metallurgical coal is mined essentially in the same manner as steam or any other type of coal. Its distinguishing characteristics reside in its physical and chemical properties. It must be low in ash, sulfur and other impurities, and its volatility content should vary to provide the optimal mix in the production of coke. Once mined, metallurgical coal must pass through a crushing and cleaning process to remove impurities before being sent to coke plants.

### B-4. Other Uses of Coal

Miscellaneous industrial and other uses of coal, comprising 9.3 percent of the domestic consumption of coal in 1976 (Table 4), include uses for private electricity generation, manufacturing and mining, in steel and rolling mills, as railroad and bunker fuel, and other uses. While these uses vary in importance, most have been declining and are expected to decline further in the future. Coal, for use as railroad and bunker fuel, is expected to continue to decline as coal is supplanted by diesel fuel. Home and business space heating is expected to be increasingly provided by electricity. Consumption of coal by steel and rolling mills will fluctuate as the market for steel fluctuates.

Private electricity generation is the only miscellaneous usage of coal which is expected to expand significantly. This coal is consumed by electricity generating plants which are privately

Table 7. United States: Bituminous Coal and Lignite Production, by Major User Class, 1976

(Thousands of tons)

| Major User | Tonnage |
|---|---|
| Total, all users[a] | 659,175 |
| Electric utilities | 454,846 |
| Coke and gas plants | 84,783 |
| Retail and other | 57,006 |
| Export | 59,375 |

a. Total coal production is not the sum of the individual end users. It includes 1,362 thousand tons of coal used at the mines, 2,113 thousand tons of inventory accumulation at mines, 41 thousand tons of Canadian Great Lakes commercial dock storage and a reduction of 351 thousand tons of U.S. Great Lakes dock storage.

Source: U.S. Department of Interior, Bureau of Mines, Bituminous Coal and Lignite Distribution, 1976 ed.

operated by industrial firms and by institutions, such as universities. The demand for coal as a fuel for private electricity generation is projected to increase in the same manner as the demand for coal by electric utilities. Because of government policies stimulating conversion from fuel oil and natural gas to coal, some increase in coal usage for industrial processes also can be anticipated.

B-5. Uses of Coke

The major use of coke has been and will continue to be in the iron and steel industry, particularly in the production of pig iron. Coke provides the heat for the process which turns iron ore into purified pig iron. Together with iron ore and limestone, coke is hoisted into a blast furnace where a heat-based chemical reaction removes the impurities from the iron ore. Modern technology allows injections of natural gas or fuel oil to be made into the blast furnace to aid in this reduction process. Although some of this injected gas is also coke gas which is recovered from the coke-making process, this process gradually reduces the proportion of coke needed per ton of pig iron production.

Blast furnaces received 52.5 of the 56.6 million tons of coke produced in 1976.[1] The remainder was split between foundries and other industrial users. In 1976, foundries consumed 2.8 million tons in the production of iron and steel castings. Shipments of coke to other industrial plants totaled 1.2 million tons in 1976. This coke was used for the manufacture of calcium carbide, the reduction of ferroalloys, nonferrous smelting and processing and the burning of lime. Some small quantities went to homes for space heating purposes.

Coke breeze, tiny particles of coke originating from the carbonization of coal, totalled 4.2 million tons in 1976.[2] Most coke plants rely on some type of recovery unit to capture this side-product. Because of its high volatility and high ash content, it is unsuitable for most metallurgical purposes. However, it is used for sintering iron-bearing dust and ores, for fueling steam plants, for agglomerating and for other industrial purposes.

The by-products of coke production, called coal chemicals, are the refined materials recovered from the gases and vapors released

1. U.S. Department of Energy, Energy Information Agency, Coke and Coal Chemicals in 1976 (Washington, D.C.: GPO, 1978).
2. Ibid.

during the coke-making process. These chemicals are broadly defined as coke-oven ammonia, coke-oven gas, coal tar and derivatives, and light oil. Except for ammonia, they are further processed into organic elements such as benzene, naphtha, and toluene. Altogether, these products account for roughly the equivalent of 30 percent of the heat value, in Btus, of the total amount of coal that is carbonized.

## C. Consumption Characteristics

The consumption characteristics of Group I commodities and products may be divided into three broad categories: economic, institutional and technological characteristics. The discussion which follows analyzes how each of these sets of characteristics impacts on the consumption of steam coal, metallurgical coal and coke.

### C-1. Steam Coal

The consumption characteristics of steam coal have changed dramatically since World War II and are still in the process of change. They are the products of shifting relative prices of energy fuels, new technologies and environmental concerns.

#### a. Economic Characteristics

The economic characteristics of steam coal usage are determined by the nature of the demand for electricity, the short-run substitution possibilities among fossil-fuels, the long-run substitutability of alternative forms of fuel for electricity generation, and possible alterations in the physical form of coal. These factors work to determine the quantity of steam coal consumed.

The demand for steam coal is a derived demand. This means that demand is determined in large part by the demand for another commodity -- in particular, electricity. For an electric utility, the demand for coal depends on the amount of electricity that is required to be generated, the price of coal, and the price of coal relative to the prices of alternative fuels.

Differences arise in the distinction between long-run and short-run demands for steam coal. The short run is distinguished by fixed capital stock. Electric utility boilers can be designed to accomodate oil, gas, and/or coal, alone or in combination. However, the range of fuel options is reduced after a power plant has been built. Thus, in the short run, the alternative fuels substitutable for coal are limited.

Power plant boilers are designed to handle efficiently whatever specific types of coal are expected to be used. In a strictly technical sense, a boiler could work with virtually any type of coal, no matter what its ash and sulfur content, heat values (the quantity of Btus per pound) or other properties. However, there would be a loss, often quite substantial, in plant efficiency if any types other than specified types of coal are used. Economic rather than technical factors limit the capability and willingness of an electric utility to substitute coals with significantly different technical characteristics for those originally planned to be used. This helps explain why electric utilities usually make long-term contracts to meet their coal requirements.

In the long run, when a utility is planning the type of boiler to be used in a new plant, or to replace an old unit, substitution possibilities are greater. An electric utility will examine the various systems available for producing electricity and select the lowest cost system. At the present time, and most likely in the future, fuel oil will not be competitive in the production of base load electricity.

The choice between nuclear fuel and coal is very unclear in terms of cost minimization. Nuclear plants had cost advantages in the late 1960s and early 1970s, but several crucial problems have arisen since those times. Construction costs and lead times of both nuclear and coal plants have increased but, because of the regulatory process, the pre-construction costs of nuclear plants have increased more than proportionately. This, coupled with increases in the price of nuclear fuel (which, in turn, increases the operating costs of a plant), has dramatically increased the total cost of new nuclear units.

This increased cost of nuclear electricity generation has been countered by increases in the capital and operating costs of coal-fired plants. Pollution control technology and emissions control attainment strategies also are impacting on the costs of coal-fired plants. Utility companies have essentially two choices in meeting emissions control levels promulgated by the Environmental Protection Agency (EPA): the installation of scrubber equipment, or the burning of low-sulfur coal. Low-sulfur coal will have a premium on its price, depending on its absolute level of sulfur. Scrubber equipment entails two costs: the initial outlay for the equipment and the cost of operations. Additionally, the current state-of-the-art in this technology is tentative at best.

Industry authorities feel that the least-cost choice between coal and nuclear fuel is unclear. Locational differences are crucial, particularly in western states where low-cost, low-sulfur coal reserves are available.

In the future, other alternatives probably will be available which will alter the costs of the various ways of generating electricity. These include solar energy and other (presently exotic) forms of energy. Also, liquefaction and gasification conversion possibilities for coal may alter its relative cost in future years, thereby altering the economic parameters which influence the choice of fuel.

b. Technological Characteristics

There are three technical elements which influence coal consumption. These are the content of ash in coal, the sulfur content, and the calorific, or heat value, of coal. The moisture content of coal differs among seams of coal as well. Most steam boilers are designed to burn coal which meets certain minimum specifications.

Coal types are ranked according to their heat values. The average Btu content of coal was 11,600 Btus per pound for U.S produced coal in 1975, with substantial regional variations. The ordering of coal types by heat value is as follows: anthracite, bituminous, sub-bituminous, and lignite. Generally, anthracite contains a minimum of 13,000 Btus per pound; bituminous, approximately 10,500-13,000 Btus per pound; sub-bituminous, 8,500-10,500 Btus per pound, and; lignite, less than 8,500 Btus per pound. Most coal reserves in the ORB are bituminous, and the higher Btu-content coals are located in the eastern areas of the Basin.

To generate a given level of electricity, boilers are designed to use coal ranked at a given Btu content. If the Btu content used is lower, a greater quantity of coal must be burned. A drastic difference between the Btu content specified by boiler design and the Btu content of coal actually burned would reduce boiler efficiency to a point which would necessitate retooling. The costs of retooling can be quite substantial: they can be in the range of one-fourth to one-third the cost of a new boiler.

In light of EPA standards on sulfur dioxide emissions, the sulfur content of coal has become an element influencing consumption. Eastern coals vary widely in their sulfur content, ranging from 0.3 percent to 5.6 percent. The sulfur contained in coal is of two types: organic sulfur, including combinations of pyrite and marsasite, as well as sulfates, and inorganic sulfur. Inorganic sulfur can be removed by mechanical cleaning and washing. Organic sulfur is immune to mechanical washing.

Ash is the non-combustable material remaining after the coal has been burned. Excessive amounts of ash reduce efficiency in a steam boiler and present problems of disposal. Currently ash generally is discarded, but research is underway to develop uses for this voluminous by-product. One experimental use is the compression of ash with other materials to make building blocks for construction.

The moisture content of coal varies among different seams of coal, but it is difficult to generalize about patterns of moisture content in the PSAs. However, some electric utility officials interviewed did indicate problems with western coal with moisture content which caused some loss in the efficiency of boilers.

Improved methods of handling and storing coal can significantly influence its consumption. Higher levels of efficiency in transshipping coal and improved storing methods can result in a lower price of coal relative to other energy commodities, and in an increase of coal consumption. The dedicated unit train, the bottom dump car and infrared thawing are some of the newer technologies for handling coal.

c. Institutional Characteristics

Several institutional characteristics of coal use influence coal consumption. The most important at this time are EPA regulations and the attainment strategies of coal users. Other factors include the ownership of reserves, the distinction between contracts and spot markets, and coal conversion policies.

EPA Regulations and Attainment Strategies. There are essentially two EPA approaches to air pollution: (1) New Source Performance Standards (NSPS), and (2) other ambient air regulations. The latter standards are achieved through state implementation plans (SIPs) in which standards are designed to deal with local problems. EPA additionally sets standards on primary (health-related) pollutant levels, and secondary (amenity-related) pollutant levels for various emissions.

NSPS standards impact on facilities which were constructed after the rules in the Clean Air Act of 1971 were promulgated. The standards set permissable emissions levels for coal boilers larger than 25 megawatts and supercede the less stringent SIPs. EPA regulations state that 1.2 pounds of sulfur oxides can be emitted per million Btus of coal burned. This translates into approximately 0.6 pounds of sulfur per million Btus of coal. The allowable percentage by weight of sulfur in coal is reached by examining each type of coal individually. For example, eastern coal, with 12,000 Btus per pound, could have 0.76 percent sulfur, while a lower Btu western coal of 8,000 Btus would be allowed to contain only 0.51 percent sulfur. Prior to 1977, the rules could be met through any feasible manner.

In 1977, two amendments were made to the Clean Air Act of 1971 which have created complications in attainment procedures and in the entire market distribution of coal. These two changes are known as the Section III amendments and the Section 125 addition.

The Section III amendments alter the definition of the EPA's "Standards of Performance." With this amendment, the attainment of EPA regulations on sulfur oxide emissions is necessary but not sufficient. This section now promulgates the use of the best available control technology (BACT). The BACT implies that even if emission control levels are met through the burning of low sulfur coal, but there exist other procedures which might further reduce emissions, these procedures must be implemented as well. For instance, a utility's future plant might conform to EPA sulfur dioxide emission regulations by burning low sulfur eastern coal. Yet, if stack gas scrubbers could reduce emissions further, then they would also have to be installed. Essentially, the regulations of Section III are restrictive enough to imply that stack gas scrubbers are the best available control technology. Prior to Section III, compliance strategies were left up to the utilities.

Section 125 involves the regional impacts of the EPA regulations on the coal industry. This section states that the President, a governor or the EPA Administrator may prohibit a major fuel burning plant from using non-local fuels if locally available fuels can be used. This presumably limits any significant disruptive effect on local or regional coal mining. This section of the law may have an impact of preventing utilities from bringing western coal into the East where higher sulfur coal is available for use. However, the effect of this amendment is yet to be seen.

Electric utilities in the PSAs have been voicing objections to these latest changes to the Clean Air Act. They contend strongly that the technology for stack gas scrubbers is not as efficient as EPA contends. Officials in one utility in the ORB claim that their scrubbers are operative at only 40 percent or less of a unit's generating capacity. This claim was affirmed by officials of the Ohio Department of Energy and essentially by all other sources questioned on this topic, including other utility companies, and university and state researchers. Certain utilities had been planning on using western coal in the near future, but as a result of the possible impacts of these two changes in the Act pertaining to scrubber requirements, their plans have been shelved.

Compliance strategies among utilities in the PSAs vary. Currently, only American Electric Power is contracting for large amounts of western coal (for a plant in southeastern Ohio). Most other utilities are attempting to get lower sulfur eastern coals or to continue to utilize the higher sulfur coals with scrubbers. This variation is due, in part, to ambiguities in the interpretation of the new changes in the Clean Air Act. It appears that scrubbers will be necessary, but those plants which are governed by regulations other than NSPS will have greater flexibility regarding the sulfur content of their coal. A good example of this variation is the TVA plan to comply with EPA regulations.

EPA evaluated all TVA coal plants on a site-specific basis to determine the allowable amount of sulfur per ton of coal. These amounts vary from 1.2 pounds to 4.0 pounds of sulfur per ton of coal. The TVA compliance strategy involves using scrubbers on their two planned units at the Cumberland plant (which fall under NSPS standards) and on 20 percent of their existing generation capacity, and to use low sulfur eastern coals for the remainder of their requirements. Other utilities in the PSAs are divided as to compliance strategy. The companies in the eastern areas of the Basin have plans which rely predominantly on scrubbers, while companies in the western areas of the Basin are divided between using low-sulfur coal or scrubbers.

The net effect of the 1977 amendments to the Clean Air Act will become known after a period of interpretation and EPA enforcement activity. Initially, however, the effect should be positive in regard to the production and consumption of eastern coals. By necessitating the use of scrubbers, the EPA regulations will prevent the need for utilities to buy low-sulfur western coal. This should allow eastern coal to remain predominant in the Ohio River Basin, and substantial imports of western coal into the river system can be postponed into the indefinite future. These conclusions are, however, subject to change, depending on how the uncertainties involving national energy and environmental health policy conflicts are resolved. It is not possible to quantify these unknown resolutions at present.

Coal Conversion. Coal conversion refers to the use of coal in place of other fossil fuels in heating water for the steam generation of electricity, or to the use of coal in place of another fossil fuel in some industrial processes. The Federal Energy Administration (FEA) was granted authority, after the oil crisis in 1974, to mandate coal conversion. The authority was granted in both the Energy Supply and Conservation Act of 1974 and the Energy Policy Act of 1975. Specifically, it prohibited any future electric utility fossil-fuel fired plants, which were in the planning stages, from burning fuels other than coal, and it gave the FEA authority to issue orders to selected plants to convert to coal as their primary energy source.

Up until now, the effects of these conversion policies have not been great. Most new or planned fossil-fuel units were already designed to burn coal, and the conversion of existing units has not been notable. This has generally been due to costs. The capital cost of converting boilers from oil and gas to coal is relatively large, and the change to coal usually demands the installation of pollution control equipment.

The net effect of the coal conversion policy in the PSAs is that coal conversion programs in the future probably will have minimal effects on the use of coal by electric utilities. The Basin has been, and will remain, dominated by coal as a fuel source for electricity generation. Industrial use of coal should increase, however, as a result of conversion. There are opportunities to utilize coal to a greater degree, especially as the cost of oil increases. As the deregulation of natural gas causes the price of gas to increase, coal conversion will become even more attractive.

Contract and Spot Market. A key element in the market demand for coal is the division of the market into contract and spot markets. The contract market includes sales to consumers over periods anywhere from five to twenty-five years. The spot market includes sales to consumers on a one time, or spot, basis.

Electric utilities contract for most of their coal because they need coal which meets particular specifications. These contracts are generally long term, but escape clauses are common. The most relevant clause allows for the cancellation of a contract if the allowable sulfur dioxide emissions levels promulgated by EPA do not correspond to the sulfur level in the coal under contract.

The contracts into which utilities enter for coal supplies are usually based on a delivered price at the utility plant. Thus, it is the seller who chooses the mode of transportation, subject to the unloading facilities at the utility plant. Purchasers of coal, therefore, only make implicit decisions as to the modal split for coal transport.

The spot market is generally more volatile than the contract market, and buyers resort to the spot market when contracted coal falls short of their requirements. Spot market prices were at a peak shortly after the oil embargo, but are now at low levels because of inventory buildups of contract coal. In general, electricity demand has not grown at rates anticipated by electric utilities; therefore, coal inventories are larger than they were five years ago.

Ownership of Reserves. The ownership of reserves determines consumption patterns, to some degree, since electric utilities will generally use their own reserves rather than purchase from others. Often, utilities will sell to other users as well. Within the PSAs, only six utilities have substantial captive reserves. One utility, Duke Power, does not provide services in the PSAs, but has reserves in the area. The ownership of reserves, and production from these reserves, is not particularly concentrated. In 1976, the captive coal production for utilities in the PSAs totalled about 17 million tons (Table 8). This compares with 172 million tons consumed by electric utilities in the PSAs in 1976.

### C-2. Metallurgical Coal

The characteristics of metallurgical coal which influence consumption are similar to those which influence the consumption of steam coal.

#### a. Economic Characteristics

The demand for metallurgical coal also is a derived demand, dependent on the demand for coke. Virtually all metallurgical coal

Table 8. Ohio River Basin: Captive Coal Production for Selected Electric Utilities, 1977

(Thousands of tons)

| Name of controlling company | Production |
|---|---|
| Total, all listed companies | 16,968 |
| American Electric Power Co. | 10,223 |
| Pennsylvania Power and Light Co. | 2,826 |
| Duke Power Co. | 1,863 |
| Columbus and Southern Ohio Electric Co. | 1,163 |
| Duquesne Light Co. | 729 |
| Ohio Edison Co. | 165 |

Source: Keystone Coal Industry Manual, 1978 ed.

is consumed in the production of coke. The demand for coke, in turn, is dependent on the demand for the products which use coke in production processes. It is this chain of demands which determines the level of metallurgical coal consumption.

b. Technological Characteristics

The differences between steam coal and metallurgical coal are found in the physical properties of these coals. The levels of sulfur, ash, and volatile content determine whether a certain coal will be amenable to coke processing. The most important properties of metallurgical coals are their low content of ash and sulfur (less than 1 percent, generally), these being impurities not desirable in various metallurgical processes. Volatility content should vary; usually coke is formed through a blend of medium and highly volatile bituminous coals. In general, metallurgical coal is a high quality steam coal. It can be used as a substitute for steam coal and is sometimes sold in steam coal markets.

c. Institutional Characteristics

The most important institutional characteristic of the metallurgical coal market is the ownership of reserves by the steel companies. The ownership of metallurgical coal reserves influences consumption in the same manner as ownership of reserves influences consumption of steam coal. Consumption is more likely to take place from captive reserves. Production from captive reserves of metallurgical coal is shown in Table 9. The extent of steel company ownership of metallurgical coal reserves is much greater than the extent of electric utility ownership of steam coal reserves. This has the effect of limiting open trade in metallurgical coal. However, despite the high degree of captive production, there still exists an extensive non-captive market in metallurgical coal. Another institutional characteristic of metallurgical coal demand concerns EPA regulations for coke plants. Sulfur and particulate emissions regulations have caused consumers of metallurgical coal to attempt to purchase the lower sulfur coals on the market.

C-3. Coke

The market demand for coke is influenced by two groups of factors: economic and technological. The economic factors impacting on the consumption of coke arise from the demand for coke in iron and steel manufacturing and the demand for by-products of the

Table 9. United States: Captive Coal Production of Steel Companies by Location of Operation, 1977

(Tons)

| Name of operating company | Name of controlling or parent company | Location of operations | 1977 Production |
|---|---|---|---|
| Total, all companies | | | 45,269,716 |
| United States Steel Corp. | United States Steel Corp. | AL, CO, KY, PA, UT | 13,959,000 |
| Bethelem Mines Corp.--Beth-Elkhom Corp. | Bethlehem Steel Co. | KY, PA, WV | 10,609,970 |
| Republic Steel Corp. | Republic Steel Corp. | AL, KY, PA, WV | 2,978,136 |
| Armco Steel Corp.--Big Mountain Coals | Armco Steel Co. | WV | 2,495,011 |
| Jones & Laughlin Steel--Gateway Coal Co. | Jones & Laughlin Steel Corp. | PA | 2,200,870 |
| Youngston Mines Corp.--Nemacolin Mines Corp./ Olga Coal Corp./Emerald Mines Corp. | Lykes Resources | PA, WV | 2,038,452 |
| National Mines Corp. | National Steel Co. | AR, KY, PA, WV | 2,004,000 |
| Cannelton Coal Co. Divs. | Algoma Steel Co. Ltd. | WV | 1,859,043 |
| Inland Steel Co. | Inland Steel Co. | IL | 1,593,790 |
| Mathies Coal Co. | Lykes Resources Inc./Steel Company of Canada Ltd./National Steel Co./Consolidation Coal Co. | PA | 1,524,000 |
| Kaiser Steel Co. | Kaiser Steel Corp. | NM, UT | 1,146,044 |
| C.F. & I Steel Corp. | C.F. & I Steel Corp. | CO (est.) | 600,000 |
| Jim Walter Resources Inc. | Jim Walter Corp. | AL | 598,122 |
| Beatrice Pocahontas Co. | Republic Steel Corp./Island Creek Coal Co. | VA | 571,928 |
| Mead Coal Co. | Mead Corp. | AL | 468,479 |
| Harmar Coal Co. | Consolidation Coal Co. | PA | 429,000 |
| National Coal Mining Co. | National Steel Co./Island Creek Coal Co. | WV | 193,871 |

Source: Keystone Coal Industry Manual, 1978 ed.

coke-making process. The major technological characteristics of the coke market include the changing locational patterns of the steel industry and the shift in the steel industry from the basic oxygen furnace to the electric arc furnace.

a. Economic Characteristics

More than 90 percent of all coke is utilized by the steel industry, so the demand for steel is the overriding determinant of the amount of coke consumed. The market for coke will fluctuate with variations in steel industry production levels.

Affecting coke prices and consumption is the increasing value of the by-products of the coke production process. These by-products are petroleum related compounds in many cases and have increased in value as the price of petroleum has risen. Ammonia, a non-petroleum related by-product, has also exhibited upward price movements, thereby increasing its value as a by-product. By-products provide the coke producer with substantial revenues in addition to the revenues from the coke sales.

b. Technological Characteristics

Developments in the technology of steelmaking have resulted in a decrease in the amount of coke used per ton of pig iron produced. Other heat-producing inputs, such as fuel oil and natural gas, are used increasingly in blast furnaces to augment the heat produced by coke. Changes in the amounts of coke required for pig iron production have been occurring over a period of 30 years and are expected to continue in the future.

Another technological factor influencing the consumption of coke has been the advent of the electric arc furnace. The generation of heat is provided solely by electricity, thus eliminating the need for coke. As the proportion of total U.S. steel output produced by the electric arc furnace increases, the amount of coke used by the steel industry will decrease. The net effect of this development on the coal industry is uncertain, however. While the amount of metallurgical coal required will decrease, there will be an increase in the demand for electricity by electric furnaces, and in turn, for steam coal (if this is the fuel used for generating electricity). As a limitation, the extent of conversion from the basic oxygen furnace to the electric arc furnace is constrained by the availability of scrap steel required for electric arc furnaces.

Another factor currently influencing the consumption of coke in the PSAs is the changing locational pattern of the steel industry. The long-standing dominance of the Pittsburgh and Cleveland areas has given way to southern and western locations, such as Birmingham and Chicago. Relocation of the industry is expected to continue into the future.[1]

## D. Existing Aggregate Demands

Consumption of coal in the PSAs increased at an average annual rate of 6.26 percent during the period 1969-76 (Table 10). This growth was stimulated almost entirely by the increased consumption of coal by electric utilities and industrial users. Consumption of metallurgical coal by coke plants decreased during the period because of underutilization of capacity in the iron and steel industry. Other consumption of coal showed only moderate increases.

### D-1. Electric Utility Consumption

Coal consumption by the electric utilities in the PSAs increased at a rate of 7.73 percent during 1969-76 (Table 10). This increase was due to the growth in the demand for electricity which resulted in the construction of new coal-fired power plants, as well as to increases in the utilization of existing plants.

The growth in steam coal consumption during the period, 1969-76, was not spread evenly throughout the PSAs. Large increases in coal consumption by electric utilities occurred in BEAs 62 (Cincinnati), 55 (Evansville), 53 (Lexington) and 52 (Huntington), with annual growth rates of 15.7 percent, 13 percent, 11.6 percent and 22.4 percent, respectively. The growth in these PSAs was in contrast to decreases in coal consumption in BEAs 115 (Padacah), 64 (Columbus), and 47 (Huntsville).

In terms of the absolute quantities of coal consumed, BEA 66 (Pittsburgh) was by far the largest in 1976. This is to be expected from the most industrialized PSA. Second in electric utility consumption was BEA 52 (Huntington). Numerous utility plants along the Ohio and Kanawha Rivers were destinations for the

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1. For additional discussion on technological changes in steel production, see the Iron Ore, Steel and Iron (Group VIII) Report.

Table 10. Ohio River System: Coal Consumption by BEAs or BEA Segments[a] and by End User, Estimated 1969-76

(Thousands of tons unless otherwise specified)

| BEA or BEA segment | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | Average annual percentage change |
|---|---|---|---|---|---|---|---|---|---|
| Primary Study Areas | 127,181.1 | 137,126.7 | 143,556.2 | 157,930.0 | 171,470.9 | 171,251.9 | 192,960.5 | 194,578.4 | 6.26 |
| Electric utilities | 96,169.7 | 106,483.9 | 114,180.6 | 126,008.8 | 136,603.1 | 136,420.6 | 159,546.8 | 161,953.2 | 7.73 |
| Coke plants | 21,033.8 | 19,592.9 | 18,088.2 | 19,396.3 | 21,359.2 | 21,203.6 | 17,952.4 | 16,880.1 | (3.09) |
| Others | 9,977.6 | 11,049.9 | 11,287.4 | 12,524.9 | 13,508.6 | 13,627.7 | 15,461.3 | 15,745.1 | 6.73 |
| BEA 47: Huntsville, AL | 3,813.5 | 3,604.4 | 3,144.1 | 2,673.9 | 3,248.9 | 3,294.9 | 3,088.6 | 3,356.6 | (1.81) |
| Electric utilities | 3,614.7 | 3,416.5 | 2,980.2 | 2,534.5 | 3,079.5 | 3,123.1 | 2,927.6 | 3,181.6 | (1.81) |
| Coke plants | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Others | 198.8 | 187.9 | 163.9 | 139.4 | 169.4 | 171.8 | 161.0 | 175.0 | (1.81) |
| BEA 48: Chattanooga, TN | 4,750.1 | 4,628.9 | 4,931.4 | 4,560.5 | 4,337.1 | 4,819.7 | 5,976.2 | 5,511.9 | 2.15 |
| Electric utilities | 4,243.8 | 4,144.0 | 4,434.7 | 4,072.5 | 3,852.2 | 4,303.1 | 5,411.1 | 4,972.4 | 2.29 |
| Coke plants | 154.4 | 142.0 | 131.4 | 150.2 | 163.6 | 159.6 | 122.4 | 131.2 | (2.30) |
| Others | 351.9 | 342.9 | 365.3 | 337.8 | 321.3 | 357.0 | 442.7 | 408.3 | 2.15 |
| BEA 49: Nashville, TN | 7,358.4 | 7,235.0 | 6,621.2 | 6,028.2 | 7,811.7 | 11,644.6 | 13,748.9 | 11,102.3 | 6.05 |
| Electric utilities | 6,813.3 | 6,699.1 | 6,130.7 | 5,581.7 | 7,233.1 | 10,774.6 | 12,730.9 | 10,279.9 | 6.05 |
| Coke plants | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Others | 545.1 | 535.9 | 490.5 | 446.5 | 578.6 | 870.0 | 1,018.0 | 822.4 | 6.05 |
| BEA 50: Knoxville, TN | 6,333.9 | 6,414.1 | 6,734.6 | 6,939.8 | 7,548.8 | 7,027.9 | 8,688.2 | 7,476.9 | 2.40 |
| Electric utilities | 5,864.7 | 5,939.0 | 6,235.7 | 6,425.7 | 6,989.6 | 6,507.3 | 8,047.6 | 6,923.1 | 2.40 |
| Coke plants | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Others | 469.2 | 475.1 | 498.9 | 514.1 | 559.2 | 520.6 | 640.6 | 553.8 | 2.40 |
| BEA 51: Bristol, VA | 4,757.1 | 4,458.1 | 4,521.4 | 4,562.4 | 5,014.1 | 4,306.7 | 5,127.4 | 5,132.4 | 1.09 |
| Electric utilities | 3,977.2 | 3,624.4 | 3,723.7 | 3,829.9 | 4,165.3 | 3,513.2 | 4,322.9 | 4,383.5 | 1.40 |
| Coke plants | 347.4 | 428.4 | 386.7 | 317.7 | 393.0 | 402.0 | 338.4 | 282.3 | (2.92) |
| Others | 432.5 | 405.3 | 411.0 | 414.8 | 455.8 | 391.5 | 466.1 | 466.6 | 1.09) |
| BEA 52: Huntington, WV | 10,351.9 | 13,062.6 | 14,726.1 | 17,380.0 | 20,538.9 | 26,963.2 | 30,773.4 | 34,708.9 | 18.87 |
| Electric utilities | 7,204.0 | 9,719.2 | 11,291.2 | 13,731.8 | 16,268.1 | 22,251.4 | 26,257.5 | 29,683.4 | 22.42 |
| Coke plants | 3,183.3 | 2,112.6 | 2,080.5 | 2,016.9 | 2,366.9 | 2,229.5 | 1,673.6 | 1,828.3 | (2.41) |
| Others | 964.6 | 1,230.8 | 1,354.4 | 1,631.3 | 1,903.9 | 2,482.3 | 2,842.3 | 3,197.2 | 18.67 |

(Continued)

Table 10.(Continued)

| BEA or BEA segment | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | Average annual percentage change |
|---|---|---|---|---|---|---|---|---|---|
| BEA 53: Lexington, KY | 1,353.5 | 1,827.8 | 2,447.5 | 2,714.5 | 3,163.0 | 2,600.9 | 2,973.4 | 2,909.3 | 11.55 |
| Electric utilities | 1,241.7 | 1,676.9 | 2,245.4 | 2,490.4 | 2,901.8 | 2,386.1 | 2,727.9 | 2,669.1 | 11.55 |
| Coke plants | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Others | 111.8 | 150.9 | 202.1 | 224.1 | 261.2 | 214.8 | 245.5 | 240.2 | 11.55 |
| BEA 54: Louisville, KY | 9,996.2 | 9,303.3 | 9,603.3 | 9,639.9 | 9,832.8 | 8,549.1 | 10,882.6 | 11,134.9 | 1.55 |
| Electric utilities | 9,170.8 | 8,535.1 | 8,810.4 | 8,843.9 | 9,020.9 | 7,843.2 | 9,984.0 | 10,215.5 | 1.55 |
| Coke plants | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Others | 825.4 | 768.2 | 792.9 | 796.0 | 811.9 | 705.9 | 898.6 | 919.4 | 1.55 |
| BEA 55: Evansville, IN | 7,491.1 | 11,550.5 | 13,093.0 | 13,916.7 | 14,075.2 | 13,163.2 | 19,492.3 | 17,665.4 | 13.04 |
| Electric utilities | 6,872.6 | 10,596.8 | 12,011.9 | 12,767.6 | 12,913.0 | 12,076.3 | 17,882.8 | 16,206.8 | 13.04 |
| Coke plants | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Others | 618.5 | 953.7 | 1,081.1 | 1,149.1 | 1,162.2 | 1,086.9 | 1,609.5 | 1,458.6 | 13.04 |
| BEA 62: Cincinnati, OH | 9,189.4 | 10,025.9 | 9,222.8 | 13,982.6 | 14,949.8 | 15,585.7 | 17,994.9 | 20,981.0 | 12.52 |
| Electric utilities | 6,127.8 | 6,798.8 | 6,254.1 | 10,343.9 | 11,108.5 | 11,783.9 | 14,439.0 | 16,957.9 | 15.65 |
| Coke plants | 2,045.5 | 1,983.9 | 1,954.5 | 2,094.2 | 2,221.2 | 2,090.6 | 1,568.0 | 1,718.7 | (2.46) |
| Others | 1,016.1 | 1,243.2 | 1,014.2 | 1,544.5 | 1,620.1 | 1,711.2 | 1,987.9 | 2,304.4 | 12.41 |
| BEA 64: Columbus, OH | 7,049.4 | 7,234.2 | 7,681.5 | 7,127.3 | 7,077.2 | 6,695.8 | 5,751.1 | 6,347.4 | (1.49) |
| Electric utilities | 6,294.1 | 6,459.1 | 6,858.5 | 6,363.6 | 6,318.9 | 5,889.1 | 5,139.4 | 5,667.3 | (1.49) |
| Coke plants | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Others | 755.3 | 775.1 | 823.0 | 763.7 | 758.3 | 706.7 | 611.7 | 680.1 | (1.49) |
| BEA 65: Clarksburg, WV | 5,187.6 | 4,918.2 | 4,658.5 | 4,788.4 | 4,864.9 | 3,612.6 | 4,548.7 | 5,321.5 | 0.36 |
| Electric utilities | 4,716.0 | 4,471.1 | 4,235.0 | 4,353.1 | 4,422.6 | 3,284.2 | 4,135.2 | 4,837.7 | 0.36 |
| Coke plants | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Others | 471.6 | 447.1 | 435.5 | 435.3 | 443.3 | 328.4 | 413.5 | 483.8 | 0.36 |
| BEA 66: Pittsburgh, PA | 41,047.2 | 44,255.3 | 47,790.8 | 55,336.5 | 60,443.5 | 54,759.7 | 54,787.7 | 54,717.3 | 4.19 |
| Electric utilities | 22,046.1 | 26,320.9 | 31,100.6 | 36,896.2 | 40,290.2 | 34,865.5 | 36,970.9 | 38,170.3 | 8.16 |
| Coke plants | 16,303.2 | 14,926.0 | 13,535.1 | 14,817.3 | 16,214.5 | 16,321.9 | 14,250.0 | 13,019.0 | (3.16) |
| Others | 2,697.9 | 3,008.4 | 3,155.1 | 3,623.0 | 3,938.8 | 3,572.3 | 3,566.8 | 3,528.0 | 3.91 |

(Continued)

Table 10 (Continued).

| BEA or BEA segment | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | Average annual percentage change |
|---|---|---|---|---|---|---|---|---|---|
| BEA 68: Cleveland, OH | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Electric utilities | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Coke plants | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Others | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| BEA 115: Paducah, KY | 8,501.8 | 8,608.4 | 8,380.0 | 8,279.3 | 8,565.0 | 8,327.9 | 9,127.1 | 8,312.0 | (0.32) |
| Electric utilities | 7,982.9 | 9,083.0 | 7,868.5 | 7,774.0 | 8,039.4 | 7,819.6 | 8,570.0 | 7,804.7 | (0.32) |
| Coke plants | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Others | 518.9 | 525.4 | 511.5 | 505.3 | 525.6 | 508.3 | 557.1 | 507.3 | (0.32) |

Note: Electric utility plant consumption of coal was estimated by aggregating the individual plants' consumption of coal into the proper BEA. This quantity was increased five percent to reflect those plants which are not required to report to the FPC or FERC.

Coke plant consumption of coal was estimated for BEAs 52, 62, and 66, by using the pig iron production estimates for these BEAs contained in the Iron Ore, Steel and Iron Report. The amount of coal necessary to produce the coke needed for these production levels was calculated using a factor of 0.7 tons of coke per ton of coal carbonized, and the historical factor of tons of coke consumed per ton of pig iron produced as reported in the Annual Statistical Report of the American Iron and Steel Institute. Coal consumption for coke plants in other BEAs, which are merchant coke plants, was estimated by multiplying steel industry capacity utilization rates by the coke plant capacity rates of coal usage to determine the coal consumed.

Other usage of coal was estimated from factors estimated by RRNA based on DOE data. These factors were applied to electric utilities coke plant consumption of coal to approximate residual usage of coal.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: U.S. Department of Energy, Federal Energy Regulatory Commission and Federal Power Commission, Annual Summary of Cost and Quality of Electric Utility Plant Fuel, 1975-77 eds.; and Steam Electric Plant Construction Cost and Annual Production Expenses, 1969-74 eds.; U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1969-75 eds.; U.S. Department of Energy, Bituminous Coal and Lignite Distribution, 1971-76 eds.; U.S. Department of Energy, Coke and Coal Chemicals, 1976 ed.; U.S. Department of the Interior, Bureau of Mines, Coke Producers in the United States, 1976 ed.; American Iron and Steel Institute, Annual Statistical Report, 1976 ed.; and Keystone Coal Industry Manual, 1978 ed.

large quantities of coal to be consumed. Following BEAs 66 and 52 were BEAs 62 (Cincinnati) and 55 (Evansville). The largest consumers of coal for electricity generation are those PSAs with large populations and/or substantial industry.

The two largest consumers of steam coal for electric utility generation were American Electric Power Company (AEP) and The Tennessee Valley Authority (TVA). The AEP is the parent company of a number of operating utilities in the ORB, including Appalachian Power Company operating in BEAs 51 (Bristol) and 52 (Huntington). The TVA provides services in parts of BEAs 47 (Huntsville), 48 (Chattanooga), 49 (Nashville), and 50 (Knoxville) in the southern area of the ORB. Both AEP and TVA have been increasing their generating capacity and, in turn, their consumption of coal during the last decade. Other major users include the Monongahela Power Company operating in BEAs 52 (Huntington), 64 (Columbus) and 65 (Clarksburg); and Southern Indiana Gas and Electric Company operating in BEA 55 (Evansville). Many of these systems also serve consumers outside the PSA.

In 1976, the PSAs accounted for 35.0 percent of the coal used by the electric utility industry in the United States. This was up from 31.2 percent in 1969.

D-2. Coke Plant Consumption

The demand for coal by coke plants in the PSAs follows the demand for coke by the iron and steel industry. Overall consumption of coal by coke plants fell from 21 million tons in 1969 to slightly less than 17 million tons in 1976 (Table 10). It should be noted that 1969 was an abnormally good year for the steel industry, while 1976 was a somewhat below-average year.

Although the steel industry had a strong year in 1969, it experienced a period of relatively slow activity from 1970-72. The industry rebounded in 1973 and 1974, with record production in those years, followed by a disastrous year in 1975. There was a modest recovery for the industry in 1976, but production was still below a level considered average in the industry.

Within the PSAs, the greatest consumption of metallurgical coal occurs in BEA 66 (Pittsburgh). More than 13 million tons of metallurgical coal were consumed in BEA 66 in 1976. The BEA contains coke plants in the Pittsburgh Iron and Steel District, as well as some plants along the Ohio River, in the panhandle of West Virginia and in the State of Ohio. In 1976, it accounted for 77.1

percent of metallurgical coal consumption in the PSAs. Other major comsuming areas of metallurgical coal are BEAs 62 (Cincinnati) and 52 (Huntington), but their combined total consumption in 1976 was only 21.0 percent of the PSAs' metallurgical coal consumption, less than one-third of BEA 66 (Pittsburgh) alone. These BEAs contain steel centers along the Kanawha and Ohio Rivers in BEA 52 (Huntington) and steel plants in the Cincinnati area.

D-3. Coal Consumption by
Other Users

Coal consumption by other users exhibited strong growth during the period 1969-76, increasing at a rate of 6.[illegible] percent yearly. Annual consumption in this eight year period increased more than 50 percent, from nearly 10 million tons in 1969 to over 15 million tons in 1976 (Table 10).

Industry sources indicated that the growth was the product of two factors. First, there was strong growth in demand for electricity produced by private generating facilities, and these facilities increased their purchases of coal to meet that demand. Second, other non-steel industrial users of coal increased their demand for coal as a result of increases in their production capacities.

Since consumption of coal is tied closely to industrial activity and population, the largest consumers of coal were the most populous and industrialized BEAs in the ORB; in particular, BEAs 52 (Huntington), 62 (Cincinnati), 55 (Evansville) and 66 (Pittsburgh).

D-4. Coke Consumption

Consumption of coke in the PSAs correlated with the activity in the iron and steel industry. Consumption decreased from 14.7 million tons in 1969 to 11.9 million tons in 1976 (Table 11). The vast majority of the coke consumption in the PSAs was in BEAs 66 (Pittsburgh), 62 (Cincinnati), and 55 (Evansville). These are the areas where major iron and steel plants, as well as other industrial users of coke, are located. Of the three areas, BEA 66 (Pittsburgh) was the largest consumer of coke.

D-5. SCA Consumption

Much more coal is produced than is consumed in the PSAs. The area, therefore, provides a surplus for shipments to other regions of the United States, and for export to Canada, Japan and Europe.

The great bulk of coal moving to points outside the PSAs is shipped by rail. Relatively small amounts are shipped by water.

In 1976, major SCA destinations of waterborne coal included points along the Illinois and upper Mississippi Rivers, BEAs 57 (Decatur), 77 (Gary), 79 (Davenport), 81 (Dubuque), 89 (LaCross), 91 (Minneapolis), 113 (Quincy), St. Louis (BEA 114); points along the lower Mississippi River, BEAs 46 (Memphis) and 138 (New Orleans); and points served by the Gulf Coast Waterway, BEAs 141 (Houston), 137 (Mobile), 38 (Tallahassee) and 39 (Pensacola). Small amounts moved via the waterways to the Great Lakes (Table 3).

The PSAs supply virtually all of the coal received by New England, the Mid-Atlantic and Southeastern states, and all of the U.S. coal exported to Canada. Most of this coal is steam coal.

During the 1971-76 period, some decreases occurred in shipments of steam coal to SCAs but only in slight amounts. These decreases resulted from shifts to fuel oil after the oil import quotas were changed in the 1960s.

Shipments to the North Central states included some metallurgical coal from the PSAs. Since 1976 was a below average year for the iron and steel industry, shipments were lower than usual.

U.S. exports to foreign consumers reached 65 million tons in 1975 (Table 12). Virtually all of this coal was mined in the PSAs, according to industry sources and Bureau of Mines data. Significant increases occurred in 1975, but this appears to be an aberration in a distinctly stagnant market. Exports are primary metallurgical coal, shipped to foreign steel centers, such as Japan and Germany. Only the movements to Canada include significant amounts of steam coal. The metallurgical coal shipments tend to follow the patterns of production levels of the international steel industry.

Exports of coal by the United States are generally limited by institutional constraints on international trade. Restrictions by foreign governments which prevent their importation of vast amounts of U.S. steam coal serve to protect their national coal mining industries. Thus, shipments of export coal are expected to remain at a stable level or grow only modestly in the future.

The transportation of coal to SCAs is generally by rail. Rail serves the markets in Canada (with Great Lakes water carriers shuttling coal across the Lakes), New England, the Mid-Atlantic states, and most of the Southeastern and North Central states. Overseas shipments are railed from the PSAs to Baltimore and

Table 12. United States: Exports of Bituminous Coal by Major Country of Destination, 1969-75

(Thousands of tons)

| Country of destination | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 |
|---|---|---|---|---|---|---|---|
| Total, all exports | 56,234 | 70,944 | 56,633 | 55,997 | 52,870 | 59,926 | 65,669 |
| Japan | 21,367 | 27,637 | 19,706 | 18,038 | 19,190 | 27,346 | 25,423 |
| Canada | 16,789 | 18,763 | 17,565 | 18,161 | 16,231 | 13,706 | 16,735 |
| West Germany | 3,451 | 5,022 | 2,911 | 2,399 | 1,633 | 1,484 | 1,989 |
| Italy | 3,679 | 4,205 | 2,680 | 3,673 | 3,294 | 3,903 | 4,493 |
| France | 2,253 | 3,346 | 3,106 | 1,575 | 1,866 | 2,510 | 3,583 |
| Spain | 1,825 | 3,153 | 2,556 | 2,139 | 2,234 | 2,017 | 2,691 |
| All others | 6,870 | 8,818 | 8,109 | 10,012 | 8,422 | 8,960 | 10,755 |

Source: U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1969-75 eds.

Hampton Roads-Newport News for transloading to ocean-going bulk carriers. Some of these overseas exports are sent to Mobile by rail and/or barge for transloading to bulk carriers, although these movements are categorized as small by industry authorities.

The only significant waterway flows of coal to the SCAs are shipments to the Southeastern and North Central states. These movements are determined by the locations of the final consumers. For example, the movements by water to the Southeastern states are made to utility plants along the Gulf Intercoastal Waterway. Shipments to the utility plants in North and South Carolina are rail shipments. Thus, if a plant is waterside on a navigable waterway it will receive waterborne coal from the PSAs; if not, it will receive coal via rail.

## E. Forecasting Procedures and Assumptions

Basic projections of coal consumption within the PSAs have been made by the U. S. Department of Energy (DOE). DOE end-use projections to 1990 are available for ten demand regions in the United States, of which four contain portions of the PSAs These projections were disaggregated to sub-regional levels in the PSAs, based on historical shares of coal consumption by end-users, and on electric utility plant expansion plans. The future consumption of metallurgical coal use was projected independently by establishing probable future technical relationships for the conversion of metallurgical coal into coke, and by estimating the amount of coke which will be needed in blast furnaces. These factors were then applied to projected future production levels of pig iron production.

Projections for years beyond 1990 were based on best judgments about the future. More than the short-run forecasts, these projections involve explicit assumptions as to the type of energy which will be used in the future and the probable forms in which energy will be consumed.

### E-1. National Projections of Coal Consumption, 1976-1990

Projections of energy demand should be based on models which explicitly account for various sources of energy, demand characteristics for the different kinds of energy, and recognize the spatial aspects of the economy. In addition, projections of energy use should be tied to a macroeconomic model that generates the level of income and prices which drive energy demand. Finally, adequate detail of the coal industry (producers and consumers) is necessary to draw inferences about supply and demand in the future. Several recent models containing projections of coal consumption and production in the United States have been examined to identify those which are most relevant to the projection of waterborne movements of coal in the ORS.

Some projections of coal demand and supply are based on models which have adequate coal market structures but do not account for other energy sources. Explicit assumptions about the prices and quantities of other fuels are made independently for these models. Since the waterborne commodity projections include projections of other energy sources, such as petroleum, it was decided that these coal specific projection models and their results should not be used. Models falling into this category include the Argonne Coal Market Model, the Bechtel RESPONS Model, and the CRA/PEPCO Coal Market Model.[1]

A second group of models examined includes broader energy models which project the demand and supply of coal as well as of other forms of energy. The analyses and projections of coal are generally made in significant detail. Unfortunately, these models predict only the aggregated production and consumption of coal in the United States. For instance, changes in the future locational pattern of coal production would not be captured in these projections. Meaningful disaggregation of this data would be difficult, and therefore none of these models was used. Models in this category include the Brookhaven TESOM, Dartmouth FOSSILI, and the Gulf/SRI models.[2]

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1. Energy Modeling Forum, "An Assessment of Results Obtained by the Argonne Coal Market Model"; "An Analysis of Coal in Transition: 1980-2000. As conducted by the Regional Energy System for the Planning and Optimization of National Scenarios (RESPONS) Model"; "CRA-PEPCO Coal Market Model Applications for the Energy Modeling Forum"; Coal in Transition: 1980-2000 (Stanford, California: EMF, 1978) Vol. III.

2. Energy Modeling Forum, "Demand Consideration, Brookhaven TESCOM Model"; "A Behavioral Description of the FOSSIL 1 Model"; "Implemention of the EMF's 'Coal in Transition' Scenarios with the Gulf/SRI Model"; Coal in Transition: 1980-2000 (Stanford, California: EMF, 1978) Vol. III.

The Oak Ridge National Laboratory's model also was carefully examined.[1] Essentially, this model disaggregates national projections of energy demand and supply by fuel type and user for BEAs. Unfortunately, the latest model was based on 1975 Federal Energy Administration projections of energy use. These projections have been revised in the 1977 DOE Annual Report.[2] Consequently, only the BEA distribution factors provided in the Oak Ridge model are currently valid.

The projected U.S. and regional coal consumption presented in the Annual Report was selected as the basis for projecting the PSAs' coal demand through the year 1990. The DOE projection series includes three scenarios about economic growth, three demand levels, and three supply levels. The economic variables are provided through integration with the projections developed by Data Resources, Inc. (DRI).[3] These economic variables drive the energy model, which then feeds back into the DRI economic model to assure simultaneous integration of the energy and economic models.

The medium projection series of DOE was selected. This series assumes moderate economic growth and moderate growth in the demand for energy. The average annual growth rate in GNP is 4.1 percent for the period 1975-85, and 3.2 percent between 1985 and 1990. U.S. energy demand will grow at an average annual rate of 3.0 percent in 1975-85 and at 2.8 percent in the period 1985-90. As described above, the energy consumption levels are determined by the rate of economic activity, subject to constraints in the energy sectors.

Projections of total U.S. coal consumption in the DOE model are 961.0 and 1,177.5 million tons in 1985 and 1990, respectively. These projections are categorized by end-use and by geographic area of destination.[4] Electrical generation accounts for 912.0 million

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1. Oak Ridge National Laboratory, Regional and Urban Studies Section, Energy Division Research, Energy Availabilities for State and Local Development: A Methodology and Data Overview. By P.L. Rice and D. D. Vogt, Sponsored by the Economic Development Administration of the U.S. Department of Commerce (Oak Ridge, TN: ORNL, 1978).

2. U.S. Department of Energy, Energy Information Administration, Annual Report to Congress, 1977 ed. (Washington, D.C.: GPO, 1978) Vol. II, p. 58, 59.

3. Energy Modeling Forum. "Results of the DRI/Zimmerman Coal Model," Coal in Transition: 1980-2000 (Stanford, California: EMF, 1978) Vol. III.

4. See Appendix Table A-2.

tons in 1990, compared with 448.5 million tons in 1976. Regional subtotals for electric utility consumption of coal are provided by regions.

The subtotals of electric utility consumption in 1990 for the four regions which overlap the PSAs are 102.7, 259.2, 230.0, and 65.2 million tons for the Middle Atlantic, South Atlantic, Midwest, and Central regions, respectively.

The projections by DOE provide implicit growth rates for use of coal in non-metallurgical industrial usages as well. These growth rates are provided at a regional level for the various regions that overlap PSAs.

E-2. Primary Study Area Consumption Projections, 1976-1990

Disaggregation of the DOE national estimates of steam coal consumption was accomplished by using the factors projected for 1985 by Oak Ridge National Laboratories. These factors estimated the percentage of electricity produced through steam coal generation in each BEA. It was assumed that the percentage of electricity generated by coal would remain constant through the period 1986-90. These factors were converted to coal consumption equivalents and were applied to DOE data for 1990 to obtain BEA estimates of coal consumption. In effect, the shares of coal consumption were applied to an updated base of total coal consumption.

These initial projections were compared with data compiled by the Federal Energy Regulatory Commission (FERC) and with coal consumption data provided by TVA. The FERC data provided plant-specific information on anticipated coal consumption by electric utility plants scheduled to start operations during 1977-86. The electric utilities in the PSAs were contacted to extend these data to 1990. The disaggregated DOE projections were then adjusted, as necessary, to reflect the most recent plans of utilities in the PSAs.

The growth rates implicit in the DOE projections of coal consumption by industrial users of non-metallurgical coal were applied to PSA consumption estimates for 1976. If a PSA fell into two or more of the DOE regions, the average of the DOE growth rates was used. This assumed that each of the PSAs would exhibit the same growth that held for the DOE region in which it was located.

Projections of metallurgical coal consumption in the PSAs were based on 1990 estimates of iron and steel production and on production characteristics provided by the Iron Ore, Steel and Iron (Group VIII) Report.

Projected consumption of coal in the PSAs for 1980 was determined by interpolation of 1976 and 1990 projections of electric utility usage and other usages. The interpolation assumes a constant growth rate between 1976, the 1980 projections, and the 1990 final projections.

E-3. Primary Study Area Consumption of Non-Metallurgical Coal, 1990-2040

Projections of the consumption of non-metallurgical, industrial coal were based on the rate of economic growth projected by OBERS for each of the BEAs and BEA segments.[1] The growth rates of coal consumption for the period 1990-2020 were assumed to be 75 percent of the OBERS predicted growth rate in personal income. For the period 2020-40, the growth in coal consumption was assumed to be 50 percent of the growth rate in personal income.

Traditionally, energy use has increased at the same rate as economic growth in the United States. A 4 percent rise in gross national product (GNP) would cause a 4 percent increase in energy demand. However, as the price of energy has increased, there has been a tendency for users of energy to conserve on energy by substituting more energy-efficient capital equipment for less energy-efficient capital equipment. Since 1974, these changes have altered the traditional ratio (one percent growth in energy to one percent growth in GNP) to a ratio approaching 0.8. This trend of decreasing energy to GNP growth ratios should continue into the future as long as energy prices remain relatively high.[2] The coal projections based on this assume that the growth in electrical energy demand is related to trend growth in all energy demand.

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1. U.S. Water Resources Council, OBERS Projections, Regional Economic Activity in the United States, Series E, 1972 ed. (Washington, D.C.: GPO, 1974).

2. Dale Jorgenson and Edward A. Hudson, "Energy Policy and U.S. Economic Growth," American Economic Review, May 1978.

E-4. Primary Study Area Consumption of Metallurgical Coal, 1976-2040

Projections of metallurgical coal consumption in the PSAs are based on projections of pig iron production. The methodology on which pig iron projections were based is found in the Iron Ore, Steel and Iron (Group VIII) Report.

The manufacture of coke from metallurgical coal is based on chemical and technological relationships. The factor for the conversion of coal to coke, at a rate of 1.42 tons of coal per ton of coke, has been relatively constant during the last 25 years. The amount of coke necessary to produce a ton of pig iron, however, has had a distinct downward trend during the last 25 years. This is due to the substitution of alternative sources of heat for blast furnaces. This trend is expected to continue into the future, but should level off by the end of the century. Currently, the rate is approximately 1100 pounds of coke per ton of pig iron produced.

Projections of metallurgical coal consumption are based on these factors. Two sets of assumptions underlie the projections. The first set concerns the assumptions underlying pig iron production projections in the Iron Ore, Steel and Iron Report. The second set of assumptions are in regard to the technical relationships involved in the transformation of metallurgical coal into coke and the rate of consumption of coke in blast furnaces. It is assumed that the ratio of metallurgical coal to coke produced will remain at its historical level of 1.42 and that the ratio of coke to pig iron production will follow its historic downward pattern to 0.55 in 1980 and to 0.45 for the period 1990-2040.

## F. Probable Future Demands

Projections of coal consumption in the PSAs during the next 60 years indicate that coal consumption will grow at a much slower rate in the future than in the past. Consumption is expected to grow at an average annual rate of 1.79 percent during the 1976-90 period and at a rate of 1.75 percent during the entire projection period (Table 13). This growth will occur largely due to consumption by electric utilities and other users of non-metallurgical coal. Metallurgical coal consumption is expected to decline during

Table 13. Ohio River Basin: Coal Consumption by BEAs or BEA Segments,[a] Estimated 1976 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

| BEA or BEA segment | Estimated 1976 | Projected 1980 | Projected 1990 | Projected 2000 | Projected 2020 | Projected 2040 | Average annual percentage change 1976-1990 | Average annual percentage change 1976-2040 |
|---|---|---|---|---|---|---|---|---|
| Primary Study Areas | 194,578.4 | 216,792.8 | 268,856.5 | 334,826.2 | 465,251.4 | 606,624.0 | 1.79 | 1.75 |
| Electric utilities | 161,953.2 | 180,779.4 | 229,820.8 | 284,983.7 | 397,122.8 | 516,516.3 | | |
| Coke plants | 16,880.1 | 17,885.9 | 12,766.6 | 13,576.5 | 15,929.8 | 20,136.7 | | |
| Others | 15,745.1 | 18,127.5 | 26,269.1 | 36,266.0 | 52,198.8 | 69,971.0 | | |
| BEA 47: Huntsville, AL | 3,356.6 | 3,050.1 | 2,246.4 | 1,919.3 | 1,732.1 | 1,018.2 | (2.83) | (1.85) |
| Electric utilities[b] | 3,181.6 | 2,839.0 | 1,909.0 | 1,475.0 | 1,027.8 | -- | | |
| Coke plants | -- | -- | -- | -- | -- | -- | | |
| Others | 175.0 | 211.1 | 337.4 | 443.3 | 704.3 | 1,018.2 | | |
| BEA 48: Chattanooga, TN | 5,511.9 | 5,576.7 | 2,888.9 | 2,638.7 | 2,307.2 | 2,122.4 | (4.51) | (1.48) |
| Electric utilities[b] | 4,972.4 | 4,940.0 | 1,974.0 | 1,459.0 | 762.1 | -- | | |
| Coke plants | 131.2 | 144.5 | 128.3 | 137.9 | -- | -- | | |
| Others | 408.3 | 492.2 | 786.6 | 1,041.8 | 1,545.1 | 2,122.4 | | |
| BEA 49: Nashville, TN | 11,102.3 | 13,963.0 | 11,674.4 | 9,146.2 | 10,174.1 | 4,583.1 | 0.36 | (1.37) |
| Electric utilities[b] | 10,279.9 | 12,971.0 | 10,089.0 | 7,000.0 | 6,902.7 | -- | | |
| Coke plants | -- | -- | -- | -- | -- | -- | | |
| Others | 822.4 | 992.0 | 1,585.4 | 2,146.2 | 3,271.4 | 4,583.1 | | |
| BEA 50: Knoxville, TN | 7,476.9 | 6,900.1 | 5,887.6 | 4,033.6 | 2,030.4 | 2,745.5 | (1.69) | (1.55) |
| Electric utilities[b] | 6,923.1 | 6,232.1 | 4,820.0 | 2,640.1 | -- | -- | | |
| Coke plants | -- | -- | -- | -- | -- | -- | | |
| Others | 553.8 | 668.0 | 1,067.6 | 1,393.5 | 2,030.4 | 2,745.5 | | |
| BEA 51: Bristol, VA | 5,132.4 | 5,178.7 | 4,917.6 | 9,358.0 | 12,908.2 | 17,698.2 | (0.30) | 1.95 |
| Electric utilities | 4,383.5 | 4,393.1 | 4,417.3 | 8,634.3 | 11,837.1 | 16,229.8 | | |
| Coke plants | 282.3 | 309.6 | -- | -- | -- | -- | | |
| Others | 466.6 | 476.0 | 500.3 | 723.7 | 1,071.1 | 1,468.4 | | |

(Continued)

Table 13.(Continued)

| BEA or BEA segment | Estimated 1976 | Projected 1980 | 1990 | 2000 | 2020 | 2040 | Average annual percentage change 1976-1990 | 1976-2040 |
|---|---|---|---|---|---|---|---|---|
| BEA 52: Huntington, WV | 34,708.9 | 36,896.2 | 42,010.8 | 51,514.9 | 69,223.2 | 87,911.6 | 1.37 | 1.46 |
| Electric utilities | 29,683.4 | 31,533.7 | 36,679.8 | 44,844.2 | 60,279.7 | 76,370.0 | | |
| Coke plants | 1,828.3 | 2,100.9 | 1,902.6 | 2,195.0 | 2,927.3 | 3,919.5 | | |
| Others | 3,197.2 | 3,261.6 | 3,428.4 | 4,475.7 | 6,016.2 | 7,622.1 | | |
| BEA 53: Lexington, KY | 2,909.3 | 3,362.5 | 4,832.2 | 6,498.2 | 9,675.0 | 13,316.1 | 3.69 | 2.41 |
| Electric utilities | 2,669.1 | 3,072.7 | 4,369.1 | 5,820.6 | 8,666.1 | 11,927.6 | | |
| Coke plants | -- | -- | -- | -- | -- | -- | | |
| Others | 240.2 | 289.8 | 463.1 | 677.6 | 1,008.9 | 1,388.5 | | |
| BEA 54: Louisville, KY | 11,134.9 | 13,089.0 | 19,623.0 | 26,626.5 | 40,427.8 | 56,525.6 | 4.13 | 2.57 |
| Electric utilities | 10,215.5 | 11,962.9 | 17,753.5 | 23,859.2 | 36,226.1 | 50,650.8 | | |
| Coke plants | -- | -- | -- | -- | -- | -- | | |
| Others | 919.4 | 1,126.1 | 1,869.5 | 2,767.3 | 4,201.7 | 5,874.8 | | |
| BEA 55: Evansville, IN | 17,665.4 | 21,617.9 | 35,812.7 | 46,811.9 | 68,075.5 | 92,049.8 | 5.18 | 2.61 |
| Electric utilities | 16,206.8 | 19,831.4 | 32,846.8 | 42,624.5 | 61,985.6 | 83,815.2 | | |
| Coke plants | -- | -- | -- | -- | -- | -- | | |
| Others | 1,458.6 | 1,786.5 | 2,965.9 | 4,187.4 | 6,089.9 | 8,234.6 | | |
| BEA 62: Cincinnati, OH | 20,969.5 | 25,069.2 | 39,727.6 | 51,691.7 | 74,252.8 | 99,347.0 | 4.67 | 2.46 |
| Electric utilities | 16,957.9 | 20,658.2 | 33,836.9 | 43,781.2 | 63,045.7 | 84,412.9 | | |
| Coke plants | 1,707.2 | 1,588.6 | 1,205.6 | 1,314.5 | 1,708.7 | 2,216.6 | | |
| Others | 2,304.4 | 2,822.4 | 4,685.1 | 6,596.0 | 9,498.4 | 12,717.5 | | |
| BEA 64: Columbus, OH | 6,347.4 | 7,542.9 | 11,625.5 | 15,724.5 | 23,503.6 | 32,413.0 | 4.42 | 2.58 |
| Electric utilities | 5,667.3 | 6,697.3 | 10,167.3 | 13,584.6 | 20,305.1 | 28,002.0 | | |
| Coke plants | -- | -- | -- | -- | -- | -- | | |
| Others | 680.1 | 845.6 | 1,458.2 | 2,139.9 | 3,198.5 | 4,411.0 | | |
| BEA 65: Clarksburg, WV | 5,321.5 | 5,863.3 | 7,492.1 | 9,645.3 | 13,809.2 | 18,416.6 | 2.47 | 1.96 |
| Electric utilities | 4,837.7 | 5,369.7 | 6,973.3 | 8,926.4 | 12,778.6 | 17,042.2 | | |
| Coke plants | -- | -- | -- | -- | -- | -- | | |
| Others | 483.8 | 493.6 | 518.8 | 718.9 | 1,030.6 | 1,374.4 | | |

(Continued)

Table 13.(Continued)

| BEA and BEA segment | Estimated 1976 | Projected 1980 | 1990 | 2000 | 2020 | 2040 | Average annual percentage change 1976-1990 | 1976-2040 |
|---|---|---|---|---|---|---|---|---|
| BEA 66: Pittsburgh, PA | 54,629.4 | 60,187.9 | 70,225.6 | 86,263.9 | 118,324.6 | 153,127.9 | 1.81 | 1.62 |
| Electric utilities | 38,170.3 | 42,428.3 | 55,270.3 | 69,043.8 | 96,916.5 | 125,979.9 | | |
| Coke plants | 12,931.1 | 13,742.3 | 9,530.1 | 9,929.1 | 11,293.8 | 14,000.6 | | |
| Others | 3,528.0 | 4,017.3 | 5,425.2 | 7,291.0 | 10,114.3 | 13,147.4 | | |
| BEA 68: Cleveland, OH | -- | -- | 750.0 | 955.4 | 1,359.7 | 1,802.7 | c | c |
| Electric utilities | -- | -- | 750.0 | 955.4 | 1,359.7 | 1,802.7 | | |
| Coke plants | -- | -- | -- | -- | -- | -- | | |
| Others | -- | -- | -- | -- | -- | -- | | |
| BEA 115: Paducah, KY | 8,312.0 | 8,495.3 | 9,142.1 | 11,998.1 | 17,448.0 | 23,546.3 | 0.68 | 1.64 |
| Electric utilities | 7,804.7 | 7,850.0 | 7,964.5 | 10,335.4 | 15,030.0 | 20,283.2 | | |
| Coke plants | -- | -- | -- | -- | -- | -- | | |
| Others | 507.3 | 645.3 | 1,177.6 | 1,662.7 | 2,418.0 | 3,263.1 | | |

Note: Except where tonnages for 1990 electric utility consumption were derived from Department of Energy (DOE) regional projections of coal consumption by end user, 1990 consumption was based on the distribution of earlier DOE projections of coal consumption by electric utilities by BEA estimated by the Oak Ridge Laboratory, and adjusted to reflect plans of electric utilities in the PSAs as ascertained by a RRNA survey of utilities. When a BEA is located in more than one DOE region, an average share of relevant regions was employed. The 1980 tonnages were estimated through interpolation of 1976 and 1990 data. Electric utility consumption for 1990-2020 were assumed to grow at 75 percent of the BEA growth rates in personal income for 1990-2000 and 2000-2020. For the period 2020-2040, this consumption was assumed to increase at 50 percent of the BEA growth rates in personal income. BEA growth rates were obtained from OBERS Projections. Tonnages for use in coke manufacture in BEAs 52, 62, and 66 were projected using projections of pig iron production contained in the Iron Ore, Steel and Iron (Group VIII) Report, and estimates of coal requirements to produce pig iron. Factors of 0.55 tons of coke per ton of pig iron and 0.7 tons of coke produced per ton of coal carbonized were used for 1980 projections. Thereafter, factors of 0.45 and 0.7, respectively, were used. Other BEAs with coke consumption were assumed to grow at the same rate as BEAs 52, 62, and 66. The one beehive coke plant in BEA 51 was assumed to shutdown during the 1981-1990 period. All small producers of coke were assumed to shutdown in 2000. Tonnages of other consumption were based on regional DOE projections of growth rates of non-metallurgical industrial use, and disaggregated and projected in a similar manner as electric utility consumption.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

b. Tonnages for electric utility plant consumption for 1980-90 based on information obtained from surveys of projected TVA steam plant coal consumption, and correspondence from TVA, Fossil Fuels Planning Branch, Chattanooga, Tennessee. Consumption after 1990 based on assumptions that the Watts Bar, Widdows Creek, and Colbert Steam Plants will continue its coal consumption trend through 2020 and will shut down in 2020-2040, and that the Bull Run and Kingston Plants will follow their trends through 1976-2000 and will shutdown between 2000 and 2020.

c. No production in 1976.

Source: Table 10 and U.S. Department of Energy, "Appendix," Annual Report to Congress, Vol. II, 1977 ed.; Oak Ridge National Laboratory, Energy Availabilities for State and Local Development, 1978; U.S. Water Resources Council, OBERS Projections, Economic Activity in the United States, Series E, 1972 ed. Correspondence from TVA, Fossil Fuels Planning Branch, Chattanooga, Tennessee, and selected Ohio River Basin Users Survey Questionnaires, provided by the U.S. Army Corps of Engineers.

the next 20 years and to increase after the year 2000.[1] The consumption of coke is expected to follow the trend in the consumption of metallurgical coal.

F-1. Future Levels of Coal Consumption by Electric Utilities, 1976-2040

Coal consumption in the PSAs by electric utilities is projected to increase from 162 million tons in 1976 to 230 million tons by 1990 and to more than 516 million tons by 2040 (Table 13). This corresponds to growth rates of 2.53 percent from 1976-90 and of 1.83 percent for the entire time frame of the study 1976-2040. The modest increase in coal growth rates is caused by two factors influencing coal consumption. First, as the price of coal and all energy commodities increases, there will be a decrease in the growth of electricity consumed. This will reduce the amount of coal needed by electric utilities. The second factor concerning the slower growth rate of coal consumption by electric utilities results from the plans of the TVA to replace their coal-fired plants with nuclear facilities. Given TVA's plans to construct these facilities prior to 1990, the rate of growth in demand for coal in the areas served by TVA will decrease substantially.

In the future, the growth in electric utility consumption of coal will be distributed unevenly through the ORS hinterland. As stated above, the BEAs which fall into the areas served by TVA will be exhibiting reductions in the growth of coal consumption for electricity generation. Other BEAs will experience faster growth in the earlier periods of the projection time frame and more modest growth in the later periods.

Current plans for expansion in generating capacity by electric utilities during the 1980s indicate that the largest expansions will take place in BEAs 62 (Cincinnati) and 55 (Evansville). Their added capacity will generate demand for 51 million tons of coal per year. The total new capacity in the PSAs will require nearly 69 million tons of coal annually by 1990. The new growth will continue to be concentrated in BEAs 62 (Cincinnati) and 55 (Evansville) with only modest growth occuring in the remaining PSAs. BEA 55 was the major area identified which will be receiving large amounts of western coal via the waterway. Indiana and Michigan

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1. This consumption trend is projected to occur as a result of changes in steel production. See Iron Ore, Steel and Iron (Group VIII) Report.

Electric Co., located in BEA 55, will install two units, one in 1983 and one in 1984. Each of these two units will require 4.5 million tons of western coal a year and will have a generating capacity of 1.3 million KW. Later in the projection period, after 2000, it is expected that there will be greater movement of western coal on the waterway.

Over the long run, electric utility consumption of coal will grow faster in the BEAs which will have the highest rates of general economic growth. Both sets of existing projections used to project ORB coal consumption (DOE and OBERS projections) incorporate explicitly the level of economic activity and population. Higher growth rates will be evident in BEAs 53 (Lexington), 54 (Louisville), 55 (Evansville), 62 (Cincinnati) and 64 (Columbus), while the more mature areas, such as BEAs 52 (Huntington) and 66 (Pittsburgh), will show large absolute growth but relatively low growth rates.

F-2. Future Levels of Coal Consumption by Coke Plants, 1976-2040

In the future, BEAs 52 (Huntington), 62 (Cincinnati), and 66 (Pittsburgh) will remain large consumers of metallurgical coal (Table 13). In 1976, these areas accounted for 97.6 percent of all metalluriqical coal consumption in the PSAs. By 1990, this share will be in the range of 99 percent. This will occur because of the expected closing of remaining small coke plants in the PSAs.

In general, it is not anticipated that the PSAs' metallurgical coal consumption in the future will be substantially greater than it is at the present time. As the iron and steel industry is relocated to other areas, and as coke plants age and shut down, regional demand for metallurgical coal will decline. In 1976, metallurgical coal accounted for 8.7 percent of coal consumption in the PSAs. By 2040, metallurgical coal is projected to account for only 3.3 percent of coal consumption.

F-3. Future Levels of Consumption of Coal by Other Users 1976-2040

Coal consumption by other users in the PSAs is projected to grow substantially over the projection period, increasing from about 15 million tons in 1976 to nearly 70 million tons in 2040 (Table 13).

The largest absolute increase in the consumption of coal for other users will occur in BEAs 66 (Pittsburgh), 62 (Cincinnati), 55 (Evansville) and 52 (Huntington), the most industrialized BEAs. However, these BEAs will account for only 60 percent of all miscellaneous uses of coal by 2040. This is compared with 67 percent in 1976. The reduction in the share of coal consumption will occur because of the more rapid growth rates projected by OBERS for other BEAs.

F-4. Future Levels of Consumption
of Coke, 1976-2040

Although there will be some upturn during the latter years of 1980-2000, coke consumption will show a decrease during that period (Table 14). Consumption will not reach the 1976 level again until sometime during the period 2020-2040. This is because production of pig iron, the main determinant of coke consumption, is expected to be at modest levels throughout the study period. Also, the amount of coke necessary to produce a ton of iron and steel will be decreasing to 2000, reducing the amount of coke that is necessary for pig iron production. Other uses of coke should either remain stable or suffer some modest decline.

Table 14. Ohio River Basin: Consumption of Coke by BEAs or BEA Segments[a], Estimated 1976 and Projected 1980-2040, Selected Years

(Thousands of tons)

| BEA or BEA segment | Estimated 1976 | Projected 1980 | 1990 | 2000 | 2020 | 2040 |
|---|---|---|---|---|---|---|
| Primary Study Areas | 11,894.0 | 12,519.9 | 8,936.4 | 9,503.3 | 11,150.7 | 14,095.4 |
| BEA 48: Chattanooga, TN | 91.8 | 101.2 | 89.8 | 96.5 | -- | -- |
| BEA 51: Bristol VA | 197.6 | 216.7 | -- | -- | -- | -- |
| BEA 52: Huntington, WV | 1,288.4 | 1,470.6 | 1,331.8 | 1,536.5 | 2,049.1 | 2,743.6 |
| BEA 62: Cincinnati, OH | 1,203.1 | 1,112.0 | 843.9 | 920.1 | 1,196.1 | 1,551.6 |
| BEA 66: Pittsburgh, PA | 9,113.1 | 9,619.4 | 6,670.9 | 6,950.2 | 7,905.5 | 9,800.2 |

a. BEA segments defined as ultimate origins or destinations of waterborne movements.
Soruce: Metallurgical coal consumption from Table 13. Production of coke assumed equal to 70 percent of metallurgical coal consumption. Consumption assumed equal to production.

# III. COMMODITY RESOURCE INVENTORY

Production of coal and coke has experienced only modest growth over the last decade in the PSAs, with increases in total production averaging 0.6 percent annually. Underground production in the PSAs decreased by 2.2 percent yearly, while surface and auger production increased at a rate of 5.4 percent annually. Three areas, BEAs 66 (Pittsburgh), 52 (Huntington) and 55 (Evansville), accounted for 63 percent of production in 1976.

The fastest growing areas of coal production were generally the PSAs with lower levels of production. The more mature areas of the ORB, such as BEAs 66, 52 and 65, have experienced a slowdown during the last decade. Areas such as BEAs 48 (Chattanooga), 49 (Nashville), 50 (Knoxville) and 53 (Lexington), in the more southern areas of the ORS hinterland, have exhibited relatively large increases in the production of coal. The BEAs which historically have been the predominant producers remained so during the period, but their share of total PSA production decreased. The future growth in coal production is expected to be in areas in central Appalachia, such as BEAs 52 (Huntington), 51 (Bristol) and 50 (Knoxville). This is primarily due to the sulfur content of the coal mined there.

## A. Production Areas

The production of Group I commodities in the PSAs is supplemented by production in Secondary Production Areas (SPAs) located outside the Ohio River Basin. These SPAs are defined as BEAs which are the origins of Group I waterborne movements which are destined to the Ohio River Basin.[1]

Since the PSAs produce more than enough coal to meet their own demands and are net shippers of coal, the amount of inbound movements from secondary production areas is minimal. Essentially, there only have been two movements in the recent past which were not simply spot purchases of coal and coke. There has been some movement of western coal into the PSAs, the origins of which have been Wyoming, Montana, and North Dakota. While the bulk of this coal has been sent to the East directly via unit train, in 1976 about 2 million tons were transferred from rail in BEA 114 (St. Louis) to barge for transport to the central area of the ORB -- in particular, to BEA 52 (Huntington). Other than this movement, however, no other substantial and sustained movements of western coal have been or are transported into the ORS.

The second movement of coal and coke from Secondary Production Areas into the PSAs via the waterway consisted of foreign-produced coke. This coke was received in BEA 138 (New Orleans), near the mouth of the Mississippi River. It, then, has moved north by barge to BEA 52 (Huntington). These foreign shipments originated in West Germany where there has been an excess of coke resulting from a slack demand for steel.

In terms of the future, the western coal producing areas should be the only significant secondary production area for the PSAs. The future importation of foreign-produced coke is expected to be of no real importance.

B. Production Characteristics

The economic characteristics of coal production reflect mining productivity, as well as capital and labor costs. Institutional characteristics reflect governmental policies and labor/management

1. An exception to these general rules is noted in the case of western coal production areas. Since 1977, some western coal was moved by trains to PE 202 in the lower Ohio River and transloaded onto barges for transporting to other areas in ORB. In this case, although areas in western states were the ultimate origins of coal transported on the ORS, these states are not considered as SPAs. Rather BEA 114 (St. Louis) was considered the origin of western coal and was grouped with these shipments. PE 202 was retained as the waterside origin for much of this western coal traffic.

B-1. Economic Characteristics

The supply of coal is determined by prices paid for coal, prices of coal substitutes, and prices of the inputs which are necessary to produce coal and which influence the cost of mining.

Because underground mining requires more complex and costly equipment than surface mining, the capital costs of underground mining must be amortized over a longer period of time. The life of an underground mine is typically longer than that of a surface mine. Also, underground mines generally are developed only after long-term sales contracts for the coal to be produced are signed, thus assuring a market. These factors explain the relative stability of underground production.

Surface mines have greater variability in production, with many small marginal mines opening and closing in response to the spot prices of coal. Surface mining requires less capital to start-up and operate than underground mining. Often equipment can be leased. This reduces the commitment of long-term capital to a particular mine.

The pattern of mine productivity in the United States and in selected eastern states is shown in Table 15. Productivity in surface mines is much higher than in underground mines, leading to lower prices at the mine for surface-mined coal. In 1975, the average productivity in surface mines was 26.7 tons per man-day. This was 280 percent higher than productivity in underground mines and yielded a national composite of 14.7 tons of coal mined per man-day in 1975.

Across the eastern states, productivity levels vary widely. Productivity in underground mining is highest in Indiana where it averages 16.10 tons per man-day. Western Kentucky has the second highest rate of productivity, reaching 14.48 tons per man-day. In 1975, West Virginia and eastern Kentucky, important regions for underground mining, had productivity rates of 8.2 and 11.4, respectively.

Surface mining productivity rates in the eastern states are generally below the national average. However, within the eastern states that overlap the study area, Indiana and western Kentucky have surface mine productivity rates which are slightly above the national average. They report 29.7 and 29.6 tons per man-day,

Table 15. United States and Selected Eastern States: Average Tons Produced per Man-Day at Bituminous Coal and Lignite Mines, by Type of Mine, Selected Years, 1960-75

(Tons)

| Area or state | 1960 Underground | 1960 Surface | 1960 Total | 1965 Underground | 1965 Surface | 1965 Total | 1970 Underground | 1970 Surface | 1970 Total | 1975 Underground | 1975 Surface | 1975 Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| United States | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 17.52 | 13.76 | 35.96 | 18.84 | 9.54 | 26.69 | 14.74 |
| Alabama | [illegible] | [illegible] | [illegible] | [illegible] | 27.77 | 13.11 | 10.22 | 31.51 | 16.41 | 7.23 | 15.29 | 11.19 |
| Georgia | 1.84 | -- | 1.84 | -- | -- | -- | -- | -- | -- | -- | 9.79 | 9.79 |
| Illinois | [illegible] | [illegible] | 21.94 | [illegible] | 37.54 | 27.84 | 21.25 | 33.58 | 26.11 | 14.25 | 24.19 | 17.61 |
| Indiana | 11.96 | [illegible] | [illegible] | 14.31 | 38.06 | 30.42 | 17.56 | 40.51 | 36.07 | 16.10 | 29.69 | 29.50 |
| Kentucky, total | [illegible] | [illegible] | 13.86 | 12.64 | 47.45 | 18.05 | 15.84 | 46.72 | 23.50 | 12.38 | 24.74 | 16.99 |
| Eastern Kentucky | N/A | [illegible] | [illegible] | [illegible] | 26.71 | 12.63 | 14.15 | 43.93 | 19.36 | 11.36 | 22.30 | 15.40 |
| Western Kentucky | N/A | [illegible] | 23.98 | 22.62 | 54.73 | 36.82 | 21.61 | 48.55 | 33.28 | 14.48 | 29.56 | 20.22 |
| Maryland | 4.37 | 15.51 | 8.22 | 9.26 | 27.02 | 15.89 | 12.03 | 25.56 | 22.53 | 9.59 | 21.74 | 20.69 |
| Ohio | 10.95 | 23.59 | 18.13 | 13.61 | 29.33 | 22.39 | 15.41 | 37.32 | 25.47 | 8.19 | 25.97 | 15.13 |
| Pennsylvania | 9.34 | 17.03 | 10.68 | 13.12 | 20.01 | 14.71 | 12.28 | 23.26 | 14.42 | 8.23 | 20.59 | 11.46 |
| Tennessee | 6.79 | 20.97 | 8.71 | 10.96 | 25.68 | 14.15 | 16.84 | 30.34 | 21.44 | 9.87 | 17.71 | 12.94 |
| West Virginia | 11.78 | 13.65 | 12.07 | 15.04 | 28.00 | 15.90 | 12.50 | [illegible] | [illegible] | 6.24 | 17.01 | 9.15 |

Source: U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1960-75 eds.

respectively. The more mature mining states, such as Pennsylvania and West Virginia, generally have low productivity rates. In 1975, these two states reported rates which were only 77.1 and 63.7 percent of the national average.

While mine size is only one factor determining mining cost, unit costs are lower in larger mines. In the United States, the greatest number of mines falls in the smallest size category, (i.e. those mines producing less than 10,000 tons per year) (Table 16). Most eastern states have many small mines, particularly eastern Kentucky, Pennsylvania and West Virginia. However, these mines produce a smaller proportion of the total output of each state. The greatest part of output in most eastern states comes from the middle or large sized mines which produce 100,000 tons per year or more.

The geological factors affecting costs differ according to the type of mine. For underground mining, the depth, thickness and uniformity of coal seams are the major geological factors determining costs. A thicker seam implies that per unit costs of extraction are lower. Also, the depth of seams is significant. For surface mining the crucial geological factor is overburden, the amount of earth and other non-coal-bearing materials which cover the coal seams. The greater the overburden, the greater is the cost of removing it and extracting the coal. Slope and general topography of an area are important factors affecting the costs of surface mining.

During the decade of the 1960s, the average price of U.S. produced coal at the mine increased modestly from $4.69/ton to $6.26/ton (Table 17). Between 1970 and 1975, however, prices increased dramatically from $6.26/ton to $19.23/ton. The increase was more substantial for underground mines: coal prices at underground mines were 355 percent of their 1970 level in 1975, while surface-mined coal prices were 280 percent of their 1970 level in 1976. This increase was due to two factors: first, the price of all other fossil-based energy commodities increased sharply, and consumers demanded more coal, causing prices to increase relative to those of other commodities; and, second, the impacts of expanded EPA and OSHA regulations, as well as the Mine Health and Safety Act of 1969, added significant costs to mining operations. Additionally, large wage and benefit increases achieved by the United Mine Workers Union increased the wage bills of mine owners.

Coal prices varied widely across states, with the highest ORB prices in West Virginia, Pennsylvania and eastern Kentucky. Lower

Table 16. United States and Selected Eastern States: Size Distribution of Mines by Mine Type, 1975

(Thousands of tons)

| Area or state | All size classes | | 500,000 tons and over | | 200,000 to 499,999 tons | | 100,000 to 199,999 tons | | 50,000 to 99,999 tons | | 10,000 to 49,999 tons | | Less than 10,000 tons | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Production | Number | Production | Number | Production | Number | Production | Number | Production | Number | Production | Number | Production | Number |
| United States | | | | | | | | | | | | | | |
| Total | 648,438 | 6,168 | 359,284 | 284 | 101,633 | 327 | 64,250 | 463 | 55,968 | 800 | 58,597 | 2,417 | 1,877 | 8,706 |
| Underground | 292,826 | 2,292 | 162,581 | 163 | 60,824 | 193 | 27,343 | 197 | 19,720 | 282 | 19,515 | 800 | 657 | 2,842 |
| Strip | 314,945 | 2,644 | 189,807 | 114 | 36,000 | 119 | 31,876 | 229 | 27,048 | 387 | 26,473 | 1,042 | 753 | 3,740 |
| Auger | 3,526 | 216 | -- | -- | -- | -- | 210 | 2 | 797 | 12 | 2,094 | 104 | 98 | 425 |
| Strip-Auger | 37,141 | 1,016 | 6,897 | 7 | 4,809 | 15 | 4,820 | 35 | 8,403 | 119 | 10,514 | 471 | 369 | 1,699 |
| Alabama | | | | | | | | | | | | | | |
| Total | 22,644 | 236 | 10,161 | 12 | 5,266 | 17 | 2,825 | 19 | 2,230 | 32 | 1,773 | 79 | 388 | 77 |
| Underground | 7,614 | 20 | 5,562 | 6 | 1,789 | 5 | -- | -- | 168 | 2 | 63 | 3 | 32 | 4 |
| Strip | 15,029 | 215 | 4,599 | 6 | 3,476 | 12 | 2,825 | 19 | 2,062 | 30 | 1,711 | 75 | 357 | 73 |
| Auger | aW | 1 | -- | -- | -- | -- | -- | -- | -- | -- | aW | 1 | -- | -- |
| Strip-Auger | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Georgia | | | | | | | | | | | | | | |
| Total | 74 | 3 | -- | -- | -- | -- | -- | -- | W | 1 | W | 1 | W | 1 |
| Underground | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Strip | 74 | 3 | -- | -- | -- | -- | -- | -- | W | 1 | W | 1 | W | 1 |
| Auger | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Strip-Auger | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Illinois | | | | | | | | | | | | | | |
| Total | 59,537 | 58 | 57,559 | 37 | 1,218 | 3 | 101 | 1 | 379 | 5 | 270 | 9 | 9 | 3 |
| Underground | 31,875 | 21 | 31,322 | 19 | 453 | 1 | 101 | 1 | -- | -- | -- | -- | -- | -- |
| Strip | 27,661 | 37 | 26,237 | 18 | 765 | 2 | -- | -- | 379 | 5 | 270 | 9 | 9 | 3 |
| Auger | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Strip-Auger | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Indiana | | | | | | | | | | | | | | |
| Total | 25,124 | 62 | 22,176 | 13 | 814 | 1 | 751 | 5 | 857 | 12 | 474 | 18 | 53 | 13 |
| Underground | 188 | 2 | -- | -- | -- | -- | -- | -- | 188 | 2 | -- | -- | -- | -- |
| Strip | 24,935 | 60 | 22,176 | 13 | 814 | 1 | 751 | 5 | 668 | 10 | 474 | 18 | 53 | 13 |
| Auger | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Strip-Auger | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Kentucky, total | | | | | | | | | | | | | | |
| Total | 143,613 | 2,401 | 66,952 | 56 | 19,053 | 64 | 15,382 | 112 | 16,505 | 242 | 21,482 | 968 | 4,240 | 959 |
| Underground | 65,632 | 896 | 33,425 | 33 | 10,318 | 34 | 7,375 | 52 | 6,012 | 90 | 6,949 | 306 | 1,553 | 381 |
| Strip | 51,678 | 493 | 32,147 | 21 | 5,862 | 21 | 4,736 | 36 | 3,557 | 53 | 4,559 | 193 | 818 | 169 |
| Auger | 1,822 | 102 | -- | -- | -- | -- | 210 | 2 | 601 | 9 | 797 | 42 | 213 | 49 |
| Strip-Auger | 24,481 | 910 | 1,380 | 2 | 2,873 | 9 | 3,060 | 22 | 6,336 | 90 | 9,177 | 427 | 1,656 | 360 |

(Continued)

Table 16. United States and Selected Eastern States: Size Distribution of Mines by Mine Type, 1975 (Continued)

| Area or state | All size classes | | 500,000 tons and over | | 200,000 to 499,999 tons | | 100,000 to 199,999 tons | | 50,000 to 99,999 tons | | 10,000 to 49,999 tons | | Less than 10,000 tons | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Production | Number | Production | Number | Production | Number | Production | Number | Production | Number | Production | Number | Production | Number |
| East Kentucky | | | | | | | | | | | | | | |
| Total | 87,257 | 2,219 | 17,772 | 18 | 16,046 | 55 | 13,822 | 101 | 15,593 | 228 | 20,058 | 909 | 3,966 | 908 |
| Underground | 40,628 | 869 | 9,205 | 12 | 9,892 | 33 | 7,207 | 51 | 5,900 | 88 | 6,871 | 304 | 1,553 | 381 |
| Strip | 20,656 | 347 | 7,186 | 4 | 3,281 | 13 | 3,489 | 27 | 2,842 | 42 | 3,302 | 140 | 557 | 121 |
| Auger | 1,822 | 102 | -- | -- | -- | -- | 210 | 2 | 601 | 9 | 797 | 42 | 213 | 49 |
| Strip-Auger | 24,150 | 901 | 1,380 | 2 | 2,873 | 9 | 2,916 | 21 | 6,250 | 89 | 9,089 | 423 | 1,643 | 357 |
| West Kentucky | | | | | | | | | | | | | | |
| Total | 56,357 | 182 | 49,181 | 38 | 3,007 | 9 | 1,560 | 11 | 912 | 14 | 1,424 | 59 | 274 | 51 |
| Underground | 25,004 | 27 | 24,220 | 21 | 426 | 1 | 168 | 1 | 112 | 2 | 78 | 2 | -- | -- |
| Strip | 31,002 | 146 | 24,961 | 17 | 2,581 | 8 | 1,247 | 9 | 715 | 11 | 1,257 | 53 | 261 | 48 |
| Auger | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Strip-Auger | 331 | 9 | -- | -- | -- | -- | 144 | 1 | 86 | 1 | 88 | 4 | 13 | 3 |
| Maryland | | | | | | | | | | | | | | |
| Total | 2,606 | 69 | -- | -- | 250 | 1 | 566 | 4 | 918 | 14 | 795 | 32 | 77 | 18 |
| Underground | 104 | 2 | -- | -- | -- | -- | -- | -- | 72 | 1 | 32 | 1 | -- | -- |
| Strip | 2,466 | 61 | -- | -- | 250 | 1 | 566 | 4 | 846 | 13 | 739 | 29 | 66 | 14 |
| Auger | 36 | 6 | -- | -- | -- | -- | -- | -- | -- | -- | 25 | 2 | 11 | 4 |
| Strip-Auger | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Ohio | | | | | | | | | | | | | | |
| Total | 46,770 | 348 | 24,126 | 25 | 9,126 | 28 | 4,639 | 32 | 4,983 | 67 | 3,488 | 125 | 408 | 71 |
| Underground | 15,455 | 33 | 13,168 | 14 | 1,515 | 4 | 488 | 3 | 193 | 3 | 48 | 2 | 43 | 7 |
| Strip | 24,908 | 267 | 6,132 | 7 | 7,262 | 23 | 4,045 | 28 | 4,577 | 61 | 2,572 | 95 | 319 | 53 |
| Auger | 495 | 25 | -- | -- | -- | -- | -- | -- | 120 | 2 | 328 | 12 | 46 | 11 |
| Strip-Auger | 5,912 | 23 | 4,826 | 4 | 349 | 1 | 106 | 1 | 93 | 1 | 539 | 16 | -- | -- |
| Pennsylvania | | | | | | | | | | | | | | |
| Total | 84,137 | 835 | 36,665 | 41 | 18,903 | 59 | 11,382 | 81 | 8,172 | 115 | 7,901 | 307 | 1,115 | 232 |
| Underground | 44,631 | 132 | 30,192 | 34 | 10,599 | 32 | 2,437 | 17 | 921 | 13 | 390 | 17 | 90 | 19 |
| Strip | 39,105 | 661 | 6,473 | 7 | 8,304 | 27 | 8,944 | 64 | 7,250 | 102 | 7,214 | 273 | 919 | 188 |
| Auger | 402 | 39 | -- | -- | -- | -- | -- | -- | -- | -- | 296 | 15 | 105 | 24 |
| Strip-Auger | [b]W | 3 | -- | -- | -- | -- | -- | -- | -- | -- | [b]W | 2 | [b]W | 1 |
| Tennessee | | | | | | | | | | | | | | |
| Total | 8,206 | 166 | 925 | 1 | 1,303 | 5 | 2,163 | 17 | 1,756 | 28 | 1,856 | 73 | 202 | 42 |
| Underground | 3,806 | 62 | 925 | 1 | 560 | 2 | 835 | 6 | 763 | 12 | 647 | 25 | 76 | 16 |
| Strip | 4,248 | 94 | -- | -- | 743 | 3 | 1,328 | 11 | 993 | 16 | 1,076 | 42 | 106 | 22 |
| Auger | 152 | 9 | -- | -- | -- | -- | -- | -- | -- | -- | 132 | 5 | 20 | 4 |
| Strip-Auger | [b]W | 1 | -- | -- | -- | -- | -- | -- | -- | -- | [b]W | 1 | -- | -- |

(Continued)

Table 16. United States and Selected Eastern States: Size Distribution of Mines by Mine Type, 1975 (Continued)

| | All size classes | | 500,000 tons and over | | 200,000 to 499,999 tons | | 100,000 to 199,999 tons | | 50,000 to 99,999 tons | | 10,000 to 49,999 tons | | Less than 10,000 tons | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area or state | Production | Number | Production | Number | Production | Number | Production | Number | Production | Number | Production | Number | Production | Number |
| West Virginia | | | | | | | | | | | | | | |
| Total | 109,283 | 1,073 | 40,074 | 45 | 27,798 | 91 | 16,849 | 122 | 13,409 | 188 | 9,893 | 372 | 1,259 | 254 |
| Underground | 88,357 | 703 | 38,728 | 43 | 23,910 | 78 | 11,193 | 82 | 7,873 | 110 | 5,867 | 215 | 786 | 175 |
| Strip | 16,846 | 323 | 655 | 1 | 2,857 | 10 | 4,936 | 35 | 4,317 | 61 | 3,644 | 143 | 437 | 73 |
| Auger | 46 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | 35 | 1 | 11 | 2 |
| Strip-Auger | 4,034 | 43 | 691 | 1 | 1,032 | 3 | 720 | 5 | 1,220 | 17 | 347 | 13 | 25 | 4 |

W= Withheld to avoid disclosing individual company data.
a. Included with strip production for class and state.
b. Included with auger production for class and state.
Source: U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1975 ed.

Table 17. United States and Selected Eastern States: Average Value of Bituminous Coal and Lignite Produced in the United States, by Type of Mine, Selected Years, 1960-75

(Dollars per ton, F.O.B. mine)

| | 1960 | | | 1965 | | | 1970 | | | 1975 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area or state | Underground | Strip | Total | Underground | Strip | Total | Underground | Strip | Total | Underground | Strip | Total |
| United States | 5.14 | 3.74 | 4.69 | 4.93 | 3.57 | 4.44 | 7.40 | 4.69 | 6.26 | 26.28 | 13.12 | 19.23 |
| Alabama | 7.61 | 5.06 | 7.10 | 8.22 | 4.99 | 7.16 | 11.33 | 5.52 | 8.09 | 33.77 | 22.87 | 26.53 |
| Georgia | 5.00 | -- | 5.00 | -- | -- | -- | -- | -- | -- | -- | W | W |
| Illinois | 4.00 | 4.01 | 4.00 | 3.78 | 3.72 | 3.74 | 5.33 | 4.53 | 4.92 | 16.30 | 12.72 | 14.64 |
| Indiana | 4.29 | 3.82 | 3.96 | 4.07 | 3.81 | 3.85 | 5.79 | 4.47 | 4.60 | 12.00 | 11.14 | 11.15 |
| Kentucky, total | 4.69 | 3.34 | 4.22 | 4.24 | 3.13 | 3.78 | 6.75 | 4.46 | 5.68 | 21.96 | 12.64 | 17.40 |
| Eastern Kentucky | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 27.03 | 15.24 | 20.79 |
| Western Kentucky | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 13.73 | 10.90 | 12.16 |
| Maryland | 4.54 | 3.32 | 3.74 | 4.02 | 3.43 | 3.63 | 5.25 | 4.87 | 5.01 | 17.97 | 19.44 | 19.38 |
| Ohio | 4.49 | 3.64 | 3.85 | 4.31 | 3.49 | 3.71 | 5.43 | 4.41 | 4.74 | 18.76 | 15.57 | 16.40 |
| Pennsylvania | 6.07 | 3.68 | 5.29 | 5.68 | 3.69 | 5.07 | 8.12 | 5.38 | 7.27 | 30.41 | 19.09 | 25.09 |
| Tennessee | 3.68 | 3.36 | 3.57 | 3.80 | 3.20 | 3.57 | 5.07 | 4.71 | 4.90 | 15.76 | 18.27 | 17.10 |
| West Virginia | 5.14 | 3.66 | 5.02 | 5.00 | 3.64 | 4.87 | 8.07 | 7.06 | 7.93 | 30.60 | 25.52 | 29.35 |

W= Withheld to avoid disclosing individual company data.
N/A= Not available.
Source: U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1960-75 eds.

prices were found in Ohio, western Kentucky and Indiana (Table 17). These differences are explained in large part by differences in coal quality and use. The coals from the eastern PSAs are higher in Btu content and slightly lower in their average sulfur content than coals from the more western PSAs. These are superior coals and command a quality premium on the price. The production of metallurgical coal in Pennsylvania, West Virginia and eastern Kentucky has a positive impact on the average price for coal. Another explanation of state price differentials is the underground/surface production mix. Thus, the states with higher proportions of surface-mined coal, such as western Kentucky and Indiana, had lower average coal prices. Areas such as West Virginia, where underground-mined coal is dominant, had higher average prices.

B-2. Institutional Characteristics

Institutional factors, such as Federal laws or regulations and the unionization of the workforce, impact on coal production. Most of these institutional impacts are negative; that is, they tend to reduce production by increasing mining costs and coal prices.

The most important Federal laws and regulations impacting on the production of coal are:

- The Surface Mining Control and Reclamation Act of 1977
- The Federal Coal Mine Health and Safety Act of 1969 and amendments to this Act passed in 1977
- The Black Lung Benefits Reform Act of 1977
- The Water Pollution Control Act of 1972 and Final Effluent Limitation Guidelines promulgated in 1977
- Federal Coal Leasing policies
- The Clean Air Act and its 1977 amendments.

The Surface Mining Control and Reclamation Act of 1977 was signed by President Carter in August of 1978. The Act superceded state laws governing the protection and reclamation of land subject to surface mining. It establishes minimum performance standards to be met by operators of mines, with primary responsibility of regulation left at the state level. A coal mine operator is now responsible for ensuring that:

- the land is reclaimed to its approximate original contour.
- erosion is controlled, and air and water pollution is minimized.
- topsoil is restored to the area that was mined.
- toxic materials at the site are treated.
- drainage of water is controlled.
- mining impacts on the wildlife and vegetation is minimized.

The mine operators are required to post bonds approximating the costs that third parties would incur if the operators defaulted on reclamation.

The effects of the Act on coal production vary from state to state. The western states already had existing surface mining controls which were as strict as the new Federal Standards. Some eastern areas, such as western Kentucky, where strip mining is prevalent, are exposed to greater impacts since less stringent state laws and enforcement patterns existed previously. On the other hand, for areas such as West Virginia where strict mining laws have been enforced, the effects of the Act will not be substantial.

The Abandoned Mine Reclamation Fund created by this Act provides resources to correct the environmental problems of mines which are no longer in operation and results in cost increases amounting to 35 cents/ton for coal which is produced. Additional increases in the cost of strip-mined coal, due to the performance standards set by this Act, could be substantial. Estimates by TVA indicate that by 1985 costs will increase by $4/ton; other estimates range up to $10/ton, depending on the location.

These added costs will probably severely effect marginal operators. These operators enter the market when the price of coal is high enough to cover the relatively low costs of surface mining and the risk of unproven reserves. They withdraw from the market when the price of coal is low. With the added costs created by the Act, marginal operators require higher prices for coal before they can increase production. As Table 16 shows, eastern Kentucky and West Virginia have the greatest number of small (marginal) surface mines.

The Federal Coal Mine Health and Safety Act of 1969 provides health and safety requirements to be met by coal operators. Unlike the Surface Mining and Reclamation Act, this Act has been in existence for the last decade and has primarily affected underground mining. The effects of health and safety regulations may be an important reason for the decline in underground coal production in the PSAs since 1969, as well as for some of the increase in the price of underground-mined coal between 1970 and 1975 (Table 17). The Act was amended in 1977 to provide for mandatory training programs for all miners. It, thereby, further increased costs.

The Black Lung Benefits Reform Act of 1977 established a trust fund comprised of revenues provided by a tax on surface-mined coal of 25 cents/ton and on underground-mined coal of 50 cents/ton. This Act liberalizes the process by which workers can apply for financial compensation for black lung disabilities. It also provides methods for miners to reapply for benefits that had been denied earlier.

The Water Pollution Control Act Amendment of 1972 and the Effluent Limitation Guidelines published in the Federal Register of September 19, 1977 provide regulations controlling the quality of water discharged from mining areas and preparation plants. Coal is often washed prior to use in order to remove some of the sulfur content. The water used in this process is more acidic after the process. Since the eastern and midwestern coal producing areas of the country have higher levels of sulfur, the cost impact of these water regulations are more strongly felt in these areas. Also, the more rugged areas of the Appalachian mining region will have more difficulty meeting the regulations regarding water control than the less rugged areas.

Federal coal leasing programs have important consequences on the supply of western coal. Much of the land containing substantial deposits of western coal is owned by the Federal government. The Federal government has been slow in leasing land, and some of the leases which have been registered are not being mined because of environmental objections and delays in issuing mining permits. The supply of coal from the western areas will expand only as the Federal government leases land and issues mining permits.

The Clean Air Act and its Amendments of 1977 necessitate the cleaning and preparation of coal before burning. Additionally, the Act impacts on the location of surface mines through regulations on airborne particulate emmissions. Since surface mines generate these particulates, the siting and activities of mines will be controlled by the Act.

Summarizing, the effects of governmental laws and regulations have been to increase mining costs and to reduce mining productivity. In some cases, the effects of these laws and regulations are felt more sharply in some parts of the ORB than in other areas of the Nation.

The impact of industry unionization on coal production differs across mining areas. The extent of unionization varies, both nationally and within the PSAs. States such as West Virginia and Pennsylvania are more highly unionized than Kentucky and Tennessee, while new mining areas in the west and in Texas are not as unionized as the eastern states. Many Appalachian PSAs have a long history of labor unrest which has adversely affected the production of coal in the region. If this should continue, other areas could gain a cost advantage.

## B-3. Technological Characteristics of Coal Production

Coal mining is a mature industry, dating to the early 19th century in the United States. Mining processes are not as radically different as when the industry was young: shafts are dug or overburden is removed, the coal seam is broken down, and the coal is removed. While the general processes are largely unchanged, the machinery utilized in mining has improved gradually. In underground mining, the continuous miner and various roof supporting improvements have increased efficiency. Equipment for surface and auger mining has improved as well. But this later-vintage equipment is only marginally better than earlier equipment; radical departures from traditional mining methods have not occurred.

Future technological breakthroughs in the production of coal probably will pertain to the form of the coal as it is used and not to mining methods. Coal gasification and liquefaction are two possible changes in the technology of the industry. According to DOE sources, perhaps 8 to 10 percent of national coal production will be in the form of synthetics (ie. liquefied or gasified coal) by the year 2000. Essentially, coal will be mined and sent to plants which will transform it into a liquid or a gas. This liquid or gas could then be sent to ultimate consumers via pipeline. Since the conversion plants probably will utilize large amounts of coal, the siting of plants will be near mining areas which can provide substantial production over a number of years.

### B-4. Production Characteristics of Coke

The characteristics of coke production are determined by the chemical and physical properties of metallurgical coal. As discussed earlier, these properties include low ash and low sulfur content as well as a mix of medium and highly volatile coals to achieve an optional blend. The appropriate blend of coals is placed into a coke-oven and is carbonized to form a porous, yet intensive, heat producing substance. There are two types of coke ovens: the beehive oven and the recovery oven. The beehive oven was once prominant in coke production, but it has given way to the recovery-type oven. There is only one beehive oven in the PSAs. It is located in BEA 51 (Bristol). The beehive oven is slightly less efficient than the recovery oven. It requires slightly more metallurgical coal per ton of coke produced, but more importantly it is unable to recover the by-products of the coke-making process. The recovery oven captures the various chemicals of the coke-making process. Industry authorities feel that the most critical problem of the coke industry is the age of the plants. Estimates from the Bureau of Mines indicate that 25-33 percent of the coke ovens in the United States will need to be replaced in the next decade to meet future levels of demand. It should be noted that these estimates of needed replacement are based on rather optimistic forecasts of steel production.

## C. Resource Reserves

Two aspects of coal reserves are of particular interest: the suitability of reserves for surface or underground mining; and the sulfur content of reserves. The latter aspect is of great importance in light of the recent regulations promulgated by EPA.

The coal reserve data presented in the 1975 Bureau of Mines two volume study, The Reserve Base of U.S. Coal by Sulfur Content,[1] is the result of an extensive effort to synthesize all available statistical and analytical coal reserve data in the United States. It sites all potentially minable coal by state, county, coalbed, rank and sulfur content given the political, economic, and physical factors governing the mining areas which were evaluated. The reserve base was also segregated into underground and surface categories. Coal reserves compiled for each category were adjusted to compensate for cumulative production and coal loss to mining, using production statistics from the Bureau of Mines' files. Although the data are considered the most authoritative available data, there are several deficiencies:

- the surveys underlying the data are dated in some cases and do not accurately reflect current knowledge of reserves
- in many cases the data do not take into account site-specific problems which would reduce the amount of coal which is recoverable.
- the data do not provide any information on the heat value of coals.

As a consequence of these deficiencies, many industry researchers assume that 50 percent of the underground demonstrated reserve base is unrecoverable and that 80 percent of the surface demonstrated coal reserve base is unrecoverable. These rules of thumb are, however, subject to debate.

The Bureau of Mines data regarding the demonstrated reserve base used in this study have not be adjusted. However, they are treated as general estimates of the availability of coal resources and not as absolute measures of the coal resources in the PSAs.

## C-1. Coal Reserves in the Primary Study Areas

Estimates of the demonstrated reserve base of coal in the PSAs are given in Tables 18, 19, and 20. Estimates of total reserves of

1. U.S. Department of the Interior, Bureau of Mines, The Reserve Base of U.S. Coals by Sulfur Content (Washington, D.C.: Bureau of Mines, 1975).

Table 1?. Ohio River Basin: Reserves of Coal by Sulfur Content, by BEAs or BEA Segments[a], 1975
(Thousands of tons)

| BEA or BEA Segment | Percent of sulfur content | | | | |
|---|---|---|---|---|---|
| | Below 1.5 | 1.5 - 3.0 | Above 3.0 | Unknown | Total |
| Primary Study Areas | 33,483,180 | 38,050,810 | 45,526,170 | 21,367,980 | 138,428,140 |
| BEA 47: Huntsville, AL | -- | -- | -- | -- | -- |
| BEA 48: Chattanooga, TN | 75,600 | 102,300 | 16,370 | 45,910 | 240,180 |
| BEA 49: Nashville, TN | 1,090 | 27,280 | 50,110 | 306,800 | 385,280 |
| BEA 50: Knoxville, TN | 1,989,000 | 456,250 | 227,850 | 412,700 | 3,085,800 |
| BEA 51: Bristol, VA | 4,005,420 | 418,740 | 14,090 | 371,650 | 4,809,900 |
| BEA 52: Huntington, WV | 18,558,690 | 4,564,790 | 1,490,590 | 3,696,970 | 28,311,040 |
| BEA 53: Lexington, KY | 3,284,070 | 652,840 | 108,630 | 1,038,400 | 5,083,940 |
| BEA 54: Louisville, KY | -- | -- | -- | 12,630 | 12,630 |
| BEA 55: Evansville, IN | 275,250 | 2,816,450 | 15,588,380 | 8,856,540 | 27,536,620 |
| BEA 62: Cincinnati, OH | -- | -- | -- | -- | -- |
| BEA 64: Columbus, OH | 394,860 | 2,349,810 | 3,778,050 | 679,770 | 7,202,490 |
| BEA 65: Clarksburg, WV | 1,481,880 | 4,284,250 | 1,879,620 | 1,364,950 | 9,010,700 |
| BEA 66: Pittsburgh, PA | 2,963,520 | 16,308,900 | 11,713,480 | 4,190,160 | 35,176,060 |
| BEA 68: Cleveland, OH | 453,800 | 6,069,200 | 10,659,000 | 370,600 | 17,531,700 |
| BEA 115: Paducah, KY | -- | -- | -- | -- | -- |

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.
Source: U.S. Department of the Interior, Bureau of Mines, The Reserve Base of U.S. Coals by Sulfur Content, May 1975.

Table 19. Ohio River Basin: Surface Reserves of Coal by Sulfur Content, by BEAs or BEA Segments[a], 1975

(Thousands of tons)

| BEA or BEA segment | Percent of sulfur content: Below 1.5 | 1.5-3.0 | Above 3.0 | Unknown | Total |
|---|---|---|---|---|---|
| Primary Study Areas | 5,947,320 | 3,381,700 | 6,142,910 | 3,461,020 | 18,932,950 |
| BEA 47: Huntsville, AL | -- | -- | -- | -- | -- |
| BEA 48: Chattanooga, TN | 24,650 | 32,160 | 5,590 | 23,500 | 85,900 |
| BEA 49: Nashville, TN | 1,090 | 23,570 | 22,930 | 284,230 | 331,820 |
| BEA 50: Knoxville, TN | 519,370 | 140,490 | 77,670 | 116,990 | 854,520 |
| BEA 51: Bristol, VA | 324,490 | 13,530 | -- | 10,850 | 348,870 |
| BEA 52: Huntington, WV | 3,606,180 | 682,970 | 310,870 | 935,990 | 5,536,010 |
| BEA 53: Lexington, KY | 1,016,840 | 245,510 | 34,840 | 264,130 | 1,561,320 |
| BEA 54: Louisville, KY | -- | -- | -- | 12,460 | 12,460 |
| BEA 55: Evansville, IN | 72,430 | 458,330 | 3,017,400 | 1,505,210 | 5,053,370 |
| BEA 62: Cincinnati, OH | -- | -- | -- | -- | -- |
| BEA 64: Columbus, OH | 33,260 | 280,290 | 1,079,740 | 69,360 | 1,462,650 |
| BEA 65: Clarksburg, WV | 149,980 | 324,350 | 155,150 | 83,320 | 712,800 |
| BEA 66: Pittsburgh, PA | 181,280 | 928,690 | 692,730 | 111,530 | 1,914,230 |
| BEA 68: Cleveland, OH | 17,750 | 251,810 | 745,990 | 43,450 | 1,059,000 |
| BEA 115: Paducah, KY | -- | -- | -- | -- | -- |

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.
Source: U.S. Department of the Interior, Bureau of Mines, The Reserve Base of U.S. Coals by Sulfur Content, May 1975.

Table 22. Ohio River Basin: Deep Reserves of Coal by Sulfur Content, by BEAs or BEA Segments[a], 1975

(Thousands of tons)

| BEA or BEA segment | | Below 1.5 | 1.5-3.0 | Above 3.0 | Unknown | Total |
|---|---|---|---|---|---|---|
| | | Percent of sulfur content | | | | |
| Primary Study Areas | | 24,604,680 | 30,300,800 | 32,601,280 | 17,445,890 | 104,952,652 |
| BEA 47: | Huntsville, AL | -- | -- | -- | -- | -- |
| BEA 48: | Chattanooga, TN | 50,950 | 70,140 | 10,780 | 22,410 | 154,280 |
| BEA 49: | Nashville, TN | -- | 3,710 | 27,180 | 22,570 | 53,460 |
| BEA 50: | Knoxville, TN | 1,469,630 | 315,760 | 150,180 | 295,710 | 2,231,280 |
| BEA 51: | Bristol, VA | 826,340 | 8,690 | -- | 115,970 | 951,000 |
| BEA 52: | Huntington, WV | 14,952,510 | 3,881,820 | 1,179,720 | 2,760,980 | 22,775,030 |
| BEA 53: | Lexington, KY | 2,267,230 | 407,330 | 73,790 | 774,270 | 3,522,620 |
| BEA 54: | Louisville, KY | -- | -- | -- | 170 | 170 |
| BEA 55: | Evansville, IN | 202,820 | 2,358,120 | 12,570,960 | 7,351,330 | 22,483,250 |
| BEA 62: | Cincinnati, OH | -- | -- | -- | -- | -- |
| BEA 64: | Columbus, OH | 361,600 | 2,069,520 | 2,698,310 | 610,410 | 5,739,840 |
| BEA 65: | Clarksburg, WV | 1,331,900 | 3,959,900 | 1,724,470 | 1,281,630 | 8,297,900 |
| BEA 66: | Pittsburgh, PA | 2,782,240 | 15,380,210 | 11,020,750 | 4,078,630 | 33,261,830 |
| BEA 68: | Cleveland, OH | 359,460 | 1,845,600 | 3,145,120 | 131,810 | 5,481,990 |
| BEA 115: | Paducah, KY | -- | -- | -- | -- | -- |

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.
Source: U.S. Department of the Interior, Bureau of Mines, The Reserve Base of U.S. Coals by Sulfur Content, May 1975.

coal are shown in Table 18. BEAs 66 (Pittsburgh), 52 (Huntington), and 55 (Evansville) account for over 65 percent of the total coal reserves in the PSAs. Together, these three areas contain more than 90 billion tons of coal, enough to supply the United States for over a hundred years at present rates of national consumption. Virtually no coal is found in BEAs 62 (Cincinnati) and 54 (Louisville), while relatively modest reserves are located in southern PSAs such as BEA 47 (Huntsville) and BEA 48 (Chattanooga).

The total reserves in the PSAs amount to more than 138 billion tons of coal, of which only 33.5 billion tons are considered to be low sulfur reserves. Most of these low sulfur reserves are in BEA 52 (Huntington), which includes much of central and southern West Virginia and eastern Kentucky. Many researchers regard this coal as the best quality coal in the world. It is low in sulfur and ash and has medium to high Btu content. Much of it is metallurgical grade but can also be used by utilities.

C-2. Low Sulfur
Coal Reserves

ORB reserves of coal in the middle range of sulfur content (1.5-3.0 percent sulfur) lie predominantly in BEAs 66 (Pittsburgh), 65 (Clarksburg) and 52 (Huntington). These BEAs cover the rich Pittsburgh seam in southwestern Pennsylvania, as well as the mining areas in northern West Virginia and most of the central and southern parts of the state.

Concentrations of coal in the higher sulfur ranges tend to be in areas such as BEAs 55 (Evansville) and 68 (Cleveland). The reserves in BEA 55 are a portion of the western Kentucky reserves, most of which are higher in sulfur than the coals in the mountains of eastern Kentucky. BEA 68 (Cleveland) includes the mining areas of east central Ohio. This area has some of the highest sulfur coal in the PSAs. Since the sulfur content of coal is especially high in Ohio, state officials are quite concerned about the EPA sulfur dioxide emissions level standards. If scrubbers become mandatory, then Ohio coal might still be burned. If not, then the future of the Ohio coal industry will be in question.

C-3. Deep and Shallow
Coal Reserves

The reserves suitable for underground mining in the PSAs greatly exceed the reserves suitable for surface mining. The underground reserves of coal amount to 117.8 billion tons, while surface reserves only amount to 22.5 billion tons (Tables 19 and 20). These surface reserves were defined before the Surface Mine and Reclamation Act of 1977 which removed some reserves from potential production. Areas with particularly large reserves are also areas where production is greatest: BEAs 66 (Pittsburgh), 52 (Huntington), and 55 (Evansville). BEAs 52 (Huntington) and 55 (Evansville) contain nearly half of the reserves suitable for surface mining in the PSAs.

## D. Existing Production Levels

Total coal production in the PSAs in 1976 reached nearly 437 million tons, over 64 percent of the national production of 678 million tons. Of these 437 million tons, 245 million tons were underground-mined coal, while 192 million tons of coal were produced through surface and auger methods. Overall underground production decreased at a rate of 2.17 percent annually during the historical period 1969-76 with many individual PSAs experiencing declines in production. Surface mining output increased at a rate of 5.35 percent during the period. All but one of the PSAs increased its output of surface-mined coal.

### D-1. Total Coal Production in the PSAs, 1969-76

Coal production of the PSAs is dispersed among all but two of the PSAs, yet three BEAs, [BEAs 66, (Pittsburgh), 52 (Huntington) and 55 (Evansville)] accounted for 63 percent of 1976 production in the PSAs.

BEA 66 (Pittsburgh) produced more than 104 million tons of coal in 1976 (Table 21). The area encompassed by this PSA includes the major coal seams in southwestern Pennsylvania, the West Virginia panhandle, and the producing areas of southeastern Ohio. BEA 66 accounted for nearly one fourth of all coal produced in the PSAs and is a major origin for waterway movements of coal, for its mining areas are served by the Allegheny, Monongahela, and Ohio Rivers. During the period 1969-76, total coal production in BEA 66 decreased slightly at a rate of 0.6 percent annually. This decrease was caused by lower demand for metallurgical coal, by the impacts of government regulations on underground mining and on labor/management disputes, and by environmental factors. Metallurgical grade coal deposits in the southern areas of this BEA are generally shipped by rail to Pittsburgh, Cleveland and to steel centers in BEA 52 (Huntington).

Table 21. Ohio River Basin: Total Coal Production by BEAs or BEA Segments[a], 1969-76
(Thousands of tons unless otherwise specified)

| BEA or BEA segment | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | Average annual percentage change |
|---|---|---|---|---|---|---|---|---|---|
| Primary Study Areas | 419,206 | 446,265 | 397,707 | 418,883 | 411,747 | 406,863 | 429,228 | 436,998 | 0.60 |
| BEA 47: Huntsville, AL | -- | -- | 21 | 20 | -- | -- | 150 | 203 | b |
| BEA 48: Chattanooga, TN | 1,374 | 2,254 | 2,321 | 2,591 | 1,596 | 1,753 | 1,506 | 2,452 | 8.63 |
| BEA 49: Nashville, TN | 556 | 935 | 1,612 | 875 | 618 | 688 | 1,109 | 1,395 | 14.04 |
| BEA 50: Knoxville, TN | 17,679 | 19,836 | 23,708 | 24,837 | 24,946 | 25,928 | 29,126 | 26,671 | 6.05 |
| BEA 51: Bristol, VA | 53,345 | 52,567 | 44,839 | 49,025 | 47,810 | 45,849 | 47,343 | 51,265 | (0.57) |
| BEA 52: Huntington, WV | 102,752 | 109,052 | 91,776 | 92,232 | 91,228 | 90,733 | 91,891 | 97,813 | (0.70) |
| BEA 53: Lexington, KY | 21,051 | 26,734 | 25,484 | 22,951 | 26,338 | 27,638 | 31,727 | 33,829 | 7.01 |
| BEA 54: Louisville, KY | -- | -- | -- | -- | -- | -- | 40 | 11 | b |
| BEA 55: Evansville, IN | 65,182 | 70,363 | 63,992 | 72,659 | 73,066 | 71,100 | 76,452 | 73,564 | 1.74 |
| BEA 62: Cincinnati, OH | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| BEA 64: Columbus, OH | 11,318 | 13,825 | 13,048 | 12,465 | 10,646 | 11,328 | 11,918 | 13,345 | 2.38 |
| BEA 65: Clarksburg, WV | 36,595 | 37,457 | 32,279 | 33,211 | 30,773 | 29,227 | 31,388 | 30,367 | (2.63) |
| BEA 66: Pittsburgh, PA | 107,811 | 111,536 | 97,046 | 106,559 | 103,611 | 101,629 | 105,564 | 104,777 | (0.41) |
| BEA 68: Cleveland, OH | 1,523 | 1,690 | 1,565 | 1,451 | 1,110 | 980 | 1,013 | 1,306 | (2.17) |
| BEA 115: Paducah, KY | 20 | 16 | 16 | 7 | 5 | 5 | 1 | -- | b |

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.
b. No production in 1969 and/or 1976.
Source: U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1969-75 eds. Totals for 1976 from: Alabama Department of Industrial Relations, Annual Statistical Report, 1975-76 eds.; Tennessee Department of Labor, Annual Report, 1976 ed., Kentucky Department of Mines and Minerals, Annual Report, 1976 ed.; West Virginia Department of Mines, Annual Report and Directory of Mines, 1976 ed.; Ohio Department of Industrial Relations, Division of Mines Report, 1976 ed.; Pennsylvania Geological Survey, Bituminous Coal Region Report, 1976 ed.; Illinois Department of Mines and Minerals, Annual Coal, Oil and Gas Report, 1977 ed.; Indiana Geological Survey, Coal Production, 1976 ed.; Maryland Bureau of Mines, Annual Report, 1976 ed.; and correspondence with the Georgia Department of Natural Resources.

BEA 55 (Evansville) had coal production totalling 73.6 million tons in 1976, based on average annual increases of 1.7 percent between 1969 and 1976. This BEA, which includes most of the mining areas of western Kentucky and some of the producing counties in southern Indiana, is the only major producing area which has more surface coal production than underground production. As a consequence, the impact of the laws governing underground mining have not greatly affected BEA 55's production levels. This area, like BEA 66 (Pittsburgh), has substantial waterborne movements of coal because of the accessibility of mining areas to either the Green or Ohio Rivers.

Other producing PSAs are listed in Table 21, along with their production levels and growth rates. Many of these areas suffered some production loss during the period 1969-76. BEAs 48 (Chattanooga), 49 (Nashville), 50 (Knoxville), 53 (Lexington) and 64 (Columbus) experienced production increases, however. Some of these BEAs experienced substantial rates of growth. In the recent past, however, these areas have been smaller producing areas relative to other PSAs and moderate absolute production increases have resulted in large growth rates. The major off-river area, BEA 51 (Bristol), had relatively large surface production increases during this period. Similar to other areas, it experienced decreases in underground mine production.

D-2. Underground and Surface Coal Production, 1969-76

Between 1969 and 1976, underground production in the PSAs remained relatively stable while surface production increased at a rate of 5.35 percent annually (Tables 22 and 23).

Historically, underground coal production has predominated in the PSAs, as Tables 22 and 23 illustrate, although the relative importance of surface mining has been increasing over time. In 1969, surface mining accounted for 31.7 precent of total ORB coal production. By 1976, the share attributable to surface mining had increased to 43.8 percent of total production. This trend was due to the relatively higher margins of profit on surface-mined coal. There is some doubt, however, of this trend continuing. The Surface Mine and Reclamation Act of 1977 is likely to make surface mining more costly in the future. Relative to underground mining, surface mining will probably remain the least costly mining operation. However, the overall effect of this Act should be a reduction in the cost spread between surface and underground mining.

Table 22. Ohio River Basin: Surface and Auger Coal Production by BEAs or BEA Segments[a], 1969-76
(Thousands of tons unless otherwise specified)

| BEA and BEA segment | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | Average annual percentage change |
|---|---|---|---|---|---|---|---|---|---|
| Primary Study Areas | 132,980 | 162,020 | 165,751 | 163,842 | 163 258 | 177,907 | 188,111 | 191,560 | 5.35 |
| BEA 47: Huntsville, AL | -- | -- | 21 | 20 | -- | -- | 15 | 203 | b |
| BEA 48: Chattanooga, TN | 453 | 1,325 | 1,559 | 1,759 | 1,032 | 982 | 705 | 1,290 | 16.13 |
| BEA 49: Nashville, TN | 431 | 786 | 1,439 | 438 | 429 | 546 | 991 | 1,197 | 15.62 |
| BEA 50: Knoxville, TN | 5,783 | 7,945 | 11,806 | 9,954 | 11,049 | 13,061 | 14,960 | 13,290 | 12.62 |
| BEA 51: Bristol, VA | 6,807 | 8,371 | 10,129 | 10,987 | 11,269 | 11,963 | 13,115 | 14,907 | 11.85 |
| BEA 52: Huntington, WV | 19,349 | 27,641 | 25,949 | 22,293 | 22,016 | 27,328 | 25,108 | 30,326 | 6.63 |
| BEA 53: Lexington, KY | 10,836 | 13,614 | 13,734 | 13,326 | 15,821 | 16,421 | 21,123 | 23,174 | 11.47 |
| BEA 54: Louisville, KY | -- | -- | -- | -- | -- | -- | 40 | 11 | b |
| BEA 55: Evansville, IN | 42,881 | 46,729 | 43,539 | 50,167 | 47,161 | 45,595 | 49,012 | 44,974 | 0.68 |
| BEA 62: Cincinnati, OH | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| BEA 64: Columbus, OH | 8,567 | 11,103 | 10,978 | 9,559 | 8,242 | 9,288 | 9,188 | 10,677 | 3.20 |
| BEA 65: Clarksburg, WV | 5,695 | 7,816 | 8,118 | 7,662 | 8,187 | 9,240 | 9,272 | 7,835 | 4.66 |
| BEA 66: Pittsburgh, PA | 30,680 | 35,045 | 37,023 | 36,248 | 36,971 | 42,546 | 43,607 | 42,456 | 4.75 |
| BEA 68: Cleveland, OH | 1,478 | 1,629 | 1,440 | 1,422 | 1,076 | 932 | 974 | 1,220 | (2.70) |
| BEA 115: Paducah, KY | 20 | 16 | 16 | 7 | 5 | 5 | 1 | -- | b |

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.
b. No production in 1969 and/or 1976.
Source: U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1969-75 eds. Totals for 1976 from: Alabama Department of Industrial Relations, Annual Statistical Report, 1975-76 eds.; Tennessee Department of Labor, Annual Report, 1976 ed.; Kentucky Department of Mines and Minerals, Annual Report, 1976 ed.; West Virginia Department of Mines, Annual Report and Directory of Mines, 1976 ed.; Ohio Department of Industrial Relations, Division of Mines Report, 1976 ed.; Pennsylvania Geological Survey, Bituminous Coal Region Report, 1976 ed.; Illinois Department of Mines and Minerals, Annual Coal, Oil and Gas Report, 1977 ed.; Indiana Geological Survey, Coal Production, 1976 ed.; Maryland Bureau of Mines, Annual Report, 1976 ed.; and correspondence with the Georgia Department of Natural Resources.

Table 23. Ohio River Basin: Underground Coal Production by BEAs or BEA Segments[a], 1969-76
(Thousands of tons unless otherwise specified)

| BEA or BEA segment | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | Average annual percentage change |
|---|---|---|---|---|---|---|---|---|---|
| Primary Study Areas | 286,226 | 284,245 | 231,956 | 255,041 | 248,489 | 228,646 | 241,029 | 245,437 | (2.17) |
| BEA 47: Huntsville, AL | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| BEA 48: Chattanooga, TN | 921 | 929 | 762 | 832 | 564 | 771 | 801 | 1,162 | 3.38 |
| BEA 49: Nashville, TN | 125 | 149 | 173 | 437 | 189 | 142 | 118 | 198 | 6.79 |
| BEA 50: Knoxville, TN | 11,896 | 11,891 | 11,902 | 14,883 | 13,897 | 11,867 | 14,166 | 13,381 | 1.69 |
| BEA 51: Bristol, VA | 46,538 | 44,196 | 34,710 | 38,038 | 36,541 | 33,576 | 34,228 | 36,357 | (3.47) |
| BEA 52: Huntington, WV | 83,403 | 81,411 | 65,827 | 69,939 | 69,212 | 63,410 | 66,830 | 67,487 | (2.98) |
| BEA 53: Lexington, KY | 10,215 | 13,120 | 11,750 | 9,625 | 10,517 | 11,217 | 10,604 | 10,655 | 0.60 |
| BEA 54: Louisville, KY | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| BEA 55: Evansville, IN | 22,301 | 23,634 | 20,453 | 22,492 | 25,905 | 25,505 | 27,440 | 28,590 | 3.61 |
| BEA 62: Cincinnati, OH | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| BEA 64: Columbus, OH | 2,751 | 2,722 | 2,070 | 2,906 | 2,404 | 2,040 | 2,730 | 2,668 | (0.44) |
| BEA 65: Clarksburg, WV | 30,900 | 29,641 | 24,161 | 25,549 | 22,586 | 19,987 | 22,116 | 22,532 | (4.41) |
| BEA 66: Pittsburgh, PA | 77,131 | 76,491 | 60,023 | 70,311 | 66,640 | 59,083 | 61,957 | 62,321 | (3.00) |
| BEA 68: Cleveland, OH | 45 | 61 | 125 | 29 | 34 | 48 | 39 | 86 | 9.69 |
| BEA 115: Paducah, KY | -- | -- | -- | -- | -- | -- | -- | -- | -- |

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.
Source: U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1969-75 eds. Totals for 1976 from: Alabama Department of Industrial Relations, Annual Statistical Report, 1975-76 eds.; Tennessee Department of Labor, Annual Report, 1976 ed.; Kentucky Department of Mines and Minerals, Annual Report, 1976 ed.; West Virginia Department of Mines, Annual Report and Directory of Mines, 1976 ed.; Ohio Department of Industrial Relations, Division of Mines Report, 1976 ed.; Pennsylvania Geological Survey, Bituminous Coal Region Report, 1976 ed.; Illinois Department of Mines and Minerals, Annual Coal, Oil and Gas Report, 1977 ed.; Indiana Geological Survey, Coal Production, 1976 ed.; Maryland Bureau of Mines, Annual Report, 1976 ed.; and correspondence with the Georgia Department of Natural Resources.

D-3. Metallurgical Coal Production, 1969-75

Production of metallurgical grade coal in the PSAs during the period 1969-75 decreased at a rate of 1.18 percent annually. Total production fell from nearly 75 million tons in 1969 to nearly 70 million tons in 1975 (Table 24).

Between 1969 and 1975, a locational shift in production occurred. Production decreased dramatically in BEAs 55 (Evansville) and 65 (Clarksburg). These BEAs mine metallurgical coal with a relatively high sulfur content. Increased production in BEAs 50 (Knoxville) and 53 (Lexington) offset this decrease.

BEAs 66 (Pittsburgh) and 52 (Huntington) were the largest producers of metallurgical grade coal. Together, they accounted for 49.4 million tons or 70.8 percent of all PSA production in 1975. The only other large producer of metallurgical coal was BEA 51 (Bristol) which accounted for 16.5 percent of production in 1975.

## E. Forecasting Procedures and Assumptions

As in the case of coal consumption, the basis for the 1976-90 projections of coal production was the DOE Annual Report to Congress[1] of 1977. Projections of coal production beyond 1990 were based on projections developed from the Coal and Electric Utility Model of ICF, Inc.,[2] and on the best judgments of industrial authorities and experts. Disaggregations of the DOE and ICF, Inc. projections were based on historical shares of production in each PSA.

E-1. National Projections of Coal Production, 1980-2040

Total coal production in the United States was projected by DOE to be 1.257 billion tons in 1990. This projection is disaggregated into twelve geographic regions of production based on

1. U.S. Department of Energy, Annual Report to the Congress, 1977 ed. Appendix to Vol. II (Washington, D.C.: GPO, 1977).
2. Energy Modeling Forum, Stanford University, Institute for Energy Studies, Coal in Transition: 1980-2000, (Stanford, CA: EMF, 1978), Vols. I and II.

Table 24. Ohio River Basin: Production of Metallurgical Coal by BEAs or BEA Segments[a] 1969-75

(Thousands of tons unless otherwise specified)

| BEA or BEA Segment | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | Average annual percentage change |
|---|---|---|---|---|---|---|---|---|
| Primary Study Areas | 74,949 | 75,167 | 62,905 | 71,177 | 72,969 | 68,994 | 69,817 | (1.18) |
| BEA 48: Chattanooga, TN | -- | -- | 108 | -- | -- | -- | 108 | b |
| BEA 50: Knoxville, TN | 3,199 | 3,560 | 3,919 | 4,587 | 4,511 | 4,350 | 5,252 | 8.61 |
| BEA 51: Bristol, VA | 16,452 | 15,591 | 11,890 | 13,871 | 13,001 | 11,571 | 11,494 | (5.80) |
| BEA 52: Huntington, WV | 24,398 | 23,224 | 19,872 | 25,028 | 27,071 | 24,629 | 24,716 | 0.22 |
| BEA 53: Lexington, KY | 1,957 | 2,791 | 2,568 | 2,837 | 3,382 | 3,624 | 2,549 | 4.50 |
| BEA 55: Evansville, IN | 242 | 234 | 373 | 125 | 85 | 157 | 117 | (11.41) |
| BEA 65: Clarksburg, WV | 2,592 | 2,179 | 1,590 | 1,310 | 934 | 505 | 871 | (16.61) |
| BEA 66: Pittsburgh, PA | 26,109 | 27,588 | 22,580 | 23,419 | 23,985 | 24,158 | 24,710 | (0.91) |

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.
b. No production in 1969.
Source: U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1969-75 eds.

Bureau of Mines coal supply districts. The PSAs overlap portions of four of these regions: Northern Appalachia, Central Appalachia, Southern Appalachia and the Midwest. Production of coal in 1990 in these regions was projected by DOE to be 213.2, 270.2, 18.8 and 243.8 million tons, respectively. Total eastern coal production in 1990, according to DOE, will be 745 million tons. Coal production in 1980 was projected from DOE estimates by interpolation of the 1976 estimates and the DOE 1990 projections. These projections were based on the same assumptions as the coal consumption estimates. Section II, E-1 of this report contains the major assumptions underlying these projections. All assumptions are documented in the Annual Report to Congress.

Projections for the production of coal beyond 1990 have been based on the ICF, Inc. Coal and Electric Utility Model projections. The ICF model is the most recent attempt to provide a comprehensive set of projections for the supply and demand of coal to the year 2000. The ICF model is a regional linear programming model developed for the Federal Energy Administration. Coal supply is disaggregated into 30 supply regions. Supply curves consider the capacity of existing mines, surge production and the possibility of opening new mines. Demand for coal is disaggregated into 35 demand regions. Estimates of demand for coal consider electric demands and inter-fuel substitution.

Since DOE and ICF, Inc. 1990 projections model differ in their geographic disaggregations, the 1990 DOE estimates were projected to 2000 by using the ICF growth rate of eastern coal production between 1990 and 2000. During this period, ICF, Inc., projected coal production to increase at 2 percent per year.

For the period beyond the year 2000 no satisfactory existing projections are available. Based on discussions with industry authorities and researchers of the coal industry, a growth rate of one percent per year has been assumed for the eastern United States for the period 2000-2040. This projection is based on the assumption that alternative sources of energy will become increasingly available, particularly solar power for heating, cooling, and electricity generation. Since adaptation to new forms of energy will be a slow process, it is judged that the rate of increase in coal production will diminish slowly. Another rationale for the lower growth rate after 2000 is an anticipated increase in the production of western coal. Western coal production will be less costly than eastern coal production. It it is expected that western coal will begin to replace eastern coal in some of the traditional markets, such as the Midwest, which are presently supplied with eastern coal. Most western coal will be transported to the Midwest via rail.

### E-2. Disaggregation of National Projections, 1980-2040

The DOE regional projections of coal production were disaggregated further to develop BEA estimates. First, the counties in the PSAs were aggregated into mining districts corresponding to the Bureau of Mines delineation of producing districts. Production of coal in these counties was then calculated as a share of the Bureau of Mines district production totals. These county groups were then aggregated into DOE production regions (a grouping of Bureau of Mines districts), and the new aggregated shares were applied to the 1990 regional production figures. This process yielded each BEA's share of a region's production in 1990.

The implicit assumption in this process was that each BEA's share of regional total production in 1976 would remain the same in 1990. For instance, BEA 66 (Pittsburgh) would have the same share of Northern Appalachia production in 1990 as in 1976. Since the DOE regional projections captured the changing regional locational pattern of production in the future, the use of a constant share assumption would still capture this changing pattern.

As described earlier, 1980 estimates were obtained by interpolation. This interpolation was performed for each BEA in the study area to determine 1980 production. The assumption underlying this methodology is that the growth rates in production would be equal for the periods 1976-80 and 1980-90.

Since the growth rate in eastern coal production was used, rather than actual tonnages projected by the ICF, Inc. model, the rate was applied to each BEA for the period 1900-2000, and one-half of that growth rate was applied for the period 2000-2040.

## F. Probable Future Production Levels

Production of coal in the PSAs is projected to grow at a rate of 2.6 percent annually during the period 1976-90 and at 1.5 percent annually for the entire projection period 1976-2040 (Table 25). This compares with an annual growth rate of 0.6 during the period 1969-76. The increased production rates are due to the increased level of demand for coal and to the limited ability of western coal to make inroads into the market areas of the PSAs prior to 2000. Production within the PSAs will increase from 437

Table 25. Ohio River Basin: Coal Production by BEAs or BEA Segments[a], Estimated 1976 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

| BEA and BEA segment | Estimated 1976 | Projected 1980 | 1990 | 2000 | 2020 | 2040 | Average annual percentage change 1976-90 | 1976-2040 |
|---|---|---|---|---|---|---|---|---|
| Primary Study Areas | 436,[illegible].0 | 431,431.0 | 627,200.0 | 763,547.8 | 931,672.6 | 1,136,818.3 | 2.61 | 1.51 |
| BEA 47: Huntsville, AL | [illegible] | 200.0 | 200.0 | 243.5 | 297.1 | 362.5 | (0.11) | 0.91 |
| BEA 48: Chattanooga, TN | 2,4[illegible].0 | 2,572.9 | 2,900.0 | 3,530.4 | 4,307.8 | 5,256.3 | 1.21 | 1.20 |
| BEA 49: Nashville, TN | 1,[illegible].0 | 1,609.5 | 2,300.0 | 2,800.0 | 3,416.5 | 4,168.8 | 3.64 | 1.73 |
| BEA 50: Knoxville, TN | 26,671.0 | 2[illegible],577.9 | 38,300.0 | 46,626.1 | 56,892.6 | 69,419.9 | 2.62 | 1.51 |
| BEA 51: Bristol, VA | 51,265.0 | 54,747.3 | 73,200.0 | [illegible] | 10[illegible],734.7 | 132,677.1 | 2.58 | 1.50 |
| BEA 52: Huntington, WV | 97,813.0 | 111,982.6 | 157,000.0 | 191,130.4 | 23[illegible],215.2 | 284,567.1 | 3.44 | 1.68 |
| BEA 53: Lexington, KY | 33,829.0 | 37,501.4 | 48,5[illegible] | 59,[illegible] | 72,[illegible].2 | 87,907.7 | 2.61 | 1.50 |
| BEA 54: Louisville, KY | 11.0 | -- | -- | -- | -- | -- | b | b |
| BEA 55: Evansville, IN | 73,564.0 | 85,927.1 | 126,700.0 | 154,243.[illegible] | [illegible],2[illegible].2 | 229,647.4 | 3.96 | 1.79 |
| BEA [illegible]: Cincinnati, OH | -- | -- | -- | -- | -- | -- | -- | -- |
| BEA [illegible]: Columbus, OH | 13,345.0 | 14,052.6 | 16,[illegible] | [illegible] | [illegible],767.2 | 29,000.5 | 1.30 | 1.22 |
| BEA [illegible]: Clarksburg, WV | 30,367.0 | 32,999.3 | 40,[illegible] | [illegible] | [illegible].2 | 73,588.7 | 2.10 | 1.39 |
| BEA [illegible]: Pittsburgh, PA | 134,777.0 | 105,901.9 | 120,[illegible] | [illegible] | [illegible].7 | 217,503.5 | 0.97 | 1.15 |
| BEA 64: Cleveland, OH | 1,306.0 | 1,358.5 | 1,5[illegible] | [illegible] | [illegible].2 | 2,718.8 | 0.99 | 1.15 |
| BEA 111: Paducah, KY | -- | -- | -- | -- | -- | -- | -- | -- |

Notes: Tonnages for 1980 derived by interpolation of 1976-90 area and BEA segment growth rates. Tonnages for 1976 [illegible] Table a1. Tonnages for 1990 were derived from Department of Energy projections. DOE projections of production [illegible] on the basis of 12 supply regions. BEA shares of these 12 supply region projections were based on the BEA [illegible] production from these regions in 1976. The shares from 1976 were applied to the 1990 regional production [illegible]. Tonnages for the year 2000 obtained by applying the ICF reference case 1990-2000 growth rate in Appalachian [illegible] to the tonnages for 1990. Growth rate for 2000-2040 assumed to be one-half the two percent ICF 1990-[illegible] growth rate.

[a] BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

[b] [illegible] production in 1976.

[illegible]: U.S. Department of Energy, "Appendix" Annual Report to Congress, 1977 [illegible], Vol. II.; ICF Inc., "Summary of [illegible] Coal and Electric Utility Model for the Energy Modeling Forum," Coal in Transition, 1978 ed.

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million tons in 1976 to 627 million tons in 1990. Production in the United States is projected by DOE to be 1.1 billion tons in 1990. Beyond 1990, production will increase from 627 million tons in 1990 to 1.1 billion tons in the year 2040.

In the PSAs, production will increase faster in the central areas, in BEAs 52 (Huntington), 51 (Bristol), 50 (Knoxville), and 49 (Nashville). Another area of large production increases will be BEA 55 ((Evansville). The more mature mining PSAs, such as BEAs 68 (Cleveland), 66 (Pittsburgh), 65 (Clarksburg), and 64 (Columbus), will experience slower growth in production.

The higher rate of growth in the central areas of the ORS hinterland is due to the high quality coal reserves in these areas. The reserves in BEAs 52 (Huntington), 51 (Bristol) and 50 (Knoxville) are more likely to be lower in sulfur and higher in Btu content than the reserves in other areas. By 1980, production should increase in BEA 52 (Huntington) allowing this BEA to surpass BEA 66 (Pittsburgh) as the largest producing PSA.

In terms of the relationship between production levels in the future and waterway flows, two of the areas which generate substantial shipments of waterborne coal are in the higher growth range. BEAs 52 (Huntington), 55 (Evansville) and 66 (Pittsburgh) generate the greatest amounts of waterborne coal traffic and BEAs 52 and 55 are expected to have relatively large production increases which will generate additional waterway traffic. BEA 66 will have a more modest growth in production. As a consequence, it will not generate large increases in waterway traffic.

Because of the assumptions underlying projections beyond 1990, increases in production will be moderate. Lower rates of growth will be the rule, with BEAs 55 (Evansville), 52 (Huntington) and 49 (Nashville) having relatively high growth rates. Table 25 provides further detail on the individual projections of PSA coal production in the future.

The lack of existing projections of regional coal production beyond 1990 necessitates the use of informed, expert judgement to project into the future. This is the best manner of handling this issue until further research is conducted in this area.

# IV. TRANSPORTATION CHARACTERISTICS

The movements of bituminous coal and lignite in the United States in 1976, by mode of transportation, are shown in Table 26. The bulk of coal was shipped by rail, accounting for 54 percent of total coal tonnage. Waterway tonnage totalled 107.5 million tons in 1976, which was 17.5 percent of total receipts. Other modes of transportation by which coal was moved included truck, Great Lakes carriers, tidewater movements, and tramways and private railroads.

## A. Existing Modal Split in the PSAs

Because of inadequate data, total shipments and receipts of coal and coke cannot be determined for the PSAs. While both rail and water data are available, there is no source of adequate data to determine inbound and outbound truck movements. The determination of total shipments and receipts requires the summation of movements by all modes. While it is not possible to establish the existing modal split of total ORS coal and coke movements, it is possible to develop judgments about the modal split on the basis of available water and rail data and on the basis of net shipments and receipts implied by the consumption and production estimates made for each PSA. Such data provide an estimate of net truck movements, and information available from shippers and receivers of coal, and from government agencies, permits analysis of truck transportation.

Most PSAs are both producers and consumers of coal. Notable exceptions are BEAs 62 (Cincinnati) and 115 (Paducah) which do not produce coal, and BEA 68 (Cleveland) which did not consume coal in 1976 (Table 27).

An important factor affecting the transportation of ORS coal is that the PSAs, as a unit, are net shippers of coal, and most of

Table 26 . United States: Bituminous Coal and Lignite Production, by Mode of Transportation, 1976

(Thousands of tons)

| Mode of transportation | Tonnage |
|---|---|
| Total, all modes[a] | 613,075 |
| Rail | 331,048 |
| River and ex-river | 107,503 |
| Great Lakes | 33,103 |
| Tidewater | 5,344 |
| Truck | 69,410 |
| Tramway, conveyor and private railroad | 66,667 |

Note: Mode of transportation refers to mode at the point of consumption, except for ex-river movements.

a. Not equal to total production because of certain uses of coal which require no transport, such as coal used at the mine and dock storage. Also, overseas exports are not included.

Source: U.S. Department of Interior, Bureau of Mines, Bituminous Coal and Lignite Distribution, 1976 ed.

Table 27. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Coal and Coke, by BEAs or BEA Segments,[a] Estimated 1976

(Thousands of tons)

| BEA and BEA segment | Production[b] | Consumption[b] | Shipments (receipts) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Water | | | | Net rail | Net truck |
| | | | | Net | Inbound | Outbound | Local | | |
| Primary Study Areas | 436,998.0 | 194,578.4 | 242,419.6 | 9,674.5 | 2,878.2[c] | 12,552.7[c] | 101,102.0[c] | 251,505.0 | (18,759.9) |
| BEA 47: Huntsville, AL | 203.0 | 3,356.6 | (3,153.6) | (3,371.0) | 3,371.0 | -- | -- | (5,712.5) | 5,938.9 |
| BEA 48: Chattanooga, TN | 2,452.0 | 5,511.9 | (3,059.9) | 740.0 | 268.6 | 1,008.6 | 566.1 | (13,885.9) | 10,086.0 |
| BEA 49: Nashville, TN | 1,395.0 | 11,102.3 | (9,707.3) | (7,354.8) | 7,500.9 | 146.1 | -- | (11,433.4) | 9,080.9 |
| BEA 50: Knoxville, TN | 26,671.0 | 7,476.9 | 19,194.1 | 512.6 | -- | 512.6 | -- | 14,966.8 | 3,714.7 |
| BEA 51: Bristol, VA | 51,265.0 | 5,132.4 | 46,132.6 | 1,269.6 | -- | 1,269.6 | -- | 26,653.0 | 18,210.0 |
| BEA 52: Huntington, WV | 97,813.0 | 34,708.9 | 63,104.1 | 13,778.2 | 5,691.4 | 19,469.6 | 9,254.9 | 64,397.6 | (15,071.7) |
| BEA 53: Lexington, KY | 33,829.0 | 2,909.3 | 30,919.7 | 1,292.2 | -- | 1,292.2 | -- | 41,092.5 | (11,465.0) |
| BEA 54: Louisville, KY | 11.0 | 11,134.9 | (11,123.9) | (8,280.8) | 8,280.8 | -- | -- | (3,451.7) | 608.6 |
| BEA 55: Evansville, IN | 73,564.0 | 17,665.4 | 55,898.6 | 36,648.5 | 215.2 | 36,863.7 | 884.0 | 59,302.5 | (40,052.4) |
| BEA 62: Cincinnati, OH | -- | 20,969.5 | (20,969.5) | (15,882.4) | 15,882.4 | -- | -- | (3,947.1) | (1,140.0) |
| BEA 64: Columbus, OH | 13,345.0 | 6,347.4 | 6,997.6 | (396.2) | 396.2 | -- | -- | 2,471.3 | 4,922.5 |
| BEA 65: Clarksburg, WV | 30,367.0 | 5,321.5 | 25,045.5 | 8,461.1 | 1,168.0 | 9,629.1 | 1,250.8 | 15,720.3 | 864.1 |
| BEA 66: Pittsburgh, PA | 104,777.0 | 54,629.4 | 50,147.6 | (15,531.5) | 21,479.6 | 5,948.1 | 25,309.3 | 73,606.6 | (7,927.5) |
| BEA 68: Cleveland, OH | 1,306.0 | -- | 1,306.0 | 4.4 | -- | 4.4 | -- | 58.4 | 1,243.2 |
| BEA 115: Paducah, KY | -- | 8,312.0 | (8,312.0) | (2,215.4) | 2,376.0 | 160.6 | 85.0 | (8,324.4) | 2,227.8 |

Note: Gross and net waterborne and rail shipments (receipts) were determined for 1976 from U.S. Army Corps of Engineers waterborne commerce data and Interstate Commerce Commission railroad waybill data. Total net shipments (receipts) were determined by subtracting production from consumption. Net truck shipments (receipts) were determined by subtracting net waterborne and rail shipments (receipts) from total net shipments (receipts).

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

b. Includes coal only. Coal represented 99.6 percent of Group I waterborne movements in 1976. Projections of coal production and consumption provide more reasonable measures of the Group's future waterborne traffic flows.

c. Total Primary Study Area shipments equal inbound, outbound and local shipments for the PSAs as a unit and do not equal the sum of shipments reported for each of the BEAs and BEA segments.

Source: Estimated production and consumption from Tables 10, 11 and 24. Water and rail shipments (receipts) were compiled by RRNA from Waterborne Commerce by Port Equivalents, revised 1976, and ICC Railroad Waybill Sample, 1976, supplied by U.S. Army Corps of Engineers. BEA 51 rail shipments were adjusted using data from U.S. Department of the Interior, Bureau of Mines, Bituminous Coal and Lignite Distribution, 1976.

the largest producing PSAs are net shippers of coal. Only BEAs 47 (Huntsville), 48 (Chattanooga), 49 (Nashville), 54 (Louisville), 62 (Cincinnati) and 115 (Paducah) are net receivers of coal. The remaining BEAs produce far more than they consume.

Within the BEAs that are net shippers of coal, there is great variability in relative modal shares. Most of the waterborne movements of coal tend to originate from or are destined for BEAs 66 (Pittsburgh), 65 (Clarksburg), 62 (Cincinnati), 52 (Huntington) and 51 (Bristol). BEA 66 (Pittsburgh) has the largest gross waterway flows, with large quantities of inbound, outbound, and local shipments of coal feeding large electric utility companies and coke plants. BEA 52 (Huntington) has a similar pattern to BEA 66 (Pittsburgh), with large quantities of inbound, outbound, and local movements of coal. BEA 55 (Evansville) is a large shipper of coal, with small amounts consumed relative to production in the BEA. In 1976, 37.7 million tons of coal were shipped from BEA 55 (Evansville) via water. In BEA 62 (Cincinnati), where no production takes place, water receipts of 15.9 million tons of coal accounted for the majority of the BEA's coal receipts.

Shipments and receipts of coal and coke in 1976 by PSA are presented in Table 27. The vast majority of coal moved in and out of the individual BEAs via railroad. The size of rail movements correlated with the amount of production and/or consumption taking place within the BEAs.

Waterway movements of coal and coke were relatively important only in the BEAs where consumption takes place near the waterway. This is mainly due to physical and economic constraints: barge-to-truck and barge-to-rail movements are essentially too costly, relative to all-rail movements. Thus, consumers who are located away from the waterway are more likely to receive coal by rail.

## B. Intramodal Characteristics

Within the ORS hinterland, coal is shipped by rail, barge, truck and other modes, such as conveyor belts for mine-mouth electricity generation facilities. In most cases, more than one mode is used for the entire haul from the mine to the point of ultimate consumption. In other cases, a movement will involve one mode. The choice of modes usually is determined by the length of the haul and the loading and unloading facilities at the points of production and consumption, as well as the relative cost of the possible modes.

## B-1. Rail Transportation of Coal

Rail movements in the PSAs totalled over 463 million tons in 1976 (Table 28). Outbound rail movements amounted to 261 million tons. This large outbound flow of coal was due to the large net surplus of coal produced in the PSAs. These shipments were made to the New England, Mid-Atlantic and Southeastern states, the Great Lakes areas and the North Central states. Local movements, amounting to 192 million tons, were generally flows from land-locked mining areas in the PSAs. They were destined for transshipment facilities on the river or were going directly to consumers within the PSAs.

Particularly large rail movements of coal occurred in BEAs and BEA segments which had large amounts of production in areas that were relatively inaccessable to the waterway. Also, while areas such as BEAs 52 (Huntington), 55 (Evansville) and 66 (Pittsburgh) have access to the waterway, the ultimate destinations of the coal produced in these BEAs necessitates the use of rail transport. Shipments from these BEAs are destined to areas away from the waterway, such as the Southeastern states, the export ports of Baltimore and Hampton Roads, and the ports along the Great Lakes. In addition, some of the shipments originating in these BEAs were shipped to points of transshipment along the ORS (in other BEAs). Some rail shipments from BEA 52 (Huntington), for example, were received at points along the Ohio River in BEA 62 (Cincinnati).

One of the most important factors influencing the transportation of coal via rail has been the unit train. A unit train has two characteristics: a single commodity is carried, and a single pair of origin and destination points is served. The train shuttles back and forth between a mine location and an ultimate consumer. The unit train will typically consist of 100 hopper cars, carrying 100 tons of coal each. Thus, each unit train will normally have a capacity of 10,000 tons of coal. Within the ORB, smaller numbers of hopper cars, generally older cars with less capacity, often are used.

National shipments of coal via unit train increased during the period 1969-76 (Table 29.) Much of this increase was accounted for by large increases in coal production in the western states, with shipments moving from the West into the eastern states. Coal movements by unit train with origin points in selected states which overlap the ORB are listed in Table 29. Of the states predominately in the ORB, West Virginia and Kentucky have the largest

Table 28. Ohio River Basin: Rail Shipments of Coal and Coke, Net, Inbound, Outbound, Local and Gross Shipments, by BEAs or BEA Segments[a], 1976

(Thousands of tons)

| BEA and BEA segment | Net | Inbound | Outbound | Local | Gross |
|---|---|---|---|---|---|
| Primary Study Areas | 251,505.0 | 9,649.7[b] | 261,154.7[b] | 192,383.8[b] | 463,188.2 |
| BEA 47: Huntsville, AL | (5,721.5) | 5,730.5 | 9.0 | -- | 5,739.5 |
| BEA 48: Chattanooga, TN | (13,885.9) | 14,043.5 | 157.6 | 1,155.3 | 15,356.4 |
| BEA 49: Nashville, TN | (11,433.4) | 11,553.4 | 120.0 | 86.2 | 11,759.6 |
| BEA 50: Knoxville, TN | 14,966.8 | 15,951.2 | 30,918.0 | 2,472.0 | 49,341.2 |
| BEA 51: Bristol, VA | 26,653.0 | 3,417.4 | 25,654.5 | -- | 29,071.9 |
| BEA 52: Huntington, WV | 64,397.6 | 2,738.6 | 71,552.1 | 23,709.4 | 98,000.1 |
| BEA 53: Lexington, KY | 41,092.5 | 2,299.6 | 43,392.1 | 1,689.8 | 47,381.5 |
| BEA 54: Louisville, KY | (3,451.7) | 3,888.4 | 436.7 | -- | 4,325.1 |
| BEA 55: Evansville, IN | 59,302.5 | 3,090.0 | 62,392.5 | 3,311.3 | 68,793.8 |
| BEA 62: Cincinnati, OH | (3,947.1) | 5,304.1 | 1,357.0 | 311.6 | 6,972.7 |
| BEA 64: Columbus, OH | 2,471.3 | 1,312.9 | 3,784.2 | 48.0 | 5,145.1 |
| BEA 65: Clarksburg, WV | 15,720.3 | 3,768.6 | 19,488.9 | 1,676.9 | 24,934.4 |
| BEA 66: Pittsburgh, PA | 73,606.6 | 6,046.7 | 79,653.3 | 5,851.3 | 91,551.3 |
| BEA 68: Cleveland, OH | 58.4 | -- | 58.4 | -- | 58.4 |
| BEA 115: Paducah, KY | (8,324.4) | 8,545.0 | 221.0 | -- | 8,766.0 |

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne shipments.
b. *Primary Study Areas'* shipments equal inbound, outbound, and local shipments for the PSAs as a unit and do not equal the sum of shipments reported for each of the BEAs and BEA segments.

Source: Compiled by RRNA from ICC Railroad Waybill Sample, 1976, supplied by the U.S. Army Corps of Engineers. BEA 51 rail shipments adjusted using data from U.S. Department of the Interior, Bureau of Mines, Bituminous Coal and Lignite Distribution, 1976 ed.

Table 29. United States and Selected Eastern States: Shipments of Bituminous Coal and Lignite by Unit Train, by Origin, 1969-75

(Thousands of tons)

| Area or state | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 |
|---|---|---|---|---|---|---|---|
| United States, all shipments | 121,722 | 123,289 | 122,832 | 136,534 | 155,093 | 154,645 | 168,536 |
| Alabama | 2,257 | 3,088 | 3,373 | 4,253 | 3,930 | 3,276 | 2,413 |
| Georgia | -- | -- | -- | -- | -- | -- | -- |
| Illinois | 17,621 | 17,217 | 17,329 | 21,777 | 22,155 | 24,262 | 21,200 |
| Indiana | 1,913 | 2,997 | 2,351 | 3,048 | 5,493 | 9,321 | 9,557 |
| Kentucky, total | 14,265 | 18,123 | 18,894 | 16,228 | 19,489 | 24,558 | 25,427 |
| Eastern Kentucky | 7,420 | 9,361 | 11,164 | 9,522 | 12,197 | 16,457 | 22,900 |
| Western Kentucky | 6,845 | 8,762 | 7,730 | 6,706 | 7,291 | 8,101 | 2,527 |
| Maryland | 150 | 232 | 210 | 60 | 122 | 559 | 341 |
| Ohio | 13,014 | 13,308 | 16,688 | 18,063 | 18,266 | 16,528 | 14,991 |
| Pennsylvania | 20,370 | 21,325 | 19,125 | 18,228 | 22,262 | 16,888 | 19,950 |
| Tennessee | -- | 398 | 1,343 | 1,171 | 1,208 | 1,134 | 1,107 |
| West Virginia | 40,733 | 30,110 | 26,793 | 33,449 | 34,203 | 23,103 | 26,039 |

Note: Totals may not add due to independent rounding.
Source: U.S. Department of Interior, Bureau of Mines, Minerals Yearbook, 1969-75 eds.

tonnages moving by unit train. West Virginia's tonnage, however, has been decreasing since 1973, mainly due to production decreases. The Louisville and Nashville Railroad serves many of the mines in Kentucky and Tennessee. The railroad has indicated that the use of the unit trains will be increasing in the future as a result of lower costs and the growing number of large electric utility plants which require large shipments of coal.

The major problem for the railroads in the PSAs, as indicated by industrial authorities, is the general disrepair of substantial amounts of track. Other problems noted were shortages of hopper-cars and other equipment. Some of the track, in the more rugged terrain of eastern Kentucky and West Virginia, is in particularly bad condition. Attempts have been made to rectify this situation. The Interstate Commerce Commision has granted the Louisville and Nashville Railroad a 38 percent rate increase for handling coal with the stipulation that the new revenues be applied toward upgrading transportation equipment in those areas where the railroad serves coal mines.[1] This will begin to alleviate some of the problems and could eventually make rail more competitive with other modes in some mining areas.

B-2. Barge Transportation of Coal

Barge transportation of coal is the second most important mode of transportation in the PSAs. The main advantage of barge transport is the efficiency of barges in transporting large volume, low-value commodities where fast delivery is not a concern. A general concensus among shippers interviewed is that barge transport is considered to be the least expensive mode of line-haul transportation for coal which must move 200 miles or more.

Barge transportation of coal has a major constraint -- the waterway is not always accessible to production and consumption areas. Transshipment, using rail or truck, to or from the waterway, can generate substantial transshipment charges, in addition to freight charges, for the use of the two or three modes involved. However, as discussed below, there appears to be a trend toward establishing rail/barge interfaces.

B-3. Truck Transportation of Coal

Truck transportation of coal is the most costly, yet the most flexible of all the modes. The most efficient use of truck is for

1. Interstate Commerce Commission, Increased Rates on Coal, L&NR., October 31, 1978.

short-distance hauls, either to the ultimate consumers or to a point of transshipment to another mode. However, short hauls of rail and water are prevalent, especially in new plants where truck deliveries are not available. The production areas of coal often coincide with the consuming areas so closely that the distance between the origin and destination points of the coal are short enough for efficient use of truck. Many of the utilities in the PSAs that are located near production areas are using truck movements to secure substantial portions of their coal supply. This is especially true for utilities located in Ohio, Pittsburgh, Tennessee and Kentucky.

The development of coal-burning power plants with very large capacities requires substantial quantities of water for cooling purposes. Unfortunately, major water sources do not coincide with coal reserves in Appalachia. Therefore, utilities are tending to locate on the major water sources and are receiving coal via the waterway. At most newer facilities, truck is used sparingly as a supplement to rail or barge. Many plants are not equipped to receive via truck.

There are disadvantages to using truck transport extensively. Many industry experts and state officials indicate that truck movements of coal cause extensive damage to the roads over which the coal travels. This damage leads to situations where both coal traffic by truck and non-coal truck traffic incur substantial delays. Weight limits for trucks are hard to enforce, and industrial authorities indicate that local roadbed construction is not designed for continual movement of coal trucks. Indications are that in southern West Virginia and eastern Kentucky coal truck traffic has caused enough extensive damage so as to restrict the capacity of these roads for coal traffic.

Truck transportation is a major factor in coal distribution patterns within the PSAs. Mining activity away from the waterway and the existing rail network necessitates the use of trucks, at least, for collection. Since rail spurs require more capital investment than the construction of roads, the use of truck transport to bring coal from minemouth to central loading point is efficient. This is especially true given the terrain and type of mining prevalent in many of the PSAs. Areas in West Virginia, eastern Kentucky, and Pennsylvania require the use of truck as the most economic means of collection.

B-4. Conveyor Belt and Minemouth Operations

Minemouth operations of electric utilities often employ some type of conveyor belt or short haul rail or truck link to bring the coal from the mine to the electric utility plant. Table 30 presents the tonnages of coal burned by minemouth generating plants in the PSAs during 1975, the latest year of data available. BEAs 66 (Pittsburgh) and 55 (Evansville) have the greatest number of minemouth plants in the PSAs. Discussions with industrial sources revealed mixed opinions as to the expected future development of minemouth plants. The trade-off involved is the low cost of coal transportation versus the higher cost of sending the electricity generated to markets which are located some distance from the mine site. Unless there is an improvement in the technology of electricity transportation from generating plants to ultimate markets, minemouth plants will be developed only when the mining areas are in proximity to the electricity market areas.

C. Intermodal Characteristics

Coal transportation in the PSAs is largely multi-modal. The modal interfaces are: rail-to-barge, truck-to-rail and truck-to-barge. Rail-to-barge movements involve longer haul shipments, while truck-to-rail movements are a means for collection.

C-1. Rail-to-Barge Transshipments

Rail-to-barge movements of coal enable the mines in areas substantial distances away from the river to supply waterside consumers of coal. These movements have become increasingly common as the mining areas near the river have been depleted.

Transshipments from rail to barge incur certain charges and costs. There are initial loading costs, a rail tariff rate, a transshipment and possibly a storage charge, charges for the barge haul and unloading charges. The total amount may be greater than an all-rail movement. The transshipment from rail-to-barge results in costs currently amounting to about $1.00/ton, but this will decrease as scale economies are reached at various facilities. Where rail and barge services are in direct competition on a given route, waterway transport rates are sometimes not low enough to offset the additional costs of rail-to-barge transfers.

Table 30. Ohio River Basin: Coal Consumption of Minemouth Electric Generating Plants, by BEAs or BEA Segments[a], Estimated 1975

(Thousands of tons)

| BEA or BEA segment | Tonnage |
|---|---|
| Primary Study Areas | 27,416 |
| BEA 50: Knoxville, TN | 106 |
| BEA 52: Huntington, W.V. | 1,269[b] |
| BEA 53: Lexington, KY | 650 |
| BEA 55: Evansville, IN | 7,928 |
| BEA 64: Columbus, OH | 869[b] |
| BEA 65: Clarksburg, W.V. | 2,277 |
| BEA 66: Pittsburgh, PA | 10,485 |
| BEA 68: Cleveland, OH | 3,832 |

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

b. Estimates based on state-level data from Bureau of Mines.

Source: U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1975 ed.

In cases where there is no direct competition on a given route between rail and water, the operators of both modes can realize economic gains by intermodal tranfers. This occurs at points along the Kanawha River and the Ohio River (particularly between Louisville and Huntington. Major rail unloading facilities link rail lines originating in eastern Kentucky and southern West Virginia to the waterway. From these linkage points, coal can flow to riverside utility plants which have no facilities to receive coal via rail.

## C-2. Methodology of Handling Rail/Barge Transshipment

Major points of transshipment occur throughout the ORS. For coal produced in non-waterside BEAs, rail-barge transfers occur in BEAs 52 (Huntington), 66 (Pittsburgh), 62 (Cincinnati) and 54 (Louisville), while the origin points of the coal are BEAs 53 (Lexington) and 51 (Bristol). Docks along the river were surveyed to ascertain the 1976 percentage distribution of coal shipped which was transshiped from landlocked origin BEAs. Adjustments were made to the Waterborne Commerce by Port Equivalents flow data to establish ultimate BEA origins and destinations of waterborne coal movements. Total coal traffic flows were determined, with identification of the producing PSA as the origin BEA, the point of transfer to water as the shipping BEA, the waterway destination as the receiving BEA, and the ultimate consumption point designated as the destination BEA. Very often the origin BEA was the same as the shipping BEA. Also, the receiving BEA was the same as the destination BEA, with consumption frequently occurring at waterside.

## C-3. The Role of Trucks in Multi-Modal Movements of Coal in the PSAs

Trucks are used extensively in the PSAs to collect coal from smaller mines which do not have rail spurs. The number of smaller mines in the areas of eastern Kentucky and West Virginia, where rail lines are not constructed due to rugged terrain, makes the use of truck invaluable as a means of collection. Trucks interface either with rail lines or with the waterway to transfer the coal to its primary mode of transport. Hauls are generally limited to under fifty miles.

## D. Factors Affecting Modal Choice

Interviews with industrial sources and researchers familiar with the coal industry have indicated two broad issues affecting modal choices for coal transport:

- the physical structure and location of the transportation network in relation to production and consumption areas

- relative transport cost.

The transportation of coal in the PSAs generally is arranged by the seller of the coal. The coal is sold on a delivered cost basis so that the seller has an incentive to provide the minimum cost transport. This general pattern differs only when the consumer provides transportation and pays a FOB price at the mine. There appears to be a trend among larger utilities to use their own transportation equipment, including locomotives and hoppers, or towboats and barges.

In general, there are two groups of coal consumers: those who are locked into a particular transport method because of the physical limitations of the transport system, and those who have flexibility in modal choice. The first group essentially has an inelastic demand for a given transport mode, and modes are not subject to change in the short run as the relative modal costs change. The second group does have a choice, generally between barge and rail. However, most of these coal consumers still have an inelastic demand for water transport over a very broad range of possible price changes. Barge rates are viewed as a "bargain," and the implementation of a waterway user charge is seen presently as a minor tax, the amount of which is not going to alter modal split. It is generally felt that increases in water transport rates of even 10-15 percent would have little, if any, impact on modal split. Contractual arrangements add to this rigidity as well.

### D-1. The Physical Structure of the Transportation Network

The modal choice for the transport of coal in the PSAs is constrained by the waterway system in the ORS and by the existing network of railroads in the area. Obviously, non-waterside consumers of coal cannot receive waterway shipments of coal. Likewise, a waterside consumer who lacks a rail spur connecting with a rail line is unable to receive coal by rail. These constraints pose a first limitation to the available modal choice.

Further constraints would be specific to the types of coal required. For instance, the production areas of metallurgical coal are in the land-locked areas of BEAs 51 (Bristol), 52 (Huntington), 53 (Lexington) and the northern portion of BEA 50 (Knoxville). Consumers of metallurgical coal are forced to utilize rail or truck as the initial mode. Beyond this is the factor of discriminatory rail rates. As long as the ultimate consumer has connecting spurs to a main rail line, these rates often serve as an inducement for all-rail hauls, regardless of the location of the consumer.

D-2. Relative Transport Costs

The existence of the physical capability to receive or ship coal by any of the possible modes between a particular origin-destination pair implies broad modal choices. Industry sources indicate, however, that transport rates are generally such that one mode clearly stands out as the least cost alternative. Since coal is most often sold on a contract basis, and since, in any event, most consumers hold relatively substantial inventories, the speed of shipment is not crucial. Thus, shippers of coal have indicated that the physical ability to ship via the waterway, coupled with the relatively low cost of water transport, would preclude any modal shift even with a waterway users charge. Essentially, the modal split for coal in the PSAs is stable and will not change unless relative transport costs change drastically.

## E. Forecasting Procedures and Assumptions

Waterway flows and net rail movements of coal and coke have been projected for 1980, 1990, 2000, 2020 and 2040. The procedures for the projections were based on the assumption that flows between 1969 and 1976 are representative of future flows, except when specific data or analyses indicate otherwise.

E-1. Forecasting Procedures for Rail Movements, 1980-2040

Gross outbound rail movements were generally treated as a function of the level of production in a given PSA, while inbound rail movements were found to be a function of the level of consumption within a PSA. The extent of this relationship, that is, the proportion of consumption or production transported on the rail, was related to the accessibility of the mining areas to the rail spurs. Since a locational-specific determination was beyond the scope of this study, the proportion of rail traffic to total production and consumption in each BEA served as a proxy for this locational variable. Net rail movements are defined as outbound minus inbound rail movements.

### E-2. Forecasting Procedures for BEA Waterway Flows 1980-2040

Waterway flows were projected in a two stage process. First, gross waterborne shipments and receipts for each BEA were estimated as a function of production, consumption and historical waterway shipments. Second, these gross flows generated BEA-to-BEA waterway flows through a flow model.

Generally, if a BEA was a net receiver by two modes, water and rail, future waterway flows were based on the historical relationship between gross inbound movements and consumption, or gross outbound movements and production during the period 1969-76. For BEAs in the ORB for which future modal shifts are expected due to locational changes of major consumers, adjustments were made to gross waterway flows. A similar process was followed for estimating gross *inbound flows*. For example, the expected closing of a TVA plant and opening of other waterside plants altered the modal split.

### E-3. Forecasting Procedures for Projecting SCA and SPA Waterway Flows

Flows from BEAs exterior to the ORB to PSAs were determined from estimates of future consumption of the PSAs based on historical relationships. Flows from PSAs to areas exterior to the ORB were assumed to be proportional to the production of the PSAs which supplied these areas. The singular exception was the movement of western coal to PSAs. For the projection period 1980-90, this flow was based on known plans of utility plants in the respective PSAs. The years beyond 1990 were estimated as a proportion of western coal production and its movement into the ORS in recent years.

### E-4. Special Assumption for 2020 and 2040 Rail/Water Flows

To deal with the issue of coal gasification or liquefaction, it was assumed that the amount of synthetic fuel production, as projected by the ICF, Inc. coal model, would double from its rate of 9 percent of coal production in the year 2000 to 18 percent of production in 2020. It was assumed to increase to 36 percent of total production by 2040. Coal used for synthetic fuel production was assumed to be supplied from sources near the point of conversion to synthetic fuel. Water and rail shipments were projected excluding this gas or liquid coal except for the year 2040. It was assumed that by 2040, synthetic fuel plants will receive one-fourth of their supplies from off-site sources. Transportation flows of this coal will reflect traffic patterns of other coal and coke. Transfers of gasified and liquefied coal energy were included in net truck shipments.

## F. Probable Future Modal Split

The modal split of coal and coke shipments, by PSA, is given in Tables 31 and 32 for the years 1980 and 1990. A summary of the 1976 shipments of coal and coke in the PSAs is provided in Table 27.

The modal split of the PSAs is not shifting drastically, although subtle changes will occur in the PSAs through 1990. The reduction of coal consumption by TVA will impact on the modal split of BEAs 47-50 in 1980 and 1990. Increases in the production of coal in the central Primary Study Areas, BEAs 50 (Knoxville) and 52 (Huntington), will increase the amount of coal available for shipment, but will not drastically alter the modal split. The most severe change in the modal split will occur between 1980 and 1990 for BEA 55 (Evansville). During this period, two large electric utility plants are scheduled to open. The new coal consumption is expected to be transported by barge, causing a large increase in the share of BEA 55's inbound shipments moving by water.

For the PSAs as a whole, local traffic on the waterway is projected to increase steadily to 2040 (Table 33). Net inbound movements will be growing at a faster rate than net outbound movements, and the PSAs as a whole become a net waterborne importer of coal in 2020. Most of the rapid increase in inbound shipments of coal will occur due to the increase in western coal production and expected use in parts of the ORB.

## G. Probable Future Waterway Flow

Future waterway flow projections for each projected year were based on the previous projected year's flows as adjusted to reflect expected changes in modal split and other factors foreseen as

Table 31. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Coal and Coke, by BEAs or BEA Segments,[a] Projected 1980

(Thousands of tons)

| BEA and BEA segment | Production[b] | Consumption[b] | Shipments (receipts): Total | Water: Net | Water: Inbound | Water: Outbound | Water: Local | Net rail | Net truck |
|---|---|---|---|---|---|---|---|---|---|
| Primary Study Areas | 481,431.0 | 216,792.8 | 264,638.2 | 7,932.3 | 3,208.6[c] | 11,140.9[c] | 116,041.1[c] | 282,921.8 | (26,215.9) |
| BEA 47: Huntsville, AL | 200.0 | 3,05[illegible] | (2,850.1) | (3,045.7) | 3,045.7 | -- | -- | (5,197.6) | 5,393.2 |
| BEA 48: Chattanooga, TN | 2,572.9 | 5,576.7 | (3,003.8) | (190.1) | 689.4 | 499.3 | 1,034.3 | (14,368.7) | 11,555.0 |
| BEA 49: Nashville, TN | 1,609.5 | 13,963.0 | (12,353.5) | (9,375.4) | 9,544.0 | 168.6 | -- | (14,400.9) | 11,422.8 |
| BEA 50: Knoxville, TN | 29,577.9 | 6,900.1 | 22,677.8 | 568.4 | -- | 568.4 | -- | 20,026.8 | 2,082.6 |
| BEA 51: Bristol, VA | 54,747.3 | 5,178.7 | 49,568.6 | 1,355.7 | -- | 1,355.7 | -- | 28,666.3 | 19,546.6 |
| BEA 52: Huntington, WV | 111,982.6 | 36,896.2 | 75,086.4 | 16,393.0 | 6,317.4 | 22,710.4 | 11,466.9 | 76,251.8 | (17,558.4) |
| BEA 53: Lexington, KY | 37,501.4 | 3,362.5 | 34,138.9 | 1,426.9 | -- | 1,426.9 | -- | 46,948.6 | (14,236.6) |
| BEA 54: Louisville, KY | -- | 13,089.0 | (13,089.0) | (9,742.3) | 9,742.3 | -- | -- | (4,057.6) | 710.9 |
| BEA 55: Evansville, IN | 85,927.1 | 21,617.9 | 64,309.2 | 42,160.9 | 246.7 | 42,407.6 | 1,020.1 | 67,033.8 | (44,885.5) |
| BEA 62: Cincinnati, OH | -- | 25,069.2 | (25,069.2) | (18,986.7) | 18,986.7 | -- | -- | (4,718.0) | (1,364.5) |
| BEA 64: Columbus, OH | 14,052.6 | 7,542.9 | 6,509.7 | (471.0) | 471.0 | -- | -- | 2,418.7 | 4,562.0 |
| BEA 65: Clarksburg, WV | 32,999.3 | 5,863.3 | 27,136.0 | 9,168.3 | 1,291.4 | 10,459.7 | 1,329.6 | 17,000.0 | 967.7 |
| BEA 66: Pittsburgh, PA | 108,901.9 | 60,187.9 | 48,714.0 | (19,069.3) | 25,100.4 | 6,031.1 | 26,448.2 | 75,765.9 | (7,982.6) |
| BEA 68: Cleveland, OH | 1,358.5 | -- | 1,358.5 | 4.6 | -- | 4.6 | -- | 60.7 | 1,293.2 |
| BEA 115: Paducah, KY | -- | 8,495.3 | (8,495.3) | (2,265.0) | 2,438.4 | 173.4 | 77.2 | (8,508.0) | 2,277.7 |

Note: Projected net shipments (receipts) were determined by subtracting projected consumption from projected production. For BEAs 47, 49, 50 and 51, waterborne gross inbound movements (inbound plus local traffic) were assumed to increase during the 1976-80 period at the same rates as net shipments (receipts) were projected to increase in each BEA. Waterborne gross outbound movements (outbound plus local traffic) were assumed to increase at the same rates as production. For BEA 48, projections of waterborne movements were based on data obtained from industrial shippers and receivers. For BEAs 64 and 66, waterborne gross inbound movements were assumed to increase during the 1976-80 period at the same rates as consumption; waterborne gross outbound movements were assumed to increase at the same rates as production. Gross inbound and outbound movements in other BEAs were projected by assuming that the relationships between these movements and net shipments in 1976 would remain constant through 1980, except when data, analyses, and conversations with industrial authorities indicated otherwise. Local waterborne movements based on 1976 relationship by BEA between waterborne gross outbound and local shipments, adjusted to reflect changes in waterborne receipts by BEA destination. Net rail (outbound minus inbound). Gross rail outbound and inbound shipments were assumed to increase during the 1976-80 at the same rates as production and consumption, respectively. Net truck was assumed equal to net shipments less net water and rail shipments.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

(Continued)

Table 31. (Continued)

b. Includes coal only. Coal represented 99.6 percent of Group I waterborne movements in 1976. Projections of coal production and consumption provide more reasonable measures of the Group's future waterborne traffic flows.

c. Primary Study Area shipments equal inbound, outbound and local shipments for the PSAs as a unit and do not equal the sum of shipments reported for each BEA and BEA segment.

Source: Tables 13, 14, 25 and 27; Waterborne Commerce by Port Equivalents, 1969-76, and Shippers Surveys, supplied by the U.S. Army Corps of Engineers.

Table 32. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Coal and Coke, by BEAs or BEA Segments,[a] Projected 1990

(Thousands of tons)

| BEA and BEA segment | Production[b] | Consumption[b] | Shipments (receipts) Total | Water Net | Water Inbound | Water Outbound | Water Local | Net rail | Net truck |
|---|---|---|---|---|---|---|---|---|---|
| Primary Study Areas | 627,200.0 | 268,856.5 | 358,343.5 | 9,292.3 | 12,982.1[c] | 22,274.4[c] | 148,239.2[c] | 409,708.9 | (60,027.7) |
| BEA 47: Huntsville, AL | 200.0 | 2,246.4 | (2,046.4) | (2,188.0) | 2,188.0 | -- | -- | (3,827.7) | 3,969.3 |
| BEA 48: Chattanooga, TN | 2,900.0 | 2,888.9 | 11.1 | 946.3 | 337.2 | 1,283.5 | 445.0 | (6,830.5) | 5,895.3 |
| BEA 49: Nashville, TN | 2,300.0 | 11,674.4 | (9,374.4) | (7,005.7) | 7,246.6 | 240.9 | -- | (11,899.5) | 9,530.8 |
| BEA 50: Knoxville, TN | 38,300.0 | 5,887.6 | 32,412.4 | 736.2 | -- | 736.2 | -- | 33,440.8 | (1,764.6) |
| BEA 51: Bristol, VA | 73,200.0 | 4,917.6 | 68,282.4 | 1,812.9 | -- | 1,812.9 | -- | 39,664.5 | 26,805.0 |
| BEA 52: Huntington, WV | 157,000.0 | 42,010.8 | 114,989.2 | 25,108.1 | 9,331.2 | 34,439.3 | 17,908.3 | 115,546.3 | (25,665.2) |
| BEA 53: Lexington, KY | 48,500.0 | 4,832.2 | 43,667.8 | 1,825.1 | -- | 1,825.1 | -- | 60,073.5 | (18,230.8) |
| BEA 54: Louisville, KY | -- | 19,623.0 | (19,623.0) | (14,607.6) | 14,607.6 | -- | -- | (6,083.2) | 1,067.8 |
| BEA 55: Evansville, IN | 126,700.0 | 35,812.7 | 90,887.3 | 50,589.2 | 9,496.0 | 60,085.2 | 1,294.2 | 100,189.8 | (59,891.7) |
| BEA 62: Cincinnati, OH | -- | 39,727.6 | (39,727.6) | (30,091.0) | 30,091.0 | -- | -- | (7,476.8) | (2,159.8) |
| BEA 64: Columbus, OH | 16,000.0 | 11,625.5 | 4,374.5 | (2,225.5) | 2,225.5 | -- | -- | 2,102.7 | 4,497.3 |
| BEA 65: Clarksburg, WV | 40,600.0 | 7,492.1 | 33,107.9 | 11,185.6 | 1,590.7 | 12,776.3 | 1,607.3 | 20,630.8 | 1,291.5 |
| BEA 66: Pittsburgh, PA | 120,000.0 | 70,225.6 | 49,774.4 | (24,358.3) | 32,507.7 | 8,149.4 | 27,637.7 | 82,636.9 | (8,504.2) |
| BEA 68: Cleveland, OH | 1,500.0 | 750.0 | 750.0 | 2.6 | -- | 2.6 | -- | 67.1 | 680.3 |
| BEA 115: Paducah, KY | -- | 9,142.1 | (9,142.1) | (2,437.6) | 2,641.6 | 204.0 | 65.7 | (9,155.8) | 2,451.3 |

Note: Projected net shipments (receipts) were determined by subtracting projected consumption from projected production. For BEAs 47, 49, 50 and 51, waterborne gross inbound movements (inbound plus local traffic) were assumed to increase during the 1980-90 period at the same rates as net shipments (receipts) were projected to increase in each BEA. Waterborne gross outbound movements (outbound plus local traffic) were assumed to increase at the same rates as production. For BEA 48, projections of waterborne movements were based on data obtained from industrial shippers and receivers. For BEAs 64 and 66, waterborne gross outbound movements were assumed to increase during the 1980-90 period at the same rates as production. Waterborne gross inbound movements for 66 were assumed to increase at the same rates as consumption. For BEAs 55 and 64, waterborne inbound movements were based on data obtained from industrial shippers and receivers. Gross inbound and outbound movements in other BEAs were projected by assuming that the relationship between these movements and net shipments in 1980 would remain constant in 1990, except when data, analyses and conversations with industrial authorities indicated otherwise. Local waterborne movements were based on 1980 BEA relationships

(Continued)

Table 32. (Continued)

between waterborne gross outbound and local shipments, adjusted to reflect changes in waterborne receipts by BEA destination. Gross rail outbound and inbound movements were assumed to increase during the 1980-90 period at the same rates as production and consumption, respectively. Net rail determined by subtracting rail inbound from rail outbound. Net truck was assumed equal to net shipments less net water and rail shipments.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

b. Includes coal only. Coal represented 99.6 percent of Group I waterborne movements in 1976. Projections of coal production and consumption provide more reasonable measures of the Group's future waterborne traffic flows.

c. Primary Study Area shipments equal inbound, outbound and local shipments for the PSAs as a unit and do not equal the sum of shipments reported for each BEA and BEA segment.

Source: Tables 13, 14, 25 and 31; Waterborne Commerce by Port Equivalents, 1969-76, and Shipper Surveys, supplied by the U.S. Army Corps of Engineers.

Table 33. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Coal and Coke, Estimated 1976 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

| | | Projected | | | | | Average annual percentage change | |
|---|---|---|---|---|---|---|---|---|
| | Estimated 1976 | 1980 | 1990 | 2000 | 2020 | 2040 | 1976-90 | 1976-2040 |
| Production[a] | 436,998.0 | 481,431.0 | 627,200.0 | 736,547.5 | 931,672.6 | 1,136,818.3 | 2.61 | 1.51 |
| Consumption[a] | 194,578.4 | 216,792.8 | 268,856.5 | 334,826.2 | 465,257.4 | 606,624.0 | 2.34 | 1.79 |
| Net shipments (receipts) | 242,419.6 | 264,638.2 | 358,243.5 | 428,721.6 | 466,421.2 | 530,194.3 | 2.83 | 1.23 |
| Net waterborne | 9,674.5 | 7,932.3 | 9,292.3 | 6,942.5 | (16,090.0) | (34,099.7) | (0.29) | b |
| Net rail | 251,505.0 | 282,921.8 | 409,078.9 | 529,092.3 | 495,326.6 | 398,738.7 | 3.54 | 0.72 |
| Net truck | (18,756.6) | (26,215.9) | (60,027.7) | (107,313.2) | (12,815.4) | 165,555.3 | 8.66 | b |
| Gross waterborne shipments: | | | | | | | | |
| Inbound | 2,878.2 | 3,208.6 | 12,982.1 | 17,385.5 | 32,387.5 | 47,141.2 | 11.36 | 4.47 |
| Outbound | 12,552.7 | 11,140.9 | 22,274.4 | 24,328.0 | 16,297.5 | 13,041.5 | 4.18 | 0.06 |
| Local | 101,102.0 | 116,041.1 | 148,239.2 | 162,447.3 | 179,415.2 | 193,474.2 | 2.77 | 1.02 |
| Total | 116,532.9 | 130,390.6 | 183,495.7 | 204,160.8 | 228,100.2 | 253,656.9 | 3.30 | 1.22 |

Note: Projected net shipments (receipts) were determined by subtracting projected consumption from projected production. Projected modal split for the PSAs was estimated from projections of modal split for each BEA and BEA segment. For BEAs 47, 49, 50 and 51, waterborne gross inbound movements (inbound plus local traffic) were assumed to increase during the 1990-2040 period at the same rates as net shipments (receipts) were projected to increase in each BEA. Waterborne gross outbound movements (outbound plus local traffic) were assumed to increase at the same rates as production. For BEAs 48, 64, 66, waterborne gross outbound movements were assumed to increase during the 1990-2040 period at the same rates as production; waterborne gross inbound movements were assumed to increase at the same rates as consumption. Gross inbound and outbound movements in other BEAs and BEA segments were projected by assuming that the relationship between these movements and net shipments in 1990 would remain constant throughout the period, except when data, analyses, or conversations with industrial authorities otherwise indicated. Local waterborne movements in 2000, 2020, 2040 based on 1990 relationship between waterborne gross outbound and local shipments; adjusted to reflect changes in waterborne receipts by BEA or BEA segment destination. Water and rail shipments (receipts) in each BEA and BEA segment in 2000 and 2020 were estimated on the basis of production, consumption and net shipments excluding coal for coal gasification and liquefaction. For the year 2040, only three-fourths of coal used for synthetic fuel purposes was assumed to be supplied from sources located at the site of conversion. Transfers of liquefied or gasified coal energy are included in net truck.

(Continued)

Table 33.(Continued)

a. Includes coal only. Coal represented 99.6 percent of Group I waterborne movements in 1976. Projections of coal production and consumption provide more reasonable measures of the Group's future waterborne traffic flows.

b. Not defined.

Source: Tables 13, 14, 25, 27, 31 and 32; Waterborne Commerce by Port Equivalents, revised 1976, supplied by the U.S. Army Corps of Engineers.

important in the future. These changes were generated by discussions with the various industry authorities and coal industry researchers. Given the large number of origin and destination links of coal movements in the PSAs, it is hard to generalize about specific linkage relationships. The projections are presented in Table 34. Growth indices implied by the projections are presented in Table 35.

Gross waterway movements will be increasing over time as production and consumption increase to serve the energy needs of the PSAs. Total waterway traffic is projected to increase from 116.5 million tons in 1976 to 253.7 million tons in 2040. Shifts will be occuring by 1990 that will alter the pattern of traditional movements. BEAs 52 (Huntington), 55 (Evansville), 66 (Pittsburgh), 62 (Cincinnati) and 51 (Bristol) will remain as stimulators of waterway flows. New linkages involving the flow of western coal into the ORS via BEA 114 (St. Louis) will be established.

Table 34. Ohio River System: Waterborne Traffic of Coal and Coke, by Origin BEA, Shipping BEA, Receiving BEA and Destination BEA; Estimated 1976 and Projected 1980-2040, Selected Years

| ORIGIN | SHIPPING | RECEIVING | DESTINATION | FOR COMMODITY GROUP 01 IN HUNDREDS OF TONS | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| BEA | BEA | BEA | BEA | 1976 | 1980 | 1990 | 2000 | 2020 | 2040 |
| 011 | 066 | 066 | 066 | 1021 | 1173 | 1387 | 1865 | 3493 | 5093 |
| 048 | 048 | 048 | 048 | 5661 | 10343 | 4450 | 3419 | 1845 | 708 |
| 048 | 047 | 052 | 052 | 45 | 48 | 54 | 64 | 67 | 90 |
| 048 | 047 | 077 | 077 | 1636 | 1449 | 2339 | 2876 | 2649 | 2097 |
| 048 | 048 | 077 | 077 | 200 | 177 | 286 | 352 | 324 | 256 |
| 048 | 048 | 089 | 089 | 189 | 138 | 185 | 258 | 241 | 198 |
| 048 | 047 | 137 | 137 | 234 | 177 | 236 | 296 | 254 | 206 |
| 048 | 048 | 138 | 138 | 7782 | 3004 | 9735 | 13945 | 15673 | 16498 |
| 048 | 115 | 052 | 052 | 794 | 934 | 1209 | 1325 | 1423 | 1450 |
| 048 | 115 | 062 | 062 | 667 | 752 | 1200 | 1344 | 1511 | 1737 |
| 050 | 048 | 048 | 048 | 315 | 565 | 295 | 227 | 151 | 65 |
| 050 | 062 | 052 | 052 | 236 | 260 | 337 | 368 | 390 | 341 |
| 050 | 062 | 062 | 062 | 2683 | 2750 | 4003 | 4427 | 5049 | 5908 |
| 050 | 054 | 066 | 066 | 381 | 581 | 709 | 827 | 961 | 932 |
| 05 | 062 | 066 | 066 | 341 | 520 | 635 | 740 | 860 | 834 |
| 050 | 062 | 114 | 114 | 56 | 48 | 86 | 100 | 90 | 74 |
| 050 | 062 | 115 | 115 | 682 | 648 | 665 | 787 | 889 | 1123 |
| 050 | 048 | 138 | 138 | 432 | 312 | 632 | 679 | 576 | 463 |
| 051 | 048 | 048 | 048 | 315 | 593 | 312 | 240 | 161 | 65 |
| 051 | 052 | 052 | 052 | 3299 | 3530 | 4704 | 5163 | 5196 | 5239 |
| 051 | 052 | 055 | 055 | 39 | 42 | 54 | 55 | 66 | 72 |
| 051 | 052 | 062 | 062 | 2533 | 2685 | 4210 | 4557 | 4714 | 5557 |
| 051 | 052 | 065 | 065 | 378 | 399 | 486 | 541 | 588 | 637 |
| 051 | 052 | 066 | 066 | 4723 | 5039 | 6419 | 7363 | 9134 | 10358 |
| 051 | 066 | 066 | 066 | 345 | 368 | 469 | 538 | 667 | 757 |
| 051 | 052 | 114 | 114 | 210 | 175 | 342 | 389 | 400 | 329 |
| 051 | 052 | 115 | 115 | 54 | 48 | 57 | 64 | 67 | 84 |
| 051 | 052 | 137 | 137 | 186 | 152 | 270 | 297 | 260 | 226 |
| 051 | 048 | 138 | 138 | 432 | 381 | 541 | 582 | 565 | 458 |
| 051 | 052 | 138 | 138 | 14 | 12 | 18 | 19 | 18 | 15 |
| 051 | 052 | 141 | 141 | 168 | 133 | 247 | 276 | 241 | 189 |
| 052 | 052 | 047 | 047 | 2408 | 2143 | 1664 | 1194 | 937 | 491 |
| 052 | 052 | 049 | 049 | 880 | 1082 | 1195 | 1144 | 1045 | 950 |
| 052 | 052 | 052 | 052 | 88634 | 109818 | 171507 | 181345 | 168139 | 159807 |
| 052 | 062 | 052 | 052 | 785 | 973 | 1519 | 1606 | 1489 | 1415 |
| 052 | 064 | 052 | 052 | 3130 | 3878 | 6057 | 6404 | 5938 | 5643 |
| 052 | 052 | 054 | 054 | 192 | 348 | 427 | 648 | 683 | 720 |
| 052 | 052 | 055 | 055 | 1144 | 1395 | 1758 | 1541 | 1510 | 1455 |
| 052 | 052 | 062 | 062 | 49058 | 56368 | 92033 | 113716 | 100814 | 113864 |
| 052 | 054 | 062 | 062 | 10 | 11 | 19 | 23 | 21 | 23 |
| 052 | 062 | 062 | 062 | 3057 | 3512 | 5735 | 7086 | 6282 | 7095 |
| 052 | 052 | 064 | 064 | 3838 | 4679 | 22218 | 27342 | 36833 | 45212 |
| 052 | 052 | 065 | 065 | 7182 | 8374 | 11103 | 12583 | 13287 | 14127 |
| 052 | 052 | 066 | 066 | 104936 | 127917 | 172830 | 184687 | 241773 | 270525 |
| 052 | 054 | 066 | 066 | 381 | 464 | 628 | 671 | 878 | 982 |
| 052 | 062 | 066 | 066 | 250 | 305 | 412 | 440 | 576 | 645 |
| 052 | 064 | 066 | 066 | 90 | 110 | 148 | 158 | 207 | 232 |
| 052 | 066 | 066 | 066 | 3353 | 4087 | 5522 | 5901 | 7725 | 8644 |
| 052 | 052 | 077 | 077 | 96 | 85 | 130 | 200 | 300 | 350 |
| 052 | 052 | 091 | 091 | 105 | 93 | 158 | 250 | 200 | 160 |
| 052 | 052 | 114 | 114 | 4508 | 3908 | 7330 | 8191 | 5423 | 4449 |
| 052 | 052 | 115 | 115 | 1036 | 1077 | 1313 | 1467 | 1664 | 1994 |

(Continued)

Table 34. (Continued)

| ORIGIN BEA | SHIPPING BEA | RECEIVING BEA | DESTINATION BEA | FOR COMMODITY GROUP 01 IN HUNDREDS OF TONS 1976 | 1980 | 1990 | 2000 | 2020 | 2040 |
|---|---|---|---|---|---|---|---|---|---|
| 052 | 054 | 115 | 115 | 2470 | 2569 | 3129 | 3498 | 3967 | 4755 |
| 052 | 052 | 137 | 137 | 6064 | 5348 | 10369 | 11425 | 7550 | 6119 |
| 052 | 052 | 138 | 138 | 355 | 312 | 441 | 444 | 417 | 389 |
| 052 | 066 | 138 | 138 | 89 | 78 | 111 | 111 | 105 | 97 |
| 052 | 052 | 141 | 141 | 3194 | 2839 | 5720 | 6241 | 4107 | 3280 |
| 053 | 052 | 047 | 047 | 602 | 501 | 356 | 278 | 227 | 93 |
| 053 | 052 | 052 | 052 | 2742 | 3126 | 4069 | 4382 | 4140 | 3724 |
| 053 | 062 | 052 | 052 | 236 | 269 | 350 | 377 | 356 | 320 |
| 053 | 052 | 054 | 054 | 48 | 58 | 82 | 91 | 129 | 137 |
| 053 | 052 | 055 | 055 | 96 | 102 | 128 | 127 | 128 | 137 |
| 053 | 052 | 062 | 062 | 2777 | 3171 | 4213 | 4663 | 5099 | 5646 |
| 053 | 062 | 062 | 062 | 3557 | 4062 | 5396 | 5972 | 6531 | 7231 |
| 053 | 052 | 064 | 064 | 26 | 31 | 37 | 45 | 55 | 78 |
| 053 | 052 | 066 | 066 | 719 | 823 | 1017 | 1121 | 1491 | 1748 |
| 053 | 054 | 066 | 066 | 190 | 218 | 269 | 296 | 394 | 462 |
| 053 | 062 | 066 | 066 | 474 | 543 | 670 | 739 | 983 | 1152 |
| 053 | 052 | 114 | 114 | 67 | 58 | 106 | 118 | 112 | 92 |
| 053 | 062 | 114 | 114 | 83 | 72 | 131 | 147 | 138 | 114 |
| 053 | 062 | 115 | 115 | 1023 | 999 | 1006 | 1178 | 1287 | 1580 |
| 053 | 052 | 137 | 137 | 282 | 236 | 421 | 454 | 308 | 248 |
| 055 | 055 | 038 | 038 | 14941 | 13223 | 26550 | 28941 | 19169 | 15150 |
| 055 | 055 | 039 | 039 | 530 | 470 | 942 | 1029 | 687 | 547 |
| 055 | 115 | 039 | 039 | 3895 | 3451 | 6925 | 7564 | 5048 | 4024 |
| 055 | 055 | 046 | 046 | 8029 | 7106 | 14251 | 15568 | 10390 | 8286 |
| 055 | 115 | 046 | 046 | 7568 | 6698 | 13433 | 14674 | 9793 | 7810 |
| 055 | 047 | 047 | 047 | 26670 | 24163 | 17229 | 12855 | 9868 | 3867 |
| 055 | 055 | 047 | 047 | 3841 | 3480 | 2481 | 1851 | 1421 | 557 |
| 055 | 055 | 048 | 048 | 529 | 1752 | 933 | 717 | 602 | 266 |
| 055 | 049 | 049 | 049 | 979 | 1272 | 874 | 468 | 398 | 112 |
| 055 | 055 | 049 | 049 | 64590 | 83902 | 57679 | 30874 | 26288 | 7363 |
| 055 | 115 | 049 | 049 | 70 | 91 | 63 | 33 | 28 | 8 |
| 055 | 055 | 052 | 052 | 13506 | 17153 | 25796 | 27201 | 27701 | 30983 |
| 055 | 055 | 054 | 054 | 82568 | 97017 | 145567 | 179668 | 230943 | 264135 |
| 055 | 055 | 055 | 055 | 8840 | 10201 | 12942 | 20403 | 11253 | 8946 |
| 055 | 055 | 057 | 057 | 33 | 39 | 55 | 59 | 60 | 61 |
| 055 | 055 | 062 | 062 | 57331 | 78027 | 135129 | 153876 | 190626 | 217628 |
| 055 | 062 | 062 | 062 | 4369 | 5946 | 10298 | 11726 | 14527 | 16585 |
| 055 | 054 | 066 | 066 | 317 | 1235 | 1825 | 1943 | 2869 | 3148 |
| 055 | 062 | 066 | 066 | 665 | 2590 | 3829 | 4076 | 6020 | 6603 |
| 055 | 055 | 077 | 077 | 6158 | 5450 | 11589 | 12254 | 7223 | 5672 |
| 055 | 115 | 077 | 077 | 223 | 197 | 420 | 444 | 262 | 205 |
| 055 | 055 | 079 | 079 | 609 | 700 | 989 | 1065 | 1072 | 1093 |
| 055 | 115 | 079 | 079 | 211 | 242 | 343 | 369 | 372 | 379 |
| 055 | 055 | 081 | 081 | 2560 | 2268 | 4552 | 4972 | 3318 | 2647 |
| 055 | 055 | 089 | 089 | 1648 | 1493 | 3093 | 3317 | 2134 | 1681 |
| 055 | 115 | 089 | 089 | 145 | 131 | 272 | 292 | 188 | 146 |
| 055 | 055 | 091 | 091 | 1496 | 1325 | 2687 | 2859 | 1874 | 1495 |
| 055 | 062 | 091 | 091 | 17 | 15 | 31 | 32 | 21 | 17 |
| 055 | 115 | 091 | 091 | 11 | 10 | 20 | 21 | 14 | 11 |
| 055 | 115 | 113 | 113 | 167 | 191 | 270 | 291 | 293 | 299 |
| 055 | 055 | 114 | 114 | 5112 | 4596 | 9677 | 10413 | 6789 | 5301 |
| 055 | 062 | 114 | 114 | 139 | 125 | 263 | 283 | 185 | 144 |
| 055 | 115 | 114 | 114 | 1669 | 1500 | 3159 | 3400 | 2216 | 1731 |
| 055 | 055 | 115 | 115 | 11530 | 12360 | 13398 | 15600 | 16142 | 19751 |
| 055 | 062 | 115 | 115 | 1705 | 1828 | 1981 | 2307 | 2387 | 2921 |
| 055 | 115 | 115 | 115 | 1350 | 1447 | 1569 | 1827 | 1890 | 2313 |
| 055 | 115 | 135 | 135 | 67 | 78 | 110 | 119 | 120 | 122 |
| 055 | 055 | 137 | 137 | 6268 | 5660 | 11859 | 12837 | 8524 | 6688 |
| 055 | 115 | 137 | 137 | 735 | 664 | 1391 | 1505 | 1000 | 784 |
| 055 | 047 | 138 | 138 | 45 | 46 | 87 | 90 | 50 | 33 |
| 055 | 055 | 138 | 138 | 29805 | 30341 | 57613 | 59729 | 32964 | 22115 |
| 055 | 115 | 138 | 138 | 78 | 79 | 151 | 156 | 86 | 58 |

(Continued)

Table 34. (Continued)

| ORIGIN BEA | SHIPPING BEA | RECEIVING BEA | DESTINATION BEA | FOR COMMODITY GROUP 01 IN HUNDREDS OF TONS 1976 | 1980 | 1990 | 2000 | 2020 | 2040 |
|---|---|---|---|---|---|---|---|---|---|
| 055 | 055 | 915 | 915 | 6458 | 5715 | 11469 | 12529 | 8363 | 6665 |
| 065 | 066 | 062 | 062 | 294 | 362 | 431 | 472 | 509 | 593 |
| 065 | 065 | 065 | 065 | 12347 | 13125 | 15866 | 16878 | 17594 | 18323 |
| 065 | 066 | 065 | 065 | 161 | 171 | 207 | 220 | 229 | 239 |
| 065 | 065 | 066 | 066 | 35540 | 38596 | 47126 | 51711 | 54554 | 57717 |
| 065 | 066 | 066 | 066 | 60368 | 65560 | 80048 | 87835 | 92665 | 98038 |
| 065 | 066 | 138 | 138 | 89 | 79 | 158 | 157 | 90 | 95 |
| 066 | 066 | 038 | 038 | 78 | 69 | 118 | 200 | 271 | 356 |
| 066 | 066 | 048 | 048 | 22 | 0 | 0 | 0 | 0 | 0 |
| 066 | 066 | 049 | 049 | 5670 | 6169 | 8930 | 8227 | 7745 | 6804 |
| 066 | 062 | 052 | 052 | 314 | 332 | 552 | 607 | 598 | 598 |
| 066 | 066 | 052 | 052 | 17520 | 18519 | 30800 | 33884 | 33393 | 33341 |
| 066 | 066 | 055 | 055 | 60 | 0 | 0 | 0 | 0 | 0 |
| 066 | 062 | 062 | 062 | 1213 | 1198 | 1416 | 1789 | 1998 | 2319 |
| 066 | 066 | 062 | 062 | 29742 | 29385 | 34769 | 43869 | 48985 | 56667 |
| 066 | 066 | 064 | 064 | 98 | 0 | 0 | 0 | 0 | 0 |
| 066 | 065 | 065 | 065 | 3333 | 3350 | 3493 | 3840 | 4156 | 4516 |
| 066 | 066 | 065 | 065 | 787 | 791 | 825 | 907 | 981 | 1066 |
| 066 | 062 | 066 | 066 | 100 | 105 | 109 | 120 | 132 | 145 |
| 066 | 065 | 066 | 066 | 14228 | 14868 | 15537 | 17002 | 18824 | 20616 |
| 066 | 066 | 066 | 066 | 238765 | 249509 | 260731 | 285324 | 315886 | 345970 |
| 066 | 066 | 114 | 114 | 60 | 53 | 58 | 62 | 60 | 59 |
| 066 | 066 | 115 | 115 | 350 | 288 | 285 | 426 | 444 | 545 |
| 066 | 066 | 137 | 137 | 57 | 0 | 0 | 0 | 0 | 0 |
| 066 | 066 | 138 | 138 | 177 | 157 | 308 | 316 | 311 | 354 |
| 068 | 068 | 066 | 066 | 22 | 29 | 11 | 11 | 11 | 13 |
| 068 | 068 | 114 | 114 | 22 | 17 | 15 | 16 | 14 | 10 |
| 077 | 077 | 047 | 047 | 43 | 35 | 33 | 32 | 30 | 17 |
| 077 | 077 | 048 | 048 | 55 | 66 | 51 | 39 | 45 | 26 |
| 077 | 077 | 055 | 055 | 345 | 392 | 499 | 716 | 1399 | 2107 |
| 114 | 114 | 049 | 049 | 2820 | 2924 | 3725 | 3869 | 7312 | 5725 |
| 114 | 114 | 052 | 052 | 10200 | 11597 | 13413 | 21440 | 40045 | 53917 |
| 114 | 115 | 052 | 052 | 794 | 903 | 1044 | 1669 | 3117 | 4197 |
| 114 | 114 | 054 | 054 | 0 | 0 | 0 | 0 | 15000 | 42195 |
| 114 | 114 | 055 | 055 | 0 | 0 | 90000 | 100800 | 142830 | 173520 |
| 114 | 115 | 062 | 062 | 667 | 707 | 900 | 1207 | 2283 | 3387 |
| 114 | 114 | 066 | 066 | 0 | 0 | 0 | 17450 | 63675 | 117107 |
| 115 | 115 | 052 | 052 | 795 | 884 | 920 | 1058 | 1349 | 1422 |
| 115 | 115 | 062 | 062 | 766 | 816 | 1068 | 1255 | 1683 | 2020 |
| 115 | 055 | 089 | 089 | 45 | 34 | 52 | 67 | 63 | 68 |
| 115 | 055 | 115 | 115 | 850 | 772 | 657 | 841 | 1126 | 1560 |
| 118 | 118 | 066 | 066 | 534 | 595 | 703 | 941 | 1762 | 2570 |
| 137 | 137 | 055 | 055 | 223 | 257 | 2190 | 2572 | 3276 | 3885 |
| 138 | 138 | 047 | 047 | 40 | 33 | 44 | 42 | 60 | 68 |
| 138 | 138 | 052 | 052 | 33 | 36 | 38 | 50 | 86 | 120 |
| 138 | 138 | 055 | 055 | 245 | 279 | 331 | 465 | 871 | 1273 |
| 138 | 138 | 066 | 066 | 56 | 69 | 81 | 110 | 233 | 361 |
| 141 | 141 | 052 | 052 | 1380 | 1540 | 1822 | 2447 | 4582 | 6682 |
| 143 | 143 | 047 | 047 | 50 | 50 | 36 | 35 | 27 | 11 |
| 143 | 143 | 052 | 052 | 80 | 86 | 137 | 146 | 161 | 188 |
| 143 | 143 | 115 | 115 | 20 | 19 | 19 | 20 | 21 | 26 |
| 144 | 144 | 047 | 047 | 56 | 52 | 37 | 28 | 21 | 10 |
| 915 | 915 | 048 | 048 | 1450 | 3918 | 1781 | 1367 | 1523 | 857 |
| 915 | 915 | 052 | 052 | 4940 | 3957 | 8067 | 11441 | 20303 | 30579 |
| 915 | 915 | 062 | 062 | 100 | 115 | 150 | 249 | 498 | 550 |
| 915 | 915 | 066 | 066 | 96 | 182 | 339 | 533 | 2960 | 2700 |
| 915 | 915 | 115 | 115 | 3540 | 3101 | 2995 | 4322 | 8262 | 14241 |
| | | | TOTAL | 1165329 | 1303906 | 1834957 | 2041608 | 2281002 | 2536569 |

Note: BEA 915, which consists of counties of BEA 115 which are origins/destinations of waterborne movements shipped from/to points on the Mississippi River, also refers to supply areas for western coal as does BEA 114. For PSAs, the origin BEA is defined at the production point. Shipping and receiving BEAs refer only to waterborne portion of the flow from origin to the point of ultimate consumption.

Source: Robert R. Nathan Associates, Inc.

Table 35. Ohio River System: Growth Rates of Coal and Coke Waterborne Commerce, BEA to BEA, Projected 1976-2040, Selected Years

| BEA Pair[a] | Group No. | Index Value[b] | Year[c] 1976 | 1980 | 1990 | 2000 | 2020 | 2040 |
|---|---|---|---|---|---|---|---|---|
| 011066 | 01 | 1021 | 1000 | 1149 | 1358 | 1827 | 3421 | 4988 |
| 048048 | 01 | 5661 | 1000 | 1827 | 786 | 604 | 326 | 125 |
| 048052 | 01 | 45 | 1000 | 1067 | 1200 | 1422 | 1489 | 2000 |
| 048077 | 01 | 1836 | 1000 | 886 | 1430 | 1758 | 1619 | 1282 |
| 048089 | 01 | 189 | 1000 | 730 | 979 | 1365 | 1275 | 1048 |
| 048137 | 01 | 234 | 1000 | 756 | 1009 | 1265 | 1085 | 880 |
| 048138 | 01 | 7782 | 1000 | 386 | 1251 | 1792 | 2014 | 2120 |
| 049052 | 01 | 794 | 1000 | 1176 | 1523 | 1669 | 1792 | 1826 |
| 049062 | 01 | 667 | 1000 | 1127 | 1799 | 2015 | 2265 | 2604 |
| 050048 | 01 | 315 | 1000 | 1794 | 937 | 721 | 479 | 206 |
| 050052 | 01 | 236 | 1000 | 1102 | 1428 | 1559 | 1653 | 1445 |
| 050062 | 01 | 2683 | 1000 | 1025 | 1492 | 1650 | 1882 | 2202 |
| 050066 | 01 | 722 | 1000 | 1525 | 1861 | 2170 | 2521 | 2447 |
| 050114 | 01 | 56 | 1000 | 857 | 1536 | 1786 | 1607 | 1321 |
| 050115 | 01 | 682 | 1000 | 950 | 975 | 1154 | 1304 | 1647 |
| 050138 | 01 | 432 | 1000 | 722 | 1463 | 1572 | 1333 | 1072 |
| 051048 | 01 | 315 | 1000 | 1883 | 990 | 762 | 511 | 206 |
| 051052 | 01 | 3299 | 1000 | 1070 | 1426 | 1565 | 1575 | 1588 |
| 051055 | 01 | 39 | 1000 | 1077 | 1385 | 1410 | 1692 | 1846 |
| 051062 | 01 | 2533 | 1000 | 1060 | 1662 | 1799 | 1861 | 2194 |
| 051065 | 01 | 378 | 1000 | 1056 | 1286 | 1431 | 1556 | 1685 |
| 051066 | 01 | 5068 | 1000 | 1067 | 1359 | 1559 | 1934 | 2193 |
| 051114 | 01 | 210 | 1000 | 833 | 1629 | 1852 | 1905 | 1567 |
| 051115 | 01 | 54 | 1000 | 889 | 1056 | 1185 | 1241 | 1556 |
| 051137 | 01 | 186 | 1000 | 817 | 1452 | 1597 | 1398 | 1215 |
| 051138 | 01 | 446 | 1000 | 883 | 1253 | 1348 | 1309 | 1061 |
| 051141 | 01 | 168 | 1000 | 792 | 1470 | 1643 | 1435 | 1125 |
| 052047 | 01 | 2408 | 1000 | 890 | 691 | 496 | 389 | 204 |
| 052049 | 01 | 880 | 1000 | 1230 | 1358 | 1300 | 1188 | 1080 |
| 052052 | 01 | 92549 | 1000 | 1239 | 1935 | 2046 | 1897 | 1803 |
| 052054 | 01 | 192 | 1000 | 1813 | 2224 | 3375 | 3557 | 3750 |
| 052055 | 01 | 1144 | 1000 | 1219 | 1537 | 1347 | 1320 | 1272 |
| 052062 | 01 | 52125 | 1000 | 1149 | 1876 | 2318 | 2055 | 2321 |
| 052064 | 01 | 3838 | 1000 | 1219 | 5789 | 7124 | 9597 | 11780 |
| 052065 | 01 | 7182 | 1000 | 1166 | 1546 | 1752 | 1850 | 1967 |
| 052066 | 01 | 109010 | 1000 | 1219 | 1647 | 1760 | 2304 | 2578 |
| 052077 | 01 | 96 | 1000 | 885 | 1354 | 2083 | 3125 | 3646 |
| 052091 | 01 | 105 | 1000 | 886 | 1505 | 2381 | 1905 | 1524 |
| 052114 | 01 | 4508 | 1000 | 867 | 1626 | 1817 | 1203 | 987 |
| 052115 | 01 | 3506 | 1000 | 1040 | 1267 | 1416 | 1606 | 1925 |
| 052137 | 01 | 6064 | 1000 | 882 | 1710 | 1884 | 1245 | 1009 |
| 052138 | 01 | 444 | 1000 | 878 | 1243 | 1252 | 1176 | 1095 |
| 052141 | 01 | 3194 | 1000 | 889 | 1791 | 1954 | 1286 | 1027 |
| 053047 | 01 | 602 | 1000 | 832 | 591 | 462 | 377 | 154 |
| 053052 | 01 | 2978 | 1000 | 1140 | 1484 | 1598 | 1510 | 1358 |
| 053054 | 01 | 48 | 1000 | 1208 | 1708 | 1896 | 2688 | 2854 |
| 053055 | 01 | 96 | 1000 | 1063 | 1333 | 1323 | 1333 | 1427 |

(Continued)

Table 35. (Continued)

| BEA Pair[a] | Group No. | Index Value[b] | Year[c] 1976 | 1980 | 1990 | 2000 | 2020 | 2040 |
|---|---|---|---|---|---|---|---|---|
| 053062 | 01 | 6334 | 1000 | 1142 | 1517 | 1679 | 1836 | 2033 |
| 053064 | 01 | 26 | 1000 | 1192 | 1423 | 1731 | 2115 | 3000 |
| 053066 | 01 | 1383 | 1000 | 1145 | 1414 | 1559 | 2074 | 2431 |
| 053114 | 01 | 150 | 1000 | 873 | 1580 | 1767 | 1667 | 1373 |
| 053115 | 01 | 1023 | 1000 | 977 | 983 | 1152 | 1258 | 1544 |
| 053137 | 01 | 282 | 1000 | 837 | 1493 | 1610 | 1092 | 879 |
| 055038 | 01 | 14941 | 1000 | 885 | 1777 | 1937 | 1283 | 1014 |
| 055039 | 01 | 4425 | 1000 | 886 | 1778 | 1942 | 1296 | 1033 |
| 055046 | 01 | 15597 | 1000 | 885 | 1775 | 1939 | 1294 | 1032 |
| 055047 | 01 | 30511 | 1000 | 906 | 646 | 482 | 370 | 145 |
| 055048 | 01 | 529 | 1000 | 3312 | 1764 | 1355 | 1138 | 503 |
| 055049 | 01 | 65639 | 1000 | 1299 | 693 | 478 | 407 | 114 |
| 055052 | 01 | 13506 | 1000 | 1270 | 1910 | 2014 | 2051 | 2294 |
| 055054 | 01 | 82568 | 1000 | 1175 | 1763 | 2176 | 2797 | 3199 |
| 055055 | 01 | 8840 | 1000 | 1154 | 1464 | 2308 | 1273 | 1012 |
| 055057 | 01 | 33 | 1000 | 1182 | 1667 | 1738 | 1818 | 1848 |
| 055062 | 01 | 61700 | 1000 | 1361 | 2357 | 2684 | 3325 | 3796 |
| 055066 | 01 | 982 | 1000 | 3895 | 5758 | 6129 | 9052 | 9930 |
| 055077 | 01 | 6381 | 1000 | 885 | 1882 | 1990 | 1173 | 921 |
| 055079 | 01 | 820 | 1000 | 1149 | 1624 | 1748 | 1761 | 1795 |
| 055081 | 01 | 2560 | 1000 | 886 | 1778 | 1942 | 1296 | 1034 |
| 055089 | 01 | 1793 | 1000 | 906 | 1577 | 2013 | 1295 | 1020 |
| 055091 | 01 | 1524 | 1000 | 886 | 1796 | 1911 | 1253 | 999 |
| 055113 | 01 | 167 | 1000 | 1144 | 1617 | 1743 | 1754 | 1790 |
| 055114 | 01 | 6920 | 1000 | 899 | 1893 | 2037 | 1328 | 1037 |
| 055115 | 01 | 14585 | 1000 | 1072 | 1162 | 1353 | 1400 | 1713 |
| 055135 | 01 | 67 | 1000 | 1164 | 1642 | 1776 | 1791 | 1821 |
| 055137 | 01 | 7003 | 1000 | 903 | 1892 | 2048 | 1360 | 1067 |
| 055138 | 01 | 29928 | 1000 | 1018 | 1933 | 2004 | 1106 | 742 |
| 055915[d] | 01 | 6458 | 1000 | 885 | 1776 | 1940 | 1295 | 1032 |
| 065062 | 01 | 294 | 1000 | 1231 | 1466 | 1605 | 1731 | 1017 |
| 065065 | 01 | 12508 | 1000 | 1063 | 1285 | 1367 | 1425 | 1[illegible]84 |
| 065066 | 01 | 95908 | 1000 | 1086 | 1326 | 1455 | 1535 | 16[illegible]4 |
| 065138 | 01 | 89 | 1000 | 888 | 1775 | 1764 | 1011 | 1067 |
| 066038 | 01 | 78 | 1000 | 885 | 1513 | 2564 | 3474 | 4564 |
| 066048 | 01 | 22 | 1000 | 0 | 0 | 0 | 0 | 0 |
| 066049 | 01 | 5670 | 1000 | 1088 | 1575 | 1451 | 1366 | 1200 |
| 066052 | 01 | 17334 | 1000 | 1057 | 1758 | 1934 | 1906 | 1903 |
| 066055 | 01 | 60 | 1000 | 0 | 0 | 0 | 0 | 0 |
| 066062 | 01 | 30955 | 1000 | 988 | 1167 | 1475 | 1647 | 1912 |
| 066064 | 01 | 98 | 1000 | 0 | 0 | 0 | 0 | 0 |
| 066065 | 01 | 4120 | 1000 | 1005 | 1048 | 1152 | 1247 | 1355 |
| 066066 | 01 | 253093 | 1000 | 1045 | 1092 | 1195 | 1323 | 1449 |
| 066114 | 01 | 60 | 1000 | 883 | 967 | 1033 | 1000 | 983 |
| 066115 | 01 | 350 | 1000 | 823 | 814 | 1217 | 1269 | 1557 |
| 066137 | 01 | 57 | 1000 | 0 | 0 | 0 | 0 | 0 |

(Continued)

Table 35. (Continued)

| BEA Pair[a] | Group No. | Index Value[b] | Year[c] 1976 | 1980 | 1990 | 2000 | 2020 | 2040 |
|---|---|---|---|---|---|---|---|---|
| 066138 | 01 | 177 | 1000 | 887 | 1740 | 1785 | 1757 | 2000 |
| 068066 | 01 | 22 | 1000 | 1318 | 500 | 500 | 500 | 591 |
| 068114 | 01 | 22 | 1000 | 773 | 682 | 727 | 636 | 455 |
| 077047 | 01 | 43 | 1000 | 814 | 767 | 744 | 698 | 395 |
| 077048 | 01 | 55 | 1000 | 1200 | 927 | 709 | 818 | 473 |
| 077055 | 01 | 345 | 1000 | 1136 | 1446 | 2075 | 4055 | 6107 |
| 114049[d] | 01 | 2820 | 1000 | 1037 | 1321 | 1372 | 2593 | 2030 |
| 114052[d] | 01 | 10994 | 1000 | 1137 | 1315 | 2102 | 3926 | 5286 |
| 114054[d] | 01 | 15000 | 0 | 0 | 0 | 0 | 1000 | 2813 |
| 114055[d] | 01 | 90000 | 0 | 0 | 1000 | 1120 | 1587 | 1928 |
| 114062[d] | 01 | 667 | 1000 | 1060 | 1349 | 1810 | 3423 | 5078 |
| 114066[d] | 01 | 17450 | 0 | 0 | 0 | 1000 | 3649 | 6711 |
| 115052 | 01 | 795 | 1000 | 1112 | 1157 | 1331 | 1697 | 1789 |
| 115062 | 01 | 766 | 1000 | 1065 | 1394 | 1638 | 2197 | 2637 |
| 115089 | 01 | 45 | 1000 | 756 | 1156 | 1489 | 1400 | 1511 |
| 115115 | 01 | 850 | 1000 | 908 | 773 | 989 | 1325 | 1835 |
| 118066 | 01 | 534 | 1000 | 1114 | 1316 | 1762 | 3300 | 4813 |
| 137055 | 01 | 223 | 1000 | 1152 | 9821 | 11534 | 14691 | 17422 |
| 138047 | 01 | 40 | 1000 | 825 | 1100 | 1050 | 1500 | 1700 |
| 138052 | 01 | 33 | 1000 | 1091 | 1152 | 1515 | 2606 | 3636 |
| 138055 | 01 | 245 | 1000 | 1139 | 1351 | 1898 | 3555 | 5196 |
| 138066 | 01 | 56 | 1000 | 1232 | 1446 | 1964 | 4161 | 6446 |
| 141052 | 01 | 1380 | 1000 | 1116 | 1320 | 1773 | 3320 | 4842 |
| 143047 | 01 | 50 | 1000 | 1000 | 720 | 700 | 540 | 220 |
| 143052 | 01 | 80 | 1000 | 1075 | 1713 | 1825 | 2013 | 2350 |
| 143115 | 01 | 20 | 1000 | 950 | 900 | 1000 | 1050 | 1300 |
| 144047 | 01 | 56 | 1000 | 929 | 661 | 500 | 375 | 179 |
| 915048[e] | 01 | 1450 | 1000 | 2702 | 1228 | 943 | 1050 | 591 |
| 915052[e] | 01 | 4940 | 1000 | 801 | 1633 | 2316 | 4110 | 6190 |
| 915062[e] | 01 | 100 | 1000 | 1150 | 1500 | 2490 | 4980 | 5500 |
| 915066[e] | 01 | 90 | 1000 | 2022 | 3767 | 5922 | 32889 | 30000 |
| 915115[e] | 01 | 3540 | 1000 | 876 | 846 | 1221 | 2334 | 4023 |

a. The first three digits indicate the BEA of origin; the last three digits indicate the BEA of destination.

b. Hundreds of tons.

c. Growth rates are reported such that 1,000 equals the index value reported in the third column.

d. BEA 114 shipments include shipments of western coal.

e. BEA 915 refers to counties of BEA 115 which are origins and destinations of waterborne movements which are shipped from and to points on the Mississippi River and includes some shipments of western coal.

# V. APPENDIX

Table A-1. Ohio River Basin: Primary Study A
(BEAs and BEA segments)

BEA 47: Huntsville, AL
- Colbert, AL
- Franklin, AL
- Lauderdale, AL
- Lawrence, AL
- Limestone, AL
- Madison, AL
- Marshall, AL
- Morgan, AL
- Alcorn, MS
- Tishomingo, MS
- Franklin, TN
- Hardin, TN
- Lincoln, TN
- McNairy, TN
- Wayne, TN

BEA 48 (segment): Chattanooga, TN
- DeKalb, AL
- Jackson, AL
- Catoosa, GA
- Chattooga, GA
- Dade, GA
- Gordon, GA
- Murray, GA
- Walker, GA
- Whitfield, GA
- Bledsoe, TN
- Bradley, TN
- Grundy, TN
- Hamilton, TN
- Marion, TN
- McMinn, TN
- Meigs, TN
- Polk, TN
- Rhea, TN
- Sequatchie, TN

BEA 49: Nashville, TN
- Allen, KY
- Barren, KY
- Butler, KY
- Christian, KY
- Clinton, KY
- Cumberland, KY
- Edmonson, KY
- Logan, KY
- Metcalfe, KY
- Monroe, KY
- Simpson, KY
- Todd, KY
- Trigg, KY
- Warren, KY
- Benton, TN
- Cannon, TN
- Cheatham, TN
- Clay, TN
- Coffee, TN
- Davidson, TN
- Dekalb, TN
- Dickson, TN
- Giles, TN
- Hickman, TN
- Houston, TN
- Humphreys, TN
- Jackson, TN
- Lawrence, TN
- Lewis, TN
- Macon, TN
- Maury, TN
- Montgomery, TN
- Moore, TN
- Overton, TN
- Perry, TN
- Pickett, TN
- Putnam, TN
- Robertson, TN
- Rutherford, TN
- Smith, TN
- Steward, TN
- Sumner, TN
- Trousdale, TN
- Van Buren, TN
- Warren, TN
- White, TN
- Williamson, TN
- Wilson, TN

BEA 50: Knoxville, TN
- Bell, KY
- Harlen, KY
- Laurel, KY
- McCreary, KY
- Wayne, KY
- Whitley, KY
- Anderson, TN
- Blount, TN
- Campbell, TN
- Claireborne, TN
- Cocke, TN
- Cumberland, TN
- Fentress, TN
- Grainger, TN
- Hamiblen, TN
- Jefferson, TN
- Knox, TN
- Loudon, TN
- Monroe, TN
- Morgan, TN
- Roane, TN
- Scott, TN
- Sevier, TN
- Union, TN

BEA 51 (segment): Bristol, VA
- Carter, TN
- Greene, TN
- Hancock, TN
- Hawkins, TN
- Johnson, TN
- Sulivan, TN
- Unicol, TN
- Washington, TN
- Buchanan, VA
- Dickenson, VA
- Lee, VA
- Russell, VA
- Scott, VA
- Tazewell, VA
- Washington, VA
- Wise, VA
- McDowell, WV
- Mercer, WV

BEA 52: Huntington, WV
- Gallia, OH
- Lawrence, OH
- Meigs, OH
- Scioto, OH
- Boyd, KY
- Carter, KY
- Elliot, KY
- Floyd, KY
- Greenup, KY
- Johnson, KY
- Lawrence, KY
- Martin, KY
- Pike, KY
- Rowan, KY
- Boone, WV
- Braxton, WV
- Cabell, WV
- Calhoun, WV
- Clay, WV
- Fayette, WV
- Gilmer, WV
- Greenbrier, WV
- Jackson, WV
- Kanawha, WV
- Lincoln, WV
- Logan, WV
- Mason, WV
- Mingo, WV
- Monroe, WV
- Nicholas, WV
- Pochahontas, WV
- Putnam, WV
- Raleigh, WV
- Roane, WV
- Summers, WV
- Wayne, WV
- Webster, WV
- Wyoming, WV

BEA 53: Lexington, KY
- Adair, KY
- Anderson, KY
- Bath, KY
- Bourbon, KY
- Boyle, KY
- Breathitt, KY
- Casey, KY
- Clark, KY
- Estill, KY
- Fayette, KY
- Franklin, KY
- Garrard, KY
- Green, KY
- Harrison, KY
- Jackson, KY
- Jesamine, KY
- Knox, KY
- Lee, KY
- Letcher, KY
- Lincoln, KY
- Madison, KY
- Magoffin, KY
- Menifee, KY
- Mercer, KY
- Monroe, KY
- Morgan, KY
- Nicholas, KY
- Owsley, KY
- Perry, KY
- Powell, KY
- Pulaski, KY
- Rockcastle, KY
- Scott, KY
- Taylor, KY
- Wofle, KY
- Woodford, KY

BEA 54: Louisville,
- Clark, IN
- Crawford, IN
- Floyd, IN
- Harrison, IN
- Jefferson, IN
- Orange, IN
- Scott, IN
- Washington, IN
- Breckinridge, KY
- Bullitt, KY
- Grayson, KY
- Hardin, KY
- Hart, KY
- Henry, KY
- Jefferson, KY
- Larue, KY
- Marion, KY
- Meade, KY
- Nelson, KY
- Oldham, KY
- Shelby, KY
- Spencer, KY
- Trimble, KY
- Washington, KY

BEA 55: Evansville,
- Edwards, IL
- Gallatin, IL
- Hamilton, IL
- Lawrence, IL
- Saline, IL
- Wabash, IL
- White, IL
- Daviess, IN
- Dubois, IN
- Gibson, IN
- Knox, IN
- Martin, IN
- Perry, IN
- Pike, IN
- Posey, IN
- Spencer, IN
- Vanderburgh, IN
- Warrick, IN
- Caldwell, KY
- Crittenden, KY

Source: Robert R. Nathan Associates, Inc.

r Basin: Primary Study Areas for Coal and Coke
(BEAs and BEA segments)

BEA 54: Louisville, KY
- Clark, IN
- Crawford, IN
- Floyd, IN
- Harrison, IN
- Jefferson, IN
- Orange, IN
- Scott, IN
- Washington, IN
- Breckinridge, KY
- Bullitt, KY
- Grayson, KY
- Hardin, KY
- Hart, KY
- Henry, KY
- Jefferson, KY
- Larue, KY
- Marion, KY
- Meade, KY
- Nelson, KY
- Oldham, KY
- Shelby, KY
- Spencer, KY
- Trimble, KY
- Washington, KY

BEA [illegible]: Evansville, IN
- Edwards, IL
- Gallatin, IL
- Hamilton, IL
- Lawrence, IL
- Saline, IL
- Wabash, IL
- White, IL
- Daviess, IN
- Dubois, IN
- Gibson, IN
- Knox, IN
- Martin, IN
- Perry, IN
- Pike, IN
- Posey, IN
- Spencer, IN
- Vanderburgh, IN
- Warrick, IN
- Caldwell, KY
- Crittenden, KY
- Daviess, KY
- Henderson, KY
- Hopkins, KY
- Hancock, KY
- McLean, KY
- Mulhlenberg, KY
- Ohio, KY
- Union, KY
- Webster, KY

BEA 62: Cincinnati, OH
- Adams, OH
- Brown, OH
- Butler, OH
- Clermont, OH
- Clinton, OH
- Hamilton, OH
- Highland, OH
- Warren, OH
- Dearborn, IN
- Fayette, IN
- Franklin, IN
- Ohio, IN
- Ripley, IN
- Switzerland, IN
- Union, IN
- Boone, KY
- Bracken, KY
- Campbell, KY
- Carroll, KY
- Fleming, KY
- Gallatin, KY
- Grant, KY
- Kenton, KY
- Lewis, KY
- Mason, KY
- Owen, KY
- Pendleton, KY
- Robertson, KY

BEA 64: Columbus, OH
- Athens, OH
- Delaware, OH
- Fairfield, OH
- Fayette, OH
- Franklin, OH
- Guernsey, OH
- Hocking, OH
- Jackson, OH
- Licking, OH
- Madison, OH
- Marion, OH
- Morgan, OH
- Muskingum, OH
- Noble, OH
- Perry, OH
- Pickaway, OH
- Pike, OH
- Ross, OH
- Union, OH
- Vinton, OH
- Washington, OH
- Pleasants, WV
- Ritchie, WV
- Wirt, WV
- Wood, WV

BEA 65: Clarksburg, WV
- Barbour, WV
- Doddridge, WV
- Harrison, WV
- Lewis, WV
- Marion, WV
- Monongalia, WV
- Preston, WV
- Randolph, WV
- Taylor, WV
- Tucker, WV
- Upshur, WV

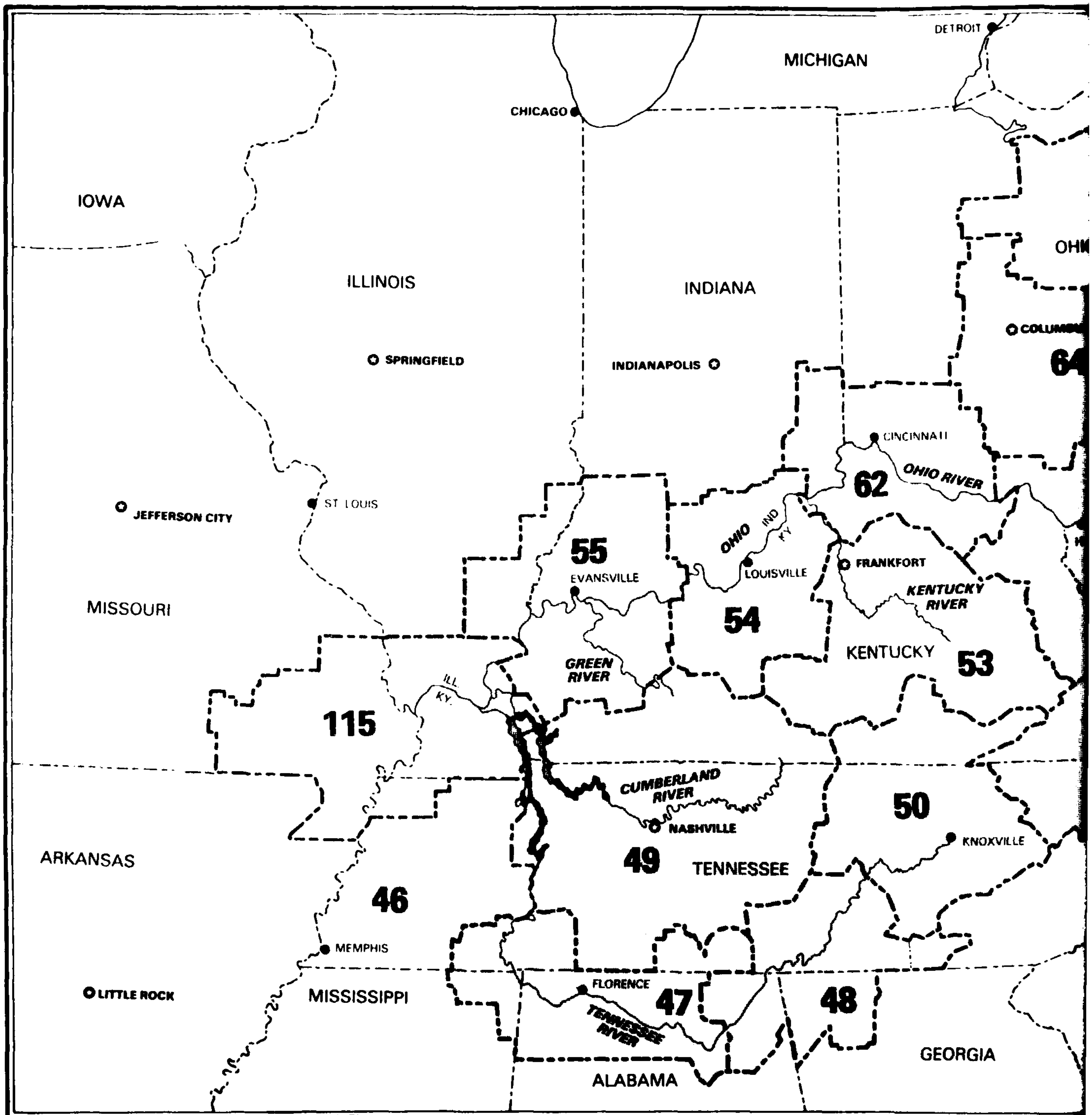
BEA 66: Pittsburgh, PA
- Allegheny, MD
- Garrett, MD
- Belmont, OH
- Harrison, OH
- Jefferson, OH
- Monroe, OH
- Allegheny, PA
- Armstrong, PA
- Beaver, PA
- Butler, PA
- Cambria, PA
- Clarion, PA
- Fayette, PA
- Greene, PA
- Indiana, PA
- Somerset, PA
- Washington, PA
- Westmoreland, PA
- Brooke, WV
- Hancock, WV
- Marshall, WV
- Ohio, WV
- Tyler, WV
- Wetzel, WV

BEA 68 (segment): Cleveland, OH
- Columbiana, OH
- Carroll, KY

BEA 115 (segment): Paducah, KY
- Johnson, IL
- Massac, IL
- Pope, IL
- Pulaski, IL
- Union, IL
- Ballard, KY
- Calloway, KY
- Graves, KY
- Livingston, KY
- Lyon, KY
- McCracken, KY
- Marshall, KY

7

MAP A-1. OHIO RIVER BASIN: PRIMARY STUDY AREAS FOR CO
(BEAS AND BEA SEGMENTS)




SOURCE: Robert R. Nathan Associates

Prim

-1. OHIO RIVER BASIN: PRIMARY STUDY AREAS FOR COAL AND COKE
(BEAS AND BEA SEGMENTS)

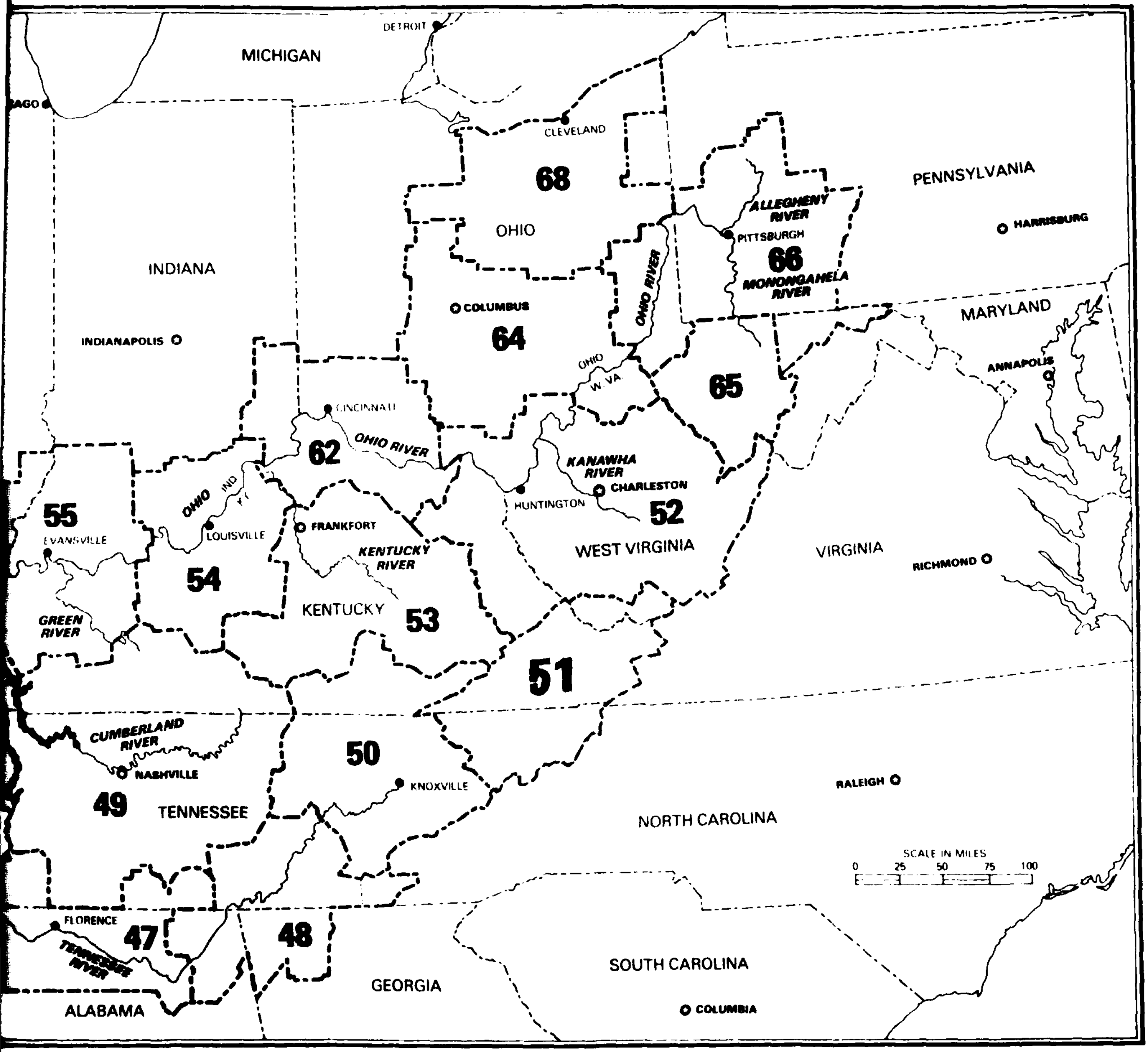


Table A-2. United States: Consumption of Coal by Region, 1976 and 1990

(Thousands of tons)

| Region | 1976 | 1990 |
|---|---|---|
| United States | 612,742 | 1,143,500[a] |
| New England[b] | 1,855 | 9,100 |
| New York and New Jersey | 16,288 | 41,600 |
| Mid Atlantic[c] | 118,652 | 157,000 |
| South Atlantic[d] | 142,361 | 286,700 |
| Midwest[e] | 227,202 | 326,000 |
| Southwest[f] | 22,060 | 147,900 |
| Central[g] | 34,946 | 74,300 |
| North Central[h] | 32,266 | 75,000 |
| West[i] | 11,855 | 17,600 |
| Northwest[j] | 5,257 | 8,300 |

Note: U.S. and regional coal consumption for 1975 and (projected) 1990 was provided by the U.S. Department of Energy (DOE). The 1976 U.S. figure was taken from table 4 and allocated to the ten regions using 1975's distribution factors. All estimates are based on DOE series C scenario (medium supply, medium demand).

a. Excluding 34 million tons of synthetic coal.

b. Region includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut.

c. Region includes Pennsylvania, Delaware, Washington, D.C., Maryland, Virginia, West Virginia, Puerto Rico, Virgin Islands.

d. Region includes Kentucky, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee.

e. Region includes Minnesota, Michigan, Wisconsin, Illinois, Indiana, Ohio, Canal Zone.

f. Region includes New Mexico, Texas, Oklahoma, Arkansas, Louisiana.

g. Region includes Kansas, Nebraska, Iowa, Missouri.

h. Region includes Montana, North Dakota, South Dakota, Wyoming, Colorado, Utah.

i. Region includes California, Nevada, Arizona, Hawaii, American Samoa, Guam.

j. Region includes Washington, Oregon, Idaho, Alaska.

Source: U.S. Department of Energy, "Appendix," <u>Annual Report to Congress</u>, 1977 ed., Vol. II, p. A-144.

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American Electric Power Company, Fuel Procurement Division, Lancaster, Ohio.

Amherst Industries, Inc., Cincinnati, Ohio and Port Amherst, Charleston, West Virginia.

Appalachia Power Company, Glasglow, West Virginia.

Big Rivers Electric Corporation, Henderson, Kentucky.

Cardinal Operating Company, Brilliant, Ohio.

Central Illinois Public Service Company, Springfield, Illinois.

Cincinnati Gas and Electric Company, Electric Production Division, Cincinnati, Ohio.

Columbus and Southern Ohio Electric Company, Fuel and Management Division, Columbus, Ohio.

Consolidated Coal Company, Osage, West Virginia and Marshall County, West Virginia.

Dayton Power and Light Company, Dayton, Ohio.

Duquesne Light Company, Pittsburgh, Pennsylvania.

East Kentucky Power Cooperative, Winchester, Kentucky.

Electric Energy, Inc., Joppa, Illinois.

Ford Coal Company, Coalburg, West Virginia.

Gatewate Coal Company, Labelle, Pennsylvania.

Gilbraltor Coal Corporation, Central City, Kentucky.

Green Coal Company, Owensboro, Kentucky.

Gulf Oil Company, Transport Department, Pittsburgh, Pennsylvania.

Hossier Electric Corporation, Energy Division, Bloomington, Indiana.

Indianapolis Power and Light Company, Indianapolis, Indiana.

Island Creek Coal Company, Hamilton, Kentucky.

Island Creek Coal Company, Uniontown, Kentucky.

Kentucky Utilities Company, Coal Procurement Division, Lexington, Kentucky.

Louisville Gas and Electric Company, Lousiville, Kentucky.

Marquette Cement Company, Neville Island, Pennsylvania.

Mathies Coal, Inc., Courtney, Pennsylvania.

National Mines Corporation, Isabelle, Pennsylvania.

National Steel Company, Transport Department, Pittsburgh, Pennsylvania.

Nemacolin Mines Corporation, McMurray, Pennsylvania.

North American Coal Corporation, Powhatan Point, Ohio.

Oglebay Norton Company, Ceredo, West Virginia.

Ohio Edison Company, Akron, Ohio.

Peabody Coal Company, Central City Kentucky and Shawnee, Illinois.

Pennsylvania Electric Company, New Castle, Pennsylvania.

Pittswick Coal, Inc., Morgantown, West Virginia.

Public Service Company of Indiana, Plainfield, Indiana.

Quarto Mining Company, Clairington, Ohio.

Rosedale Coal Company, Morgantown, West Virginia.

Ruane Arnold Coal Company, Marion, Pennsylvania.

Semet-Solvay (Division of Allied Chemicals, Inc.), Longacre, West Virginia and Ashland, Kentucky.

Shenango, Inc., Neville Island, Pennsylvania.

Southern Illinois Power Corporation, Marion, Illinois.

Southern Indiana Gas and Electric Company, Evansville, Indiana.

Union Carbide Corporation, Alloy, West Virginia and Riverview, Ohio.

U.S. Steel Corporation, Pittsburgh, Pennsylvania and Clariton, Pennsylvania.

Valley Camp Coal Company, Cleveland, Ohio.

Weirton Ice and Supply Company, Weirton, West Virginia.

Wheeling Pittsburgh Steel Corporation, Pittsburgh, Pennsylvania.

C. Associations, Government Agencies, and Educational Institutions

Kentucky Center for Energy Research, Lexington, Kentucky.

Oak Ridge National Laboratories, Energy Division, Oak Ridge, Tennessee.

Office of the Governor of West Virginia, Department of Community and Economic Development, Charlestown, West Virginia.

Ohio Department of Commerce and Community Development, Office of Research, Columbus, Ohio.

Ohio Department of Energy, Columbus, Ohio.

Ohio Department of Transportation, Division of Planning and Design, Columbus, Ohio.

Ohio State University, Department of Agriculture Economics, Columbus, Ohio.

Port Authority of Greater Pittsburgh, Pittsburgh, Pennsylvania.

Regional Industrial Development Corporation of Southwestern Pennsylvania, Pittsburgh, Pennsylvania.

Tennessee Valley Authority, Fossil Fuels Planning Branch, Chattanooga, Tennessee.

U.S. Environmental Protection Agency, Office of Energy, Minerals, and Industry, Office of Research and Development, Washington, D.C.

University of Kentucky, Department of Economics, Louisville, Kentucky.

University of Pittsburgh, Department of Economics, Pittsburgh, Pennsylvania.

University of Pittsburgh, School of Engineering, Pittsburgh, Pennsylvania.

University of Tennessee, College of Business Administration, Knoxville, Tennessee.

University of West Virginia, Department of Mineral Economics, Morgantown, West Virginia.

West Virginia Coal Association, Charleston, West Virginia.

West Virginia University, Department of Business and Economics, Morgantown, West Virginia.

D. Terminals, Barges and Towing Companies and Railways

Central Transfer Company, Inc., Caseyville, Kentucky.

Chessie System, Pittsburgh, Pennsylvania.

Cleancoal Terminals, Ghent, Kentucky.

East Bank Dock Company, East Bank, Virginia.

Kenova Terminal Company, Kenova, West Virginia.

Louisville and Nashville Railroad Company, Louisville, Kentucky.

Ohio River Company, Cincinnati, Ohio and Huntington, West Virginia.

River Road Terminals, Inc., Louisville, Kentucky.

River Transport Company, Cincinnati, Ohio.

Riverway Louisville Terminal Company, Louisville, Kentucky.

Sebree Dock, Sebree, Kentucky.

United Dock Company, Rochester, Kentucky.

Yankeetown Dock Corporation, Newburgh, Indiana.

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