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**THE DEVELOPMENT OF COAL-BASED TECHNOLOGIES
FOR DEPARTMENT OF DEFENSE FACILITIES**

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By

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By

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**Appendix A. Description of the 1,000 lb Steam/h Watertube
Research Boiler**

DESCRIPTION OF THE 1,000 LB STEAM/H WATERTUBE RESEARCH BOILER

The 1,000 lb steam/h watertube research boiler is a standard Cleaver Brooks "A-frame" watertube boiler with a maximum thermal input of 2 million Btu/h. A schematic diagram of the boiler and auxiliaries is given in Figure 1. The boiler operates at a maximum steam pressure of 200 psig. The combustion chamber is 3 ft wide, 3 ft high and 7'ft long, and designed for a maximum heat release rate of 42,000 Btu/ft³ h. The boiler contains 288 ft² of heating surface.

To promote evaporation and ignition of difficult-to-burn fuels, a ceramic quarl extends the length of the combustion chamber by two feet. The quarl and the boiler are preheated by burning natural gas prior to introducing of the test fuel. The preheated quarl acts as a source of radiant heat to help support the flame. Figure 2 shows the burner/nozzle /quarl section of the boiler.

Pulverized coal was fed from a two foot diameter hopper to an eductor via a 1.5-inch diameter screw feeder. The pulverized coal was entrained into an annular section and then through a swirler. The feed rate of pulverized coal was monitored by load cells.

The boiler is equipped with nine pairs of 3-inch diameter side ports for gaseous and particulate sampling. The combustion gases, at the end of the radiant section, are split into two convective passes, one on each side of the radiant combustion chamber. There are access doors into each end of the convective sections, two ash hoppers under each convective section (to collect ash when burning solid fuels), and a doorway into the combustion chamber. The gases exiting the convective section are cooled to below 500°F in an economizer located on top of the combustion chamber and then pass into a baghouse. The products of combustion (O₂, CO₂, CO, NO_x and SO₂) are monitored at the economizer outlet with a series of on-line gas analyzers. The baghouse contains sixteen 5 inches diameter by 8 ft long high-temperature fiber glass bags with out-to-in flow and pulse-jet cleaning.

Figure 1. SCHEMATIC DIAGRAM OF THE RESEARCH BOILER (1,000 lb/h Steam)
(not to scale)

Figure 2. SCHEMATIC DIAGRAM OF THE REFRACTORY QUARL AND BURNER

Appendix B. The Pennsylvania CGE Model

The Aggregation Scheme for the Pennsylvania CGE Model

Sector	Sector Definition	Two-Digit BEA Code
1	Agriculture	1-4
2	Mining, except energy	5-6, 9-10
3	Coal mining	7
4	Crude oil and natural gas	8
5	Construction	11-12
6	Manufacturing	13-30, 33-34, 39-64
7	Petroleum refining	31
8	Rubber and plastics	32
9	Glass	35
10	Stone	36
11	Primary iron and steel	37
12	Nonferrous metal	38
13	Transportation	65
14	Communication	66-67
15	Electric utility	68.01
16	Gas production and distribution	68.02
17	Trade and finance	68.03
18	Services	71-85

Note: Sectors 3, 4, 7, 15, and 16 form the energy aggregates.
Sectors 7 to 12 form the material aggregate.

Appendix. The Major Equations of the Pennsylvania CGE Model

A list of major equations of the Pennsylvania CGE model is as follows:

A. The production equations

The producers' technologies are defined by two-tiered Generalized Leontief (GL) cost functions.

• First tier

$$C_i = XD_i \sum_k \sum_l \alpha_{kl}^i (AP_{kj} AP_{lj})^{1/2} \quad (1)$$

with $\alpha_{kl}^i = \alpha_{lk}^i$, and $k, l = K, L, EN, MT$

where, C = Variable cost of production

XD = Regional production

AP = Price of aggregate inputs (K, L, EN, MT)

• Second tier

$$AP_{kj} = \sum_m \sum_n \gamma_{mn}^j (P_m P_n)^{1/2} \quad (2)$$

with $\gamma_{mn}^j = \gamma_{nm}^j$, $k = EN, MT$

and m, n = individual energy and materials

where, P = Price of composite goods

The input demand for labor and capital can be derived by applying Shephard's Lemma to the total GL cost functions (1):

$$PI_{kj} = XD_i \sum_l \alpha_{kl}^i (AP_{lj} / AP_{kj})^{1/2} \quad (3)$$

where, PI = Factor inputs (K, L)

The sector-specific factor prices for labor and capital are:

$$AP_{kj} = fds_j^k AP_k \quad \text{for } k = K, L \quad (4)$$

where, AP_{kj} = sector-specific factor prices for labor and capital

fds = Factor market distortion parameters

B. The trade equations

• Imports

Our model specifies the two-stage CES import equations. At the first stage, the composite goods consumptions, X_j , are CES aggregates of domestic goods, S_j , and foreign imports, M_j :

$$X_j = ac_j [\delta_j M_j^{-\rho_j} + (1 - \delta_j) S_j^{-\rho_j}]^{-1/\rho_j} \quad j = \text{traded goods} \quad (5)$$

At the second stage, domestic goods, S_j , are the aggregation of locally produced goods, XS_j , and domestic imports, RM_j :

$$S_j = ac_j [\bar{\delta}_j RM_j^{-\bar{\rho}_j} + (1 - \bar{\delta}_j) XS_j^{-\bar{\rho}_j}]^{-1/\bar{\rho}_j} \quad j = \text{traded goods} \quad (6)$$

The local prices of foreign imports, PM_j , are simply the exchange rate, EXR , multiplied by the tariff-impacted world prices, pwm_j :

$$PM_j = pwm_j (1 + tm_j) EXR \quad j = \text{traded goods} \quad (7)$$

The following two equations define the prices of composite goods, P_j , and the prices of domestic goods, PS_j :

$$P_j = (PM_j M_j + PS_j S_j) / X_j \quad (8)$$

$$PS_j = (prm_j RM_j + PXS_j XS_j) / S_j \quad (9)$$

From the consumer's utility maximization problem, imports from foreign countries can be represented as:

$$M_j = S_j \left(\frac{\delta_j}{1 - \delta_j} \frac{PS_j}{PM_j} \right)^{\eta_j} \quad j = \text{traded goods} \quad (10)$$

Regional imports can be specified as:

$$RM_j = XS_j \left(\frac{\bar{\delta}_j}{1 - \bar{\delta}_j} \frac{PXS_j}{prm_j} \right)^{\bar{\eta}_j} \quad j = \text{traded goods} \quad (12)$$

• Exports

This model adopts the two-stage CET export equations. At the first stage, total production, XD_i , is specified as a CET aggregate of domestic sales, D_i , and foreign exports, E_i :

$$XD_i = \alpha_i [\theta_i E_i^{\eta_i} + (1 - \theta_i) D_i^{\eta_i}]^{1/\eta_i} \quad i = \text{traded goods} \quad (13)$$

At the second stage, domestic sales, D_i , are the CET aggregations of local sales, XS_i , and exports to other regions, RE_i :

$$D_i = \bar{\alpha}_i [\bar{\theta}_i RE_i^{\bar{\eta}_i} + (1 - \bar{\theta}_i) XS_i^{\bar{\eta}_i}]^{1/\bar{\eta}_i} \quad i = \text{traded goods} \quad (14)$$

For tradable goods, the local prices of exports, PE_i , are the subsidized world prices, pwe_i , times the exchange rate:

$$PE_i = pwe_i (1 + te_i) EXR \quad i = \text{traded goods} \quad (15)$$

The prices of domestic productions, PXD_i , and the prices of domestic sales, PD_i , are defined as:

$$PXD_i = (PE_i E_i + PD_i D_i) / XD_i \quad (16)$$

$$PD_i = (pre_i RE_i + PXS_i XS_i) / D_i \quad (17)$$

Using the producers' cost minimization conditions, exports to foreign countries and shipments to other regions are respectively:

$$E_i = D_i \left(\frac{1 - \theta_i}{\theta_i} \frac{PE_i}{PD_i} \right)^{\eta_i} \quad i = \text{traded goods} \quad (18)$$

$$RE_i = XS_i \left(\frac{1 - \bar{\theta}_i}{\bar{\theta}_i} \frac{pre_i}{PXS_i} \right)^{\bar{\eta}_i} \quad i = \text{traded goods} \quad (19)$$

C. The demand equations

Demand can be classified as intermediate demand and final demand.

• Intermediate demand

By applying Shephard's Lemma to (1), the aggregate intermediate input demand for energy and materials, AIK_{kj} , is derived as:

$$AIK_{kj} = XD_j \sum_{k=1}^4 \alpha_{kj}^j (AP_{kj} / AP_{Xj})^{1/2} \quad k = \text{EN, MT} \quad (20)$$

Again, by applying Shephard's Lemma to (2), the disaggregated intermediate input demand for energy and materials is obtained as:

$$X_{mj} = AIK_{kj} \sum_{n=1}^5 \gamma_{mn}^j (\mu_n / \mu_m)^{1/2} \quad k = \text{EN, MT} \quad (21)$$

Intermediate input demands for other goods and services are specified by fixed coefficient Leontief technology. That is,

$$X_{ij} = a_{ij} XD_j \quad (22)$$

i = intermediate inputs other than energy and materials
where, a_{ij} = Leontief input coefficients

• Final demand

Aggregate household consumption demand is specified by the simplified linear expenditure system (LES):

$$P_i CD_i = \sum_h^1 sd_{ih} Y_h (1 - ms_h) (1 - ht_h^F - ht_h^{SL}) \quad (23)$$

where, CD = Personal consumption expenditure

Y = Household income

sd = Household consumption share

ms = Household savings rate

ht^F = Federal government household income tax rate

ht^{SL} = State and local government household income tax rate

Government consumption of the composite good i is modeled in terms of the value share of good i in the aggregate government expenditure:

$$GD_i^F = gs_i^F GDTOT^F \quad \text{for federal government} \quad (24)$$

$$GD_i^{SL} = gs_i^{SL} GDTOT^{SL} \quad \text{for state and local government} \quad (25)$$

Investment demand is divided into inventory investment demand and fixed investment demand. The inventory investment demand, DST_i , is assumed to be a fixed proportion of domestic production:

$$DST_i = dst_i XD_i \quad (26)$$

Total fixed investment, $FXDINV$, is thus the difference between total investment, $INVEST$, and the aggregate inventory investment:

$$FXDINV = INVEST - \sum_i^{18} DST_i P_i \quad (27)$$

The demand for new composite capital by sector i , DK_i , is defined as:

$$PK_j DK_j = k_{sj} FXDINV \quad (28)$$

where, PK_j = the price of new composite capital j .

The price vector, PK , is transformed from the price vector of composite goods, P , using the capital composition matrix, mt_{ij} :

$$PK_i = \sum_j^{18} P_j mt_{ij} \quad (29)$$

Finally, DK_j is transformed to investment goods by sector of origin, ID_i , through the use of the same capital composition matrix:

$$ID_i = \sum_j^{18} mt_{ij} DK_j \quad (30)$$

D. The income equations

Institutional incomes are defined respectively for the enterprise and labor accounts as follows:

$$YINSTK = \left(\sum_j^{18} AP_{Kj} K_j \right) + GTENT - ENTAX - ENTSAV - DEPREC \quad (31)$$

$$YINSTL = \left(\sum_j^{18} AP_{Lj} L_j \right) - SSTAX \quad (32)$$

where, $YINSTK$ = Total capital income

$GTENT$ = Transfer payments from federal govt to enterprise

$ENTAX$ = Enterprise tax revenue

$ENTSAV$ = Enterprise savings

$DEPREC$ = Total depreciation

$YINSTL$ = Total labor income

$SSTAX$ = Social security tax revenue

The institutional incomes are combined with other receipts and are apportioned to three types of households through distributional factors:

$$Y_h = th_h^K YINSTK + th_h^L YINSTL + gh_h^F HHT^F + gh_h^{SL} HHT^{SL} + rh_h REMIT \quad (33)$$

where, HHT^F = Transfer payments from federal govt to households

HHT^{SL} = State and local transfers to households

$REMIT$ = Net remittance from abroad

Government incomes are from tax revenues and borrowings:

$$GR^F = TARIFF + IND TAX^F + SSTAX + ENT TAX + HHTAX^F - NETSUB + CTAX + FBOR \cdot EXR \quad (34)$$

$$GR^{SL} = IND TAX^{SL} + HHTAX^{SL} + GOVTRANS^F \quad (35)$$

where, GR^F = Federal government revenue

$IND TAX^F$ = Federal indirect tax revenue

$HHTAX^F$ = Federal household tax revenue

$NETSUB$ = Total export subsidies

$CTAX$ = Carbon tax revenue

$FBOR$ = Net foreign borrowing

GR^{SL} = State and local government revenue

$IND TAX^{SL}$ = State and local indirect tax revenue

$HHTAX^{SL}$ = State and local household tax revenue

$GOVTRANS^F$ = Federal transfers to state and local govts

The total savings is:

$$SAVINGS = ENT SAV + DEPREC + HHS AV + GOV SAV^F + GOV SAV^{SL} + FSAV \cdot EXR + RSV \quad (36)$$

where, $ENT SAV$ = Enterprise savings rate

$HHS AV$ = Household savings

$GOV SAV^F$ = Federal government savings

$GOV SAV^{SL}$ = State and local government savings

$FSAV$ = Foreign savings

RSV = Net regional savings

E. Macro balances and closure equations

Macro balances are equilibrium identities that apply to the flow of funds. They are as follows:

Producer's equilibrium:

$$PXD_j XD_j = C_j + XD_j \sum_{i=1}^{18} P_i a_{ij} + (tx_j^F + tx_j^{SL}) PXD_j XD_j \quad (37)$$

Goods market clearing:

$$X_i = \sum_j X_{ij} + CD_i + GD_i^F + GD_i^{SL} + ID_i + DST_i \quad (38)$$

Government deficit balancing:

$$GR^F = \left(\sum_i P_i GD_i^F \right) + GTENT + HHT^F + GOVTRANS^F + GOV SAV^F \quad (39)$$

$$GR^{SL} = \left(\sum_i P_i GD_i^{SL} \right) + HHT^{SL} + GOV SAV^{SL} \quad (40)$$

Foreign exchange market clearing:

$$\sum_j p_{wmj} M_j = \sum_i p_{we_i} E_i + FSAV + REMIT + FBOR \quad (41)$$

Balance of domestic trade:

$$\sum_j p_{rmj} RM_j = \sum_i p_{re_i} RE_i + RSV \quad (42)$$

Appendix C. Phase II, Subtask 3.9: Coal Market Analysis

Phase II Final Report
Subtask 4.9
Coal Market Analysis

The Center for Energy and Mineral Policy Research
The College of Earth and Mineral Sciences
The Pennsylvania State University

**UNITED STATES COAL PRODUCTION AND CONSUMPTION
DEVELOPMENTS FROM 1947 TO 1992**

by D. Robert Crombie

With Introduction, Textual Comments, and Appendices by Richard L. Gordon

Introduction

At my request, Mr. Crombie undertook analysis of extensive data that other students and I assembled on the production, consumption, and distribution of coal in the United States. The analysis served as Mr. Crombie's M.S. thesis. The present report consists of an edited version of the thesis into which comments are inserted with the initials RLG appended to make clear that these are my additions and additional appendixes that (1) deal more fully with data source problems on which Mr. Crombie touched only briefly and (2) attempt to deal with the movements between 1960 and 1991 and problems of determining the experience of many key producing states that Mr. Crombie did not treat. In the latter case, heavy reliance was placed on graphics to facilitate my appraisal. The mass of charts produced was unfeasible to reproduce so that a verbal summary is provided.

The report concentrates on the 1960-1991 period. The critical influence on that choice is that data on energy consumption by state begin coverage with 1960 and do not appear until 18 months after the end of the last year covered. Thus, when Mr. Crombie began his work, the latest report was that issued in 1993 covering the period to 1991. By the time this report was edited, the data for 1992 had been published and are available on disk, but the enormous task of organizing them for use in updating Crombie's work had not been completed. My comments generally incorporate both the 1992 data and data on 1993 from other sources.

The attribution of authorship here follow my long-standing approach of not listing myself as an author when I did not undertake the writing. Had the increasingly widespread practice of naming as authors everyone who provided input been used, this would have been a joint effort of me, Mr. Crombie, Mikhail Nekrich, and Yulaing Li. Nekrich undertook the extremely tedious task of putting the U.S. government data on interregional coal flows into a more usable form (see appendix B). Li made numerous tabulations such as rearranging Nekrich's (and my) annual flow matrices into the time series format and completing work that I initiated on tabulating electric generation by state by fuel.

To check Crombie's calculations, the files from which they were generated were reopened, the critical material was copied into new files, and the tables were recalculated. It proved more convenient in many cases to change the format from that used by Crombie.

Richard L. Gordon
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ABSTRACT

Coal consumption and production in the United States declined from after the end of World War II until the early 1960s, when an increasing trend commenced. Although coal has historically been the main fuel for electric utilities, the electricity generation sector only accounted for 17 percent of coal use in 1949. However, electricity has gradually become the predominant market for coal, accounting for 86 percent of coal use in 1992. Not only has there been a shift in the shares of end-users as consumers of coal, but also the amount of coal consumed by electric utilities between 1947 and 1992 increased sharply, while coal use in other sectors declined.

The location of the growth in consumption and supply is related to the growth in electric utility coal use and the shift of coal from a multi-use fuel to a predominantly single use fuel. An analysis of principal coal consuming states revealed that the rate of increase of coal use by electric utilities was greater in the West than in the East. Furthermore, in the principal western coal consuming states, where coal is almost exclusively consumed by electric utilities, coal increased its share of an expanding electricity market. Coal lost share of the electricity market in nearly all the main eastern coal using states; however, the growth of electricity offset these losses, resulting in increased coal use by eastern utilities. Considering principal coal consuming states, more state energy in the West is in the form of electricity than in the East, and a greater proportion of state energy is generated by coal in the West than in the East.

Growth in coal output necessarily occurred for suppliers of the areas of increasing consumption. The majority of the growth in coal supply came from western states, particularly the Mountain region states, Texas in the West South Central region, and North Dakota in the West North Central region. The relatively low production costs and sulfur content of Wyoming and Montana coal have resulted in broad distribution of coal shipments from these states, enabling them to capture markets from Illinois Basin producers.

At least four major developments produced the differential use of coal by electric utilities across states: (1) the shift of the New England states to oil, (2) the emergence of nuclear power, (3) rising natural gas prices, and (4) increasing incremental costs of expanding hydropower projects.

D. Robert Crombie

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Foremost, the author would like to extend his appreciation to Dr. Richard L. Gordon, who not only acted as my thesis advisor, but also provided me with a plethora of coal data in a manageable format. Yuliang Li and Mikhail Nekrich also vastly simplified my data analysis through their previous work in constructing historical spreadsheets of coal data. Dr. Gordon arranged coal output data by state, national coal consumption and production figures, and was assisted by Yulaing Li in preparing state energy and electricity generation data. Coal distribution data were formatted by Dr. Gordon, Mikhail Nekrich, and Yuliang Li. (I did a number of the annual flow matrices that were generated, Nekrich did the majority of these tabulations, and Li undertook the conversions in to time series of the origins by end use for every destination and the destinations for every origin. RLG)

D. Robert Crombie

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CHAPTER 1

INTRODUCTION

Coal deposits are located across the 48 contiguous United States, as well as in Alaska. Production is often categorized as either western or eastern, the dividing line usually being the Mississippi River. The East is comprised of the Appalachian and Illinois Basin (or Midwest) regions.¹ Deposits in the West generally lie close to surface and are, on average, much thicker than eastern seams. Seams mined in the Powder River Basin, in Wyoming and southeastern Montana, average 70 feet in thickness, while Appalachian deposits average only 4 feet in thickness and tend to occur at deeper levels than western deposits (National Coal Association, 1992, p. 10). In 1992, the West accounted for 64 percent of surface production; about three quarters of all underground production came from Appalachia.

About a billion short tons of coal were produced in the U.S. in 1993. Regionally, 44 percent of this was from Appalachia, 45 percent from the West, and 11 percent from the Illinois Basin. Production in 1947 was over two-thirds of the 1993 level. However, the regional shares were strikingly different: Appalachia, 77 percent; the Illinois Basin, 17; the West, 6. Not only has production increased and shifted regionally since World War II, but also the share of production by mining method has sharply changed. In 1992, 59 percent of coal was produced by surface mining; in 1947, only 23 percent was produced by surface mining.

The consumption of coal has also markedly changed since the end of World War II. Coal consumption measured in British thermal units (Btus) was 58 percent greater in 1992 than in 1949. Similarly to production, consumption has undergone significant regional shifts as western states have increased coal use. Moreover, the composition of coal consumption has also been sharply altered. Coal, once a multi-use fuel, is now predominantly consumed by electric utilities. Electricity generation, which had a 17 percent share of coal consumption in 1949, accounted for over 86 percent of coal use in 1992.

This study reviews these developments. National trends from 1947 to 1992 are considered. However, consistent regionally disaggregated data are not available for all this period, and the stress is on the 1960 to 1991 period, on which consumption data were available at the time of writing. Particularly at the state level, the analysis focuses on comparing 1991 data with 1960 data, rather than studying trends between these dates for every state. (An appendix summarizes variations over the 31 year period. RLG)

The Quality of Coal

Coal quality is determined by its heating value, sulfur content, and ash content, the first two being the most important properties. (The ash content refers to the amount of noncombustible material in the coal.) Coal is categorized into one of four varieties, or ranks, which are based on heating value, hardness, and moisture content. Carbon content is an indicator of heating value and hardness. Anthracite is the highest ranking coal and has a heating value of approximately 15,000 Btu per pound. It is the hardest coal, with a carbon content ranging from 86-97 percent and less than a 15 percent moisture content. All anthracite production comes from Appalachia. In fact, anthracite is produced solely in Pennsylvania, although small occurrences exist elsewhere in the country. Bituminous coal follows anthracite in rank. Bituminous coal has a heating value that averages between 10,500-15,500 Btu per pound, a carbon content between 45-86 percent, and typically less than 20 percent moisture.

¹An alternative arrangement, used in Department of Energy coal production reports, is to define a central region consisting of the Illinois basin and mines in West Central states such as Texas and Missouri. (RLG)

Bituminous coal is mined principally in Appalachia and the Illinois Basin. Ranking below bituminous is subbituminous with a heating value of 8,300-10,500 Btu per pound, carbon content ranging from 35-45 percent, and 20-30 percent moisture. Subbituminous coal is found chiefly in the Mountain states: Wyoming, Montana, Utah, Colorado, and New Mexico. Washington and Alaska also have subbituminous deposits. The lowest ranking coal is lignite, referred to in many other countries as brown coal.² Lignite has the lowest heating value, usually between 4,000-8,300 Btu per pound. The carbon content is usually between 25-35 percent, while the moisture content can reach 45 percent. Lignite occurs primarily in Texas, North Dakota, Montana, and Louisiana.

In general, then, heating value declines from East to West. Due to the differing heating values of coal, consumption figures in this paper are presented in Btus, rather than short tons. In particular, this normalizes Texas consumption figures, which would be skewed upwards if tons were used, as Texas is a large consumer of lignite mined within the state. (The low heat content of lignite produces high transportation costs per million Btu, and to overcome this problem, lignite-burning facilities often are located near the mines. This is the case in Texas. Similarly, heat content, while an imperfect common denominator, is universally employed to convert fuel data into the forms in which the roles of fuels are compared. RLG)

In addition to heating value, the quality of coal became increasingly dependent upon sulfur content, as environmental legislation was imposed to reduce sulfur dioxide emissions. Western coal generally has a low sulfur content, Illinois Basin coal is generally high, and Appalachian coal varies considerably in sulfur content from one deposit to another.

Coal and the Environment

Environmental Considerations and Coal Production

Underground mining is typically considered to be less disruptive to the environment than surface mining. Surface subsidence and acid mine runoff are the principal problems associated with underground mining. Strip mining, in the absence of reclamation, can damage the natural features of the landscape and leave the land in a state that is unfit for other uses. Moreover, unreclaimed land is unattractive. In the hilly Appalachian region, both the potential for damage and reclaiming the land are more difficult than in the flatter western mining districts. Another concern is the potential for contamination of waterways and ground water. Disturbing the land exposes material that contains sulfur, which can react with rain to produce sulfuric acid. Water contamination is not as important a consideration in the arid western coal mining states. However, the dry land itself presents revegetation problems.

Environmental Considerations and Coal Consumption

Burning coal produces sulfur dioxide and particulate matter, both pollutants that have been associated with breathing disorders. Sulfur dioxide is considered the more pressing issue, as coal burning is a relatively insignificant source of particulates, and particulate control technologies are quite effective. Sulfur exists in two forms in coal: organic, in which the sulfur is bound to the coal, and pyritic, in which the sulfur is contained in pyritic particles not bound to the coal. If the sulfur is present in the pyritic form, washing the coal prior to burning can remove some of the pyritic particles. However,

² Since the U.S. once had a large, geographically separate anthracite industry and modest subbituminous and lignite production, U.S. data long separately reported anthracite and combined reporting of bituminous, subbituminous, and lignite. Elsewhere in the world, lignite tends to be separate and in some cases produced in large amounts, and anthracite is a minor part of output. Thus, anthracite, bituminous, and subbituminous are combined into hard coal, and lignite is reported separately. RLG

washing does not completely remove the sulfur. Controlling sulfur emissions is best accomplished by either burning lower sulfur coal or using a process to remove sulfur from the effluent gases during combustion. The most common device used to remove sulfur from the effluent is a stack gas scrubber.

An interaction occurs between the two most prominent coal industry environmental goals of reducing sulfur emissions and strip mining damage (Zimmerman, 1980, p. 11). As Zimmerman notes, these goals conflict because the incremental low sulfur coal supplies will largely come from the West and that coal will be produced by strip mining. A trade-off arises among sulfur pollution, strip mining, and the cost of attaining the environmental goals.

A review of the impacts of air pollution control regulations, particularly the Clean Air Act Amendments of 1970 and 1977, requires studying the trends in coal shipment data and electric utility coal use from 1970 to 1991. This study only treats the differences between 1960 and 1991 and does not trace the fluctuations in between. Therefore, impacts of air pollution control on coal use and output are not analyzed. Moreover, the impacts of the 1990 Amendments to the Clean Air Act will not be clearly discernible for a few years. However, an overview of the federal regulation governing emissions of sulfur dioxide and nitrogen oxides is presented.

The Clean Air Act Amendments of 1970 (amending the Clean Air Act of 1963) were the first aggressive step the federal government took in an attempt to control air pollution. A key feature of the 1970 amendments was the introduction of national emissions standards for new stationary sources of air pollution. The standards limited the amount of sulfur dioxide and nitrogen oxides certain classes of coal-fired boilers could emit. In setting the national emissions standards, the Environmental Protection Agency (EPA) in 1971 issued the New Source Performance Standards (NSPS) which required that electric utility coal-fired boilers with 73 megawatt output or greater, constructed or modified after August 1971 could emit no more than 1.2 pounds of sulfur dioxide per million Btus.

The 1977 Clean Air Act Amendments imposed more stringent pollution control standards than the 1970 amendments. New coal-fired plants were required to use the "best available control technology" (BACT) to limit emissions. Preliminary new NSPS were introduced in 1978 and revised in 1979. The preliminary standards maintained the 1.2 pounds of sulfur dioxide per million Btu of energy input limit; however, plants with 73 megawatt output capacity or greater, constructed or modified in 1978 or after, were required to remove 90 percent of the sulfur dioxide from their emissions. The 90 percent removal control applied to all coal types. Thus even low sulfur coal needed to have 90 percent of the sulfur removed, even if it met the 1.2 pound per million Btu limit.

In essence, this meant all coal had to be scrubbed as this was the only means of achieving a 90 percent reduction in the sulfur level. This restriction was a result of the EPA advocating stack gas scrubbing as, not only the best, but the only available control technology. In doing so, EPA precluded the use of low sulfur coal as means of compliance. The revisions in 1979 were more flexible. If 90 percent scrubbing reduced emissions below .6 pounds of sulfur dioxide per million Btu, then scrubbing reductions between 70 and 90 percent were permitted, based on the sulfur content of the coal.

BACT was strongly supported by a coalition of environmentalists and high sulfur eastern coal producers. High sulfur coal producers were motivated to support forced scrubbing because of its distributional implications. In short, forced scrubbing reduces low sulfur coal production in the West and increases demand for eastern coal. It would not make economic sense for eastern utilities to pay a premium to transport low sulfur western coal to the East if all coal had to be scrubbed. Eastern utilities would rather scrub high sulfur eastern coal. The more flexible NSPS revisions in 1979 somewhat compensated

western producers as scrubbing low sulfur coal to remove 70 percent of the sulfur dioxide is cheaper than removing 90 percent of the sulfur dioxide from high sulfur coal.

Environmentalists saw forced scrubbing as a way of achieving two goals. First, sulfur emissions will be reduced nationally, even if they may be higher in some areas where utilities find it cheaper to switch from low sulfur coal to scrubbing high sulfur coal. Second, reducing the demand for low sulfur coal would slow the development of western strip mining.

Ackerman and Hassler, in a review of the developments leading to the 1977 amendments, suggested that one of the chief problems in formulating the amendments was the EPA's lack of technical competence in dealing with scrubber technology (Ackerman and Hassler, 1981, p. 14). They claimed that, as a result of technical incompetence, the EPA was manipulated into advocating BACT by the scrubbing lobby--a lobby whose very success depended on avoiding focused debate on the status of scrubber technology (Ackerman and Hassler, 1981, p. 55). Ackerman and Hassler, among other critics of BACT, considered forced scrubbing an inefficient method of controlling pollution. They argued it is considerably more efficient to allow the polluters to determine the least costly means (for example, using low sulfur coal, washing with lower sulfur coal, or scrubbing) of meeting emission standards.

Little evidence is available that the NSPS in 1978-79 led to widespread installation of scrubbers in the East. In many of the principal eastern polluting states, very few coal-fired plants were constructed after revision of the NSPS in 1979. (BACT may have contributed to this development. RLG)

Major revisions to the Clean Air Act were passed in 1990. Title IV of these amendments required the EPA to establish an Acid Rain Program. A principal aim of this program is to reduce sulfur dioxide emissions from electric utilities by 10 million tons below their 1980 level by the year 2010. The plan is divided into two phases. Phase I commences in 1995 and sets limits for a number of the worst polluting units, identified by name in the act, all are located in the East or Midwest. Phase II begins in the year 2000 and further reduces limits for the Phase I plants and sets standards for smaller, less offensive plants.

Title IV of the amendments represents a break from the traditional command and control approach of specifying both limits and actions that must be undertaken by the polluters. Greater flexibility was achieved by establishing a system of emission allowances, or marketable permits. A set number of allowances are available, the total of which represents the acceptable limit for national sulfur dioxide emissions. The allowances are allocated to the Phase I plants based on a formula that considers the plant's sulfur dioxide emission rate and fuel consumption rate. Each allowance allows the holder to emit 1 ton of sulfur dioxide. Plants may not emit more sulfur dioxide than they hold in allowances. If they do, they can purchase additional allowances from plants that reduce their emissions below their number of allowances, or else they will be fined for exceeding their limit.

(However, the program starts with a major extension of command and control by naming in the law the specific units at individual plants that must reduce pollution. Then, tradability is supposed to lessen the impacts. Thus, the frequently expressed jubilation about adoption of market solutions is surely excessive and possibly baseless. RLG)

In a March 1994 Energy Information Administration (EIA) report, *Acid Rain Compliance Strategies for the Clean Air Act Amendments of 1990*, six options are listed for Phase I plants in complying with sulfur dioxide restrictions: (1) fuel switching or blending, (2) obtaining additional allowances, (3) installing scrubbers, (4) using controls previously implemented to comply with state regulations, (5) closing a facility, and (6) replacing an existing boiler with one using a different fuel or technology.

The EIA study concluded that significant impacts on coal distribution will arise, as more than half of the Phase I plants will meet the emission standards by fuel switching. This option appears attractive as the premium for low sulfur coal is sufficiently low and capital costs are typically lower for this option. The study indicated that utilities switching to low sulfur coal will buy over two-thirds of it from central Appalachia (eastern Kentucky, western Virginia, and southern West Virginia) and the remainder from the Powder River Basin in Wyoming and Montana. As noted, however, it is too early to quantify definitively the impacts of the 1990 amendments. (Low sulfur Appalachian coal supply historically proved more elastic than feared by producers and consumers, but the extent to which using this coal can economically be the best way to comply with the 1990 requirements can only be determined in the marketplace. RLG)

Study Overview

This study analyzes developments in United States coal production and consumption patterns between 1947 and 1992. As noted, the emphasis is on the period from 1960 to 1991. A primary objective is to establish a relationship between changes in location of coal production and changes in location and end-use in coal consumption. Chapter 2 reviews consumption and production trends at a national level. The consumption overview considers changes in the amount of coal consumed, the impact that changes in consumption by end-use have had on both, the shares of the end-use sectors as consumers of coal, and coal's share of total energy consumed in the end-use sectors. On the production side, the growth in output is presented, as are changes in the regional shares of production by both tons produced and method of mining.

Chapter 3 presents a more detailed analysis of the changing role of states as coal consumers and producing districts as coal suppliers between 1960 and 1992. Consumption trends are addressed first. The analysis begins by identifying the changes in location of coal use. The composition of the locational demand shifts are then analyzed by considering changes in end-use consumption. The emphasis is on the role of electric utility coal use as the principal factor in explaining differences in coal use across states. To a lesser extent, changes in coking coal use are considered. The production analysis also begins by establishing the changes in location of coal production. Coal shipment data are then used to track the flow of coal from origin to destination and the end-use of coal. This assesses the impact, in terms of tons of coal shipped, of changing consumption patterns on producing districts.

In Chapter 4, factors that explain the differential use of coal by electric utilities across states are presented. Included is both a national and regional review of electricity generation by method between 1947 and 1991. Lastly, Chapter 5 presents a summary and conclusions.

CHAPTER 2

OVERVIEW OF UNITED STATES CONSUMPTION AND PRODUCTION TRENDS FROM 1949 TO 1992

National Consumption Trends By End Use, 1949-1992

After reaching peak consumption levels during World War II, coal use declined until 1961, when a trend to increasing consumption commenced. The increasing trend has continued through 1992 (see table 2.1). The Btu share of coal in total United States energy consumption declined from 22 percent in 1960 to 17 percent in 1972 as a result of increased oil use. After 1972, coal's share increased, reaching a peak of 24 percent in 1985, and through 1992 coal's share of total energy has been just over 23 percent.

The general trends of declining consumption until 1960 and increasing thereafter are attributable to separate consuming-sector trends. Table 2.1 also presents a comparative overview of consumption changes by end use sector for 1949, 1960, and 1992. The most striking observation is the shift in coal consumption from a multi-use fuel to a predominantly single use fuel. Since 1949, coal use by electric utilities has steadily increased, recording a 711 percent increase in use between 1949 and 1992. Coal consumption by electric utilities increased in the period from the end of World War II until 1960, but these gains were more than offset by losses in other sectors. Coal use in the transportation sector was virtually eliminated by 1960 as diesel became the predominant fuel. At the same time, coal consumption in the residential and commercial sectors dropped almost 65 percent between 1949 and 1960 as these sectors converted to fuel oil and natural gas. It appears that it became increasingly uneconomic to use coal on a small scale in an environmentally acceptable manner (Gordon, 1978, p. 135). Significant declines were also recorded in the coking and other industrial (industries other than steel making and mining) sectors between 1949 and 1960, with 11 and 21 percent decreases in coal use respectfully:

The national downward trend in coal consumption ended in the early 1960s as the substantial growth in electric utility coal use was sufficient to outweigh losses in the other sectors (see table 2.2). Nonetheless, total coal consumption did not exceed the 1949 level until 1964, and the previous record level of 1947 was not matched until 1977. After 1960, little coal consumption in the transportation sector was left to lose. While residential and commercial consumption decreased by 95 percent between 1960 and 1992, the drop in consumption, measured in Btus, was less than half the drop experienced between 1949 and 1960. In fact, since 1978, no coal consumption by the transportation sector has been reported, and household and commercial use has been negligible since the early 1970s. Consumption trends in the coking coal and in the other industry sector have been more erratic; however, 1992 consumption in both sectors is considerably less than 1949 levels. Principally because of developments in the steel market, coking coal use was reduced by 50 percent between 1979 and 1983 and has not regained any of the losses.

Further insight into consumption trends is gained by considering how such developments have altered the relative share of end use sectors as coal consumers, and the relative share of coal as a percent of total energy consumption in each end use sector (see table 2.2). Looking first at the period between 1949 and 1960, the residential, commercial, and transportation sectors, which accounted for 38 percent of coal use in 1949, represented only 11 percent by 1960. A decline in coal use by the manufacturing sector reduced the other industrial share of overall coal consumption. Since the relative share of coal consumption in other sectors declined, or remained stable, that of electric utilities had to increase. This sector, accounting for 17 percent of coal use in 1949, accounted for 43 percent of total coal consumption by 1960.

Table 2.1
Coal Consumption in the United States 1949-1992
(Billion Btu)

Year	Resides	Coking	Q	Transportation	Electricity Generation	Total
1949	2,825,709	2,445,125	2,988,752	1,726,474	1,995,095	11,981,153
1950	2,802,787	2,783,046	2,999,147	1,562,925	2,199,093	12,347,172
1951	2,465,231	3,040,406	3,162,681	1,377,681	2,506,758	12,552,833
1952	2,248,335	2,616,055	2,901,158	983,523	2,557,448	11,306,353
1953	1,931,340	3,025,023	2,906,360	732,637	2,777,355	11,372,527
1954	1,682,845	2,288,479	2,441,317	461,162	2,840,701	9,714,669
1955	1,668,126	2,877,704	2,742,029	421,092	3,458,314	11,167,347
1956	1,553,524	2,838,468	2,828,282	339,876	3,789,672	11,349,711
1957	1,188,616	2,894,936	2,640,677	241,303	3,855,175	10,820,786
1958	1,164,007	2,052,344	2,480,503	115,091	3,721,414	9,533,237
1959	988,484	2,122,051	2,290,670	87,819	4,029,379	9,518,292
1960	991,996	2,171,202	2,372,010	74,944	4,227,608	9,837,831
1961	904,440	1,980,011	2,365,107	18,918	4,354,876	9,623,284
1962	882,691	1,990,222	2,394,287	16,871	4,622,359	9,906,462
1963	755,931	2,080,564	2,509,358	16,431	5,050,126	10,412,523
1964	652,963	2,378,688	2,535,954	17,412	5,379,586	10,964,711
1965	616,947	2,540,077	2,586,364	15,973	5,821,096	11,580,480
1966	611,899	2,569,906	2,645,079	14,754	6,301,645	12,143,120
1967	524,232	2,472,890	2,460,716	11,234	6,444,909	11,913,828
1968	472,025	2,432,502	2,422,252	10,022	6,993,751	12,330,328
1969	443,054	2,489,747	2,222,323	7,430	7,219,175	12,381,928
1970	373,886	2,573,041	2,083,158	6,846	7,227,387	12,264,313
1971	350,996	2,219,281	1,724,612	4,689	7,299,044	11,598,610
1972	269,261	2,338,890	1,654,466	3,674	7,810,555	12,076,998
1973	253,813	2,509,391	1,547,302	2,620	8,658,365	12,971,375
1974	256,647	2,405,220	1,464,956	1,794	8,534,196	12,662,705
1975	209,478	2,231,690	1,435,217	539	8,785,941	12,662,814
1976	203,049	2,259,883	1,400,649	270	9,720,440	13,584,384
1977	205,221	2,073,489	1,380,873	201	10,262,134	13,921,769
1978	213,673	1,904,890	1,408,648		10,238,154	13,765,199
1979	186,565	2,063,841	1,529,069		11,260,040	15,039,480
1980	145,446	1,782,012	1,373,006		12,122,628	15,422,881
1981	166,803	1,631,798	1,525,123		12,583,472	15,906,844
1982	187,004	1,095,048	1,456,938		12,582,444	15,321,580
1983	192,405	991,734	1,497,809		13,212,801	15,894,412
1984	208,560	1,178,878	1,663,284		14,019,761	17,070,555
1985	176,163	1,099,497	1,660,410		14,542,055	17,478,442
1986	175,938	961,906	1,678,604		14,443,943	17,260,554
1987	161,813	989,456	1,683,455		15,173,402	18,008,324
1988	168,058	1,121,392	1,706,171		15,849,938	18,845,609
1989	145,871	1,084,569	1,702,418		15,987,924	18,925,502
1990	155,573	1,040,992	1,714,988		16,189,303	19,101,483
1991	140,857	906,939	1,693,888		16,028,177	18,770,253
1992	142,009	897,130	1,686,586		16,185,210	18,916,434
	-64.9%	-11.2%	-20.6%	-95.7%	111.9%	-17.9%
Percent Change 1960-1992	-85.7%	-58.7%	-28.9%	-100.0%	282.8%	92.3%
Percent Change 1949-1992	-95.0%	-63.3%	-43.6%	-100.0%	711.3%	57.9%

Sources: Department of Energy, *Annual Energy Review 1992*, disk version.

Table 2.2
End Use Sectors Position as Coal Consumers
Versus Coal's Share of These Markets

a) End Use Consumption as a Percent of Coal Use 1949-1992

Year	Residential- Commercial	Coking Industrial	Other Industrial	Transportation	Electricity Generation	Total
1949	23.6%	20.4%	24.9%	14.4%	16.7%	100.0%
1950	22.7%	22.5%	24.3%	12.7%	17.8%	100.0%
1951	19.6%	24.2%	25.2%	11.0%	20.0%	100.0%
1952	19.9%	23.1%	25.7%	8.7%	22.6%	100.0%
1953	17.0%	26.6%	25.6%	6.4%	24.4%	100.0%
1954	17.3%	23.6%	25.1%	4.7%	29.2%	100.0%
1955	14.9%	25.8%	24.6%	3.8%	31.0%	100.0%
1956	13.7%	25.0%	24.9%	3.0%	33.4%	100.0%
1957	11.0%	26.8%	24.4%	2.2%	35.6%	100.0%
1958	12.2%	21.5%	26.0%	1.2%	39.0%	100.0%
1959	10.4%	22.3%	24.1%	0.9%	42.3%	100.0%
1960	10.1%	22.1%	24.1%	0.8%	43.0%	100.0%
1961	9.4%	20.6%	24.6%	0.2%	45.3%	100.0%
1962	8.9%	20.1%	24.2%	0.2%	46.7%	100.0%
1963	7.3%	20.0%	24.1%	0.2%	48.5%	100.0%
1964	6.0%	21.7%	23.1%	0.2%	49.1%	100.0%
1965	5.3%	21.9%	22.3%	0.1%	50.3%	100.0%
1966	5.0%	21.2%	21.8%	0.1%	51.9%	100.0%
1967	4.4%	20.8%	20.7%	0.1%	54.1%	100.0%
1968	3.8%	19.7%	19.6%	0.1%	56.7%	100.0%
1969	3.6%	20.1%	17.9%	0.1%	58.3%	100.0%
1970	3.0%	21.0%	17.0%	0.1%	58.9%	100.0%
1971	3.0%	19.1%	14.9%	0.0%	62.9%	100.0%
1972	2.2%	19.4%	13.7%	0.0%	64.7%	100.0%
1973	2.0%	19.3%	11.9%	0.0%	66.7%	100.0%
1974	2.0%	19.0%	11.6%	0.0%	67.4%	100.0%
1975	1.7%	17.6%	11.3%	0.0%	69.4%	100.0%
1976	1.5%	16.6%	10.3%	0.0%	71.6%	100.0%
1977	1.5%	14.9%	9.9%	0.0%	73.7%	100.0%
1978	1.6%	13.8%	10.2%	0.0%	74.4%	100.0%
1979	1.2%	13.7%	10.2%	0.0%	74.9%	100.0%
1980	0.9%	11.6%	8.9%	0.0%	78.6%	100.0%
1981	1.0%	10.3%	9.6%	0.0%	79.1%	100.0%
1982	1.2%	7.1%	9.5%	0.0%	82.1%	100.0%
1983	1.2%	6.2%	9.4%	0.0%	83.1%	100.0%
1984	1.2%	6.9%	9.7%	0.0%	82.1%	100.0%
1985	1.0%	6.3%	9.5%	0.0%	83.2%	100.0%
1986	1.0%	5.6%	9.7%	0.0%	83.7%	100.0%
1987	0.9%	5.5%	9.3%	0.0%	84.3%	100.0%
1988	0.9%	6.0%	9.1%	0.0%	84.1%	100.0%
1989	0.8%	5.7%	9.0%	0.0%	84.5%	100.0%
1990	0.8%	5.4%	9.0%	0.0%	84.8%	100.0%
1991	0.8%	4.8%	9.0%	0.0%	85.4%	100.0%
1992	0.8%	4.7%	8.9%	0.0%	85.6%	100.0%

Table 2.2

End Use Sectors Position as Coal Consumers Versus Coal's Share of These Markets

b) Coal Share in End Use

Year	Residential Commercial	Industrial	Electricity Generation	Total
1949	34.4%	38.1%	45.8%	39.3%
1950	31.6%	36.8%	46.8%	37.3%
1951	26.5%	36.2%	49.2%	35.4%
1952	23.6%	32.9%	47.7%	32.0%
1953	20.3%	33.6%	48.3%	31.4%
1954	17.2%	28.5%	49.0%	27.5%
1955	16.0%	29.8%	53.2%	28.8%
1956	14.2%	29.0%	54.3%	28.1%
1957	10.8%	28.2%	53.1%	26.7%
1958	10.0%	24.2%	51.5%	23.6%
1959	8.1%	22.5%	51.5%	22.6%
1960	7.6%	22.5%	51.6%	22.5%
1961	6.7%	21.5%	51.4%	21.6%
1962	6.2%	20.8%	51.2%	21.3%
1963	5.1%	20.9%	52.5%	21.5%
1964	4.3%	21.1%	52.1%	21.7%
1965	3.8%	21.2%	52.9%	22.0%
1966	3.6%	20.5%	52.5%	21.8%
1967	2.9%	19.2%	50.8%	20.7%
1968	2.5%	18.0%	50.4%	20.2%
1969	2.2%	16.8%	47.6%	19.3%
1970	1.7%	16.3%	44.4%	18.5%
1971	1.6%	13.8%	42.6%	17.1%
1972	1.1%	13.4%	42.2%	16.9%
1973	1.1%	12.9%	43.6%	17.5%
1974	1.1%	12.6%	42.6%	17.5%
1975	0.9%	12.9%	43.2%	17.9%
1976	0.8%	12.1%	45.1%	18.3%
1977	0.8%	11.1%	45.2%	18.2%
1978	0.8%	10.6%	43.2%	17.6%
1979	0.7%	11.0%	46.7%	19.1%
1980	0.6%	10.3%	49.5%	20.3%
1981	0.7%	10.8%	50.8%	21.5%
1982	0.7%	9.8%	51.8%	21.6%
1983	0.8%	9.7%	52.9%	22.5%
1984	0.8%	10.2%	53.9%	23.0%
1985	0.7%	10.1%	54.8%	23.6%
1986	0.7%	9.9%	54.1%	23.2%
1987	0.6%	9.6%	55.0%	23.4%
1988	0.6%	9.8%	55.3%	23.5%
1989	0.5%	9.5%	54.6%	23.3%
1990	0.5%	9.2%	54.7%	23.5%
1991	0.5%	8.8%	53.6%	23.1%
1992	0.5%	8.4%	54.8%	23.0%

Sources: Department of Energy, *Annual Energy Review 1992*, disk version.

During the period between 1960 and 1992, further reductions in coal use in the residential commercial and transportation sectors eroded their share's of the coal market. Residential and commercial consumption, which accounted for 10 percent of total coal consumption in 1960 (24 percent in 1949), was less than 1 percent in 1992. Analogously coal represented 8 percent of the fuel use in the residential and commercial sectors in 1960, but in 1992 coal accounted for less than 1 percent of that sector's fuel use. As noted, coal use was virtually eliminated from the transportation sector by 1978. The small remaining amounts are only reported separately in detailed reports.

Although the coking and other industrial sectors held their individual shares of total coal use between 20 and 25 percent from 1949 to 1960, both sectors had substantial drops in their relative shares between 1960 and 1992. Decreasing coking coal consumption, especially after the steel industry restructuring, meant that the coking sector only accounted 5 percent of coal use by 1992. Similarly, falling manufacturing coal use reduced the share of industrial consumption to 9 percent. Declines in coking and manufacturing coal use reduced the share of coal in total industrial fuel use from 23 percent in 1960 to 9 percent in 1992.

Electric utility coal use continued to grow in both absolute and relative terms. As shown in table 2.1, consumption in Btus increased 283 percent between 1960 and 1992. Increased consumption coupled with the declining relative shares of coal consumption in the other sectors, pushed the electric utility share of total coal consumption to 86 percent by 1992, representing a 43 percentage point increase in total consumption share since 1960.

The growth of the electricity share of the coal market, however, was not paralleled by a similar trend in coal's share of the electricity generation market. In 1960, coal held a 52 percent share of the electricity market and continued to hold a majority of the market until 1968. To some extent, coal was able to maintain this position because natural gas price controls resulted in shortages and curtailments in the interstate gas markets. By the late 1960s, gas was not considered an economically attractive fuel source for large new utility projects (Zimmerman, 1981, p. 1). Competition from oil reduced coal's share of the electricity market to a low of 42 percent in 1972, and it was not until 1981 that coal once again regained the majority of the market. (1981 was also the year that coal's share of total energy consumption started to increase). Between 1981 and 1992, coal's share ranged from a low of 51 percent to a high of 55 percent. The net result between 1960 and 1991 is that coal has only increased its share of the electricity market by 2 percent.

Although between 1960 and 1992, coal lost its market share in the residential, commercial, transportation, and industrial markets and only gained 2 percent in the electricity generation sector, changes in the composition of overall energy consumption offset these results (Gordon, 1978, p. 24). The salient point is that electricity gained an increasing share of the total United States energy market (see table 2.3). In 1960, electricity accounted for about 19 percent of energy consumption, while in 1992 the electricity share was almost 36 percent. Thus, even though coal has not significantly increased its share of the electricity market, the large use of coal by electric utilities, together with an increasing share of electricity in energy, and an 85 percent increase in total energy consumption since 1960, explain the increase in coal consumption since 1960.

National Production Trends 1947-1992

Following record coal production in 1947 of almost 688 million short tons, output declined until 1961, when only 61 percent of the 1947 level was produced. Since 1961, coal production has trended upward (see table 2.4), surpassing the 1947 mark in 1977, and exceeding 1 billion short tons in 1990. Output in 1993 was just under 1 billion short tons.

The growth in output since the mid 1960s consists predominantly of the increase in western production. Between 1960 and 1993 western production increased from 21 million

to 424 million short tons. Since eastern production has remained relatively flat, the western share of total coal production has ascended from 5 percent in 1960 to 45 percent in 1993.

The growth in western production is largely explained by four factors. First, in complying with regulations (for example, the Clean Air Act of 1963 and the amendments to this act in 1970 and 1977) that imposed limits on sulfur emissions, low sulfur western coal was an attractive alternative to implementing stack gas scrubbers, employing unproved technologies to reduce the sulfur content by cleaning the coal, or at the extreme, retrofitting. The second reason also stems from a regulatory development. The Coal Mine Health and Safety Act (CMHSA) of 1969 was enacted to improve worker health and safety in coal mines. The act affected underground mining more severely than surface mining. Additional miners were required underground to work on projects that increased safety in the mine. The result of increasing the number of men per shift employed in tasks that do not increase production is declining productivity in output per man-days. A 1980 benefit-cost study of the effects of the CMHSA in Illinois, eastern and western Kentucky, Ohio, Pennsylvania, and West Virginia indicated that productivity declined in all the states studied (Julian, 1980 p. 407). Underground mining costs also rose because of the increase in man-hours worked. Costs, however, were not only affected by the legislated safety measures designed to provide protection against the risks of underground mining. At the same time, as the industry expanded, younger coal miners, with a greater recognition of the hazards of their occupation, demanded higher wages as compensation for the risks they faced (Gordon, 1978, p. 6). Both decreasing worker productivity and rising labor costs encouraged the development of strip mining.

Deposits amenable to strip mining are relatively low cost because they are more capital intensive than deposits requiring underground mining. Technological developments in large scale mining equipment for strip mining further this advantage. Thus, strip mining is not burdened to the same degree as underground mining by rising real labor costs and decreasing worker productivity. The West benefited from these developments as a greater supply of strippable reserves is available in the West than in the hilly Appalachian region. Third, as previously noted, natural gas price controls resulted in gas supply problems in the late 1960s. In the West, lower cost coal from strip mines was an attractive economic alternative to natural gas. Lastly, western coal developed partly in response to new western demand centers. According to Zimmerman, these areas would use western coal simply because it is the lowest cost coal available, regardless of sulfur content (Zimmerman, 1981 p. 63).

As table 2.5 indicates, the majority of the coal produced in the United States since 1975 has been produced by surface mining. The West only accounted for approximately 11 percent of surface mining output in 1946. However, by 1992 the western share had risen to 63 percent (see table 2.5).

While the majority of surface production comes from the West, almost 92 percent of underground production is in the East, 75 percent from Appalachia. Although Appalachia's share of surface production was eroded from 65 percent in 1946 to 26 percent in 1992 because of increased western surface output, Appalachia has maintained at least a 75 percent share of total underground production since 1946.

The United States produces bituminous, subbituminous, lignite, and anthracite coals. Anthracite production, which comes entirely from Pennsylvania, accounted for 9 percent of total coal production in 1949; however, production has declined in virtually

Table 2.3
Coal and Electricity Share of U.S. Total Energy 1949-1992

Year	Total Energy Consumption Brillion Btu	Coal Share Of Total Energy	Electricity Share of Energy	Coal Share Of Electricity Generation	Electricity Share of Coal Consumption
1949	30,456,749	39.3%	14.3%	45.8%	16.7%
1950	33,077,955	37.3%	14.2%	46.8%	17.8%
1951	35,466,898	35.4%	14.4%	49.2%	20.0%
1952	35,302,332	32.0%	15.2%	47.7%	22.6%
1953	36,269,761	31.4%	15.9%	48.3%	24.4%
1954	35,268,783	27.5%	16.4%	49.0%	29.2%
1955	38,820,859	28.8%	16.7%	53.2%	31.0%
1956	40,376,695	28.1%	17.3%	54.3%	33.4%
1957	40,484,409	26.7%	17.9%	53.1%	35.6%
1958	40,349,253	23.6%	17.9%	51.5%	39.0%
1959	42,141,326	22.6%	18.6%	51.5%	42.3%
1960	43,801,879	22.5%	18.7%	51.6%	43.0%
1961	44,461,839	21.6%	19.0%	51.4%	45.3%
1962	46,532,654	21.3%	19.4%	51.2%	46.7%
1963	48,324,861	21.5%	19.9%	52.5%	48.5%
1964	50,496,035	21.7%	20.5%	52.1%	49.1%
1965	52,684,147	22.0%	20.9%	52.9%	50.3%
1966	55,658,722	21.8%	21.5%	52.5%	51.9%
1967	57,569,130	20.7%	22.1%	50.8%	54.1%
1968	60,999,041	20.2%	22.8%	50.4%	56.7%
1969	64,191,660	19.3%	23.7%	47.6%	58.3%
1970	66,430,608	18.5%	24.5%	44.4%	58.9%
1971	67,885,046	17.1%	25.3%	42.6%	62.9%
1972	71,258,268	16.9%	26.0%	42.2%	64.7%
1973	74,282,208	17.5%	26.7%	43.6%	66.7%
1974	72,542,904	17.5%	27.6%	42.6%	67.4%
1975	70,545,730	17.9%	28.8%	43.2%	69.4%
1976	74,362,016	18.3%	29.0%	45.1%	71.6%
1977	76,288,215	18.2%	29.8%	45.2%	73.7%
1978	78,088,990	17.6%	30.4%	43.2%	74.4%
1979	78,897,499	19.1%	30.6%	46.7%	74.9%
1980	75,955,287	20.3%	32.3%	49.5%	78.6%
1981	73,989,580	21.5%	33.5%	50.8%	79.1%
1982	70,847,899	21.6%	34.3%	51.8%	82.1%
1983	70,524,338	22.5%	35.4%	52.9%	83.1%
1984	74,144,063	23.0%	35.1%	53.9%	82.1%
1985	73,980,574	23.6%	35.8%	54.8%	83.2%
1986	74,296,846	23.2%	35.9%	54.1%	83.7%
1987	76,894,292	23.4%	35.9%	55.0%	84.3%
1988	80,217,808	23.5%	35.7%	55.3%	84.1%
1989	81,325,352	23.3%	36.0%	54.6%	84.5%
1990	81,264,753	23.5%	36.4%	54.7%	84.8%
1991	81,137,544	23.1%	36.9%	53.6%	85.4%
1992	82,360,067	23.0%	35.9%	54.8%	85.6%

Sources: Department of Energy, *Annual Energy Review 1992* , disk version.

Table 2.4				
U.S. Coal Production 1946-1993				
(Includes Pennsylvania Anthracite)				
a) Thousand Short Tons				
	USA with anthracite	Appalachia with Anthracite	Illinois Basin	West
1946	594,429	451,205	102,377	40,848
1947	687,814	527,583	115,491	44,740
1948	656,658	503,917	111,588	41,153
1949	480,570	362,442	81,787	36,341
1950	560,388	424,145	100,281	35,961
1951	576,365	446,224	95,541	34,599
1952	507,423	391,467	83,322	32,634
1953	488,240	374,532	83,136	30,572
1954	420,790	317,601	77,822	25,367
1955	490,838	375,839	88,392	26,607
1956	529,774	409,253	94,756	25,766
1957	518,042	401,551	91,839	24,652
1958	431,617	324,308	87,015	20,293
1959	432,677	322,473	89,885	20,319
1960	434,330	320,935	92,102	21,293
1961	420,423	307,684	90,964	21,776
1962	439,043	321,386	96,251	21,406
1963	477,196	350,938	102,552	23,706
1964	504,182	370,544	107,953	25,685
1965	526,954	386,281	113,248	27,425
1966	546,822	394,013	123,088	29,722
1967	564,882	405,679	130,295	28,909
1968	556,706	399,547	127,442	29,715
1969	570,978	405,402	132,274	33,302
1970	612,661	427,573	140,185	44,901
1971	560,919	382,308	127,617	50,993
1972	602,492	394,355	143,802	64,335
1973	598,567	381,628	140,504	76,436
1974	610,023	384,334	133,782	91,905
1975	654,641	402,690	141,017	110,934
1976	684,913	412,391	136,442	136,081
1977	697,205	399,672	133,596	163,938
1978	670,164	374,940	112,238	182,986
1979	781,134	429,526	130,178	221,430
1980	829,700	444,314	134,374	251,012
1981	823,775	433,007	120,854	269,914
1982	838,112	433,199	131,058	273,853
1983	782,091	383,110	124,283	274,697
1984	895,921	444,029	143,591	308,303
1985	883,638	427,192	131,538	324,909
1986	890,315	428,479	135,919	325,916
1987	918,762	443,280	138,648	336,831
1988	950,265	449,374	130,193	370,698
1989	980,729	464,458	134,557	381,714
1990	1,029,076	488,994	141,226	398,857
1991	995,984	457,808	133,486	404,690
1992	997,545	456,567	132,009	408,967
1993	943,824	414,502	104,913	424,409

Table 2.4				
U. S. Coal Production 1946-1993				
(Includes Pennsylvania Anthracite)				
b) Share of Total Production				
Year	Appalachia	Illinois Basin	West	Total
1946	75.9%	17.2%	6.9%	100.0%
1947	76.7%	16.8%	6.5%	100.0%
1948	76.7%	17.0%	6.3%	100.0%
1949	75.4%	17.0%	7.6%	100.0%
1950	75.7%	17.9%	6.4%	100.0%
1951	77.4%	16.6%	6.0%	100.0%
1952	77.1%	16.4%	6.4%	100.0%
1953	76.7%	17.0%	6.3%	100.0%
1954	75.5%	18.5%	6.0%	100.0%
1955	76.6%	18.0%	5.4%	100.0%
1956	77.3%	17.9%	4.9%	100.0%
1957	77.5%	17.7%	4.8%	100.0%
1958	75.1%	20.2%	4.7%	100.0%
1959	74.5%	20.8%	4.7%	100.0%
1960	73.9%	21.2%	4.9%	100.0%
1961	73.2%	21.6%	5.2%	100.0%
1962	73.2%	21.9%	4.9%	100.0%
1963	73.5%	21.5%	5.0%	100.0%
1964	73.5%	21.4%	5.1%	100.0%
1965	73.3%	21.5%	5.2%	100.0%
1966	72.1%	22.5%	5.4%	100.0%
1967	71.8%	23.1%	5.1%	100.0%
1968	71.8%	22.9%	5.3%	100.0%
1969	71.0%	23.2%	5.8%	100.0%
1970	69.8%	22.9%	7.3%	100.0%
1971	68.2%	22.8%	9.1%	100.0%
1972	65.5%	23.9%	10.7%	100.0%
1973	63.8%	23.5%	12.8%	100.0%
1974	63.0%	21.9%	15.1%	100.0%
1975	61.5%	21.5%	16.9%	100.0%
1976	60.2%	19.9%	19.9%	100.0%
1977	57.3%	19.2%	23.5%	100.0%
1978	55.9%	16.7%	27.3%	100.0%
1979	55.0%	16.7%	28.3%	100.0%
1980	53.6%	16.2%	30.3%	100.0%
1981	52.6%	14.7%	32.8%	100.0%
1982	51.7%	15.6%	32.7%	100.0%
1983	49.0%	15.9%	35.1%	100.0%
1984	49.6%	16.0%	34.4%	100.0%
1985	48.3%	14.9%	36.8%	100.0%
1986	48.1%	15.3%	36.6%	100.0%
1987	48.2%	15.1%	36.7%	100.0%
1988	47.3%	13.7%	39.0%	100.0%
1989	47.4%	13.7%	38.9%	100.0%
1990	47.5%	13.7%	38.8%	100.0%
1991	46.0%	13.4%	40.6%	100.0%
1992	45.8%	13.2%	41.0%	100.0%
1993	43.9%	11.1%	45.0%	100.0%
U.S. Department of Energy, Coal Production , various years.				

every subsequent year. By 1993 output was just over three million short tons, or less than .3 percent of total coal production. Since 1969, production of both subbituminous coal and lignite has steadily increased. In 1991 the percent share of total production for each type of coal was the following: bituminous: 65.5; subbituminous: 25.4; lignite: 8.8; and anthracite: .3.

Summary and Conclusions

In summary, coal consumption in the United States declined until 1960 and subsequently displayed an increasing trend through 1993. The most significant changes in consumption were the elimination of the transportation sector, the virtual elimination of the residential and commercial sectors, and the growth of coal use in electricity generation. On the production side, the trend of declining output between 1947 and 1960 was reversed, and since 1970 considerable growth in output prevailed, with a flat trend in the East and a marked increase in the West. The following chapter studies consumption and production trends at the state level in an effort to establish a relationship between the two.

Table 2.5
U.S. Coal Mining Methods 1946-1992

a. National Role

	Thousand Tons		Percent U.S.	
	Surface	Underground	Surface	Underground
1946	135,386	459,043	22.8%	77.2%
1947	159,622	528,192	23.2%	76.8%
1948	159,471	497,188	24.3%	75.7%
1949	121,716	358,853	25.3%	74.7%
1950	139,387	421,000	24.9%	75.1%
1951	133,945	442,389	23.2%	76.8%
1952	124,744	382,679	24.6%	75.4%
1953	120,795	367,444	24.7%	75.3%
1954	114,825	305,964	27.3%	72.7%
1955	132,874	357,964	27.1%	72.9%
1956	148,945	380,829	28.1%	71.9%
1957	144,777	373,265	27.9%	72.1%
1958	134,034	297,583	31.1%	68.9%
1959	139,828	292,849	32.3%	67.7%
1960	141,746	292,584	32.6%	67.4%
1961	140,873	279,551	33.5%	66.5%
1962	151,104	287,939	34.4%	65.6%
1963	168,224	308,971	35.3%	64.7%
1964	176,485	327,697	35.0%	65.0%
1965	188,996	337,958	35.9%	64.1%
1966	204,210	342,612	37.3%	62.7%
1967	212,493	352,391	37.6%	62.4%
1968	210,114	346,592	37.7%	62.3%
1969	221,740	349,238	38.8%	61.2%
1970	272,131	340,530	44.4%	55.6%
1971	283,745	277,175	50.6%	49.4%
1972	297,446	305,047	49.4%	50.6%
1973	298,488	300,079	49.9%	50.1%
1974	332,057	277,966	54.4%	45.6%
1975	361,174	293,467	55.2%	44.8%
1976	389,448	295,464	56.9%	43.1%
1977	430,616	266,591	61.8%	38.2%
1978	427,476	242,772	63.8%	36.2%
1979	460,243	320,891	58.9%	41.1%
1980	492,192	337,508	59.3%	40.7%
1981	507,279	316,496	61.6%	38.4%
1982	495,514	337,010	59.1%	40.2%
1983	478,315	298,320	61.2%	38.1%
1984	543,870	352,050	60.7%	39.3%
1985	532,838	350,800	60.3%	39.7%
1986	529,877	360,438	59.5%	40.5%
1987	545,888	372,874	59.4%	40.6%
1988	568,109	382,156	59.8%	40.2%
1989	586,893	393,835	59.8%	40.2%
1990	604,529	424,546	58.7%	41.3%
1991	588,759	407,225	59.1%	40.9%
1992	590,306	407,239	59.2%	40.8%

		Table 2.5			
Role of Mining Methods in U.S. Coal Production 1946-1992					

b. Role of Regions in Method

	Appalachian Share	Illinois Basin Share	West Share Surface	Appalachian Share Underground	Illinois Basin Share Underground	West Share Underground
1946	65.0%	24.3%	10.7%	79.1%	15.1%	5.7%
1947	64.4%	25.4%	10.2%	80.4%	14.2%	5.4%
1948	63.5%	26.5%	10.0%	81.0%	13.9%	5.1%
1949	61.3%	26.8%	11.9%	80.2%	13.7%	6.1%
1950	60.9%	28.6%	10.6%	80.6%	14.4%	5.0%
1951	60.4%	28.7%	11.0%	82.6%	12.9%	4.5%
1952	60.2%	28.3%	11.4%	82.7%	12.5%	4.8%
1953	60.3%	28.7%	11.0%	82.1%	13.2%	4.7%
1954	58.2%	30.1%	11.7%	82.0%	14.1%	3.9%
1955	59.1%	31.3%	9.6%	83.1%	13.1%	3.9%
1956	60.7%	30.9%	8.4%	83.7%	12.8%	3.5%
1957	60.0%	31.9%	8.1%	84.3%	12.2%	3.4%
1958	57.0%	35.2%	7.8%	83.3%	13.4%	3.3%
1959	56.6%	35.4%	8.0%	83.1%	13.8%	3.1%
1960	55.6%	36.1%	8.3%	82.8%	14.0%	3.2%
1961	54.4%	37.2%	8.4%	82.6%	13.8%	3.6%
1962	54.2%	37.3%	8.5%	83.2%	13.9%	3.0%
1963	54.3%	36.4%	9.2%	84.0%	13.4%	2.6%
1964	38.8%	37.9%	9.4%	84.7%	12.5%	2.8%
1965	52.6%	37.9%	9.5%	84.9%	12.3%	2.8%
1966	52.2%	38.6%	9.2%	84.4%	12.9%	2.7%
1967	50.8%	39.8%	9.4%	84.5%	13.0%	2.5%
1968	51.8%	38.6%	9.7%	83.9%	13.4%	2.7%
1969	53.2%	36.2%	10.6%	82.3%	14.9%	2.8%
1970	55.5%	31.8%	12.7%	81.2%	15.7%	3.1%
1971	57.1%	28.4%	14.5%	79.5%	17.0%	3.5%
1972	50.7%	31.0%	18.3%	79.8%	17.0%	3.2%
1973	49.5%	28.4%	22.1%	78.0%	18.6%	3.5%
1974	51.6%	23.9%	24.5%	76.6%	19.6%	3.8%
1975	49.4%	23.2%	27.4%	76.5%	19.4%	4.1%
1976	47.6%	20.8%	31.6%	76.9%	18.7%	4.4%
1977	46.7%	18.6%	34.7%	74.6%	20.0%	5.5%
1978	44.6%	16.1%	39.3%	76.0%	17.8%	6.2%
1979	39.4%	16.7%	43.9%	77.3%	16.6%	6.1%
1980	37.3%	16.1%	46.6%	77.2%	16.4%	6.4%
1981	36.8%	14.5%	48.7%	77.8%	15.0%	7.1%
1982	34.4%	15.5%	50.1%	76.4%	16.0%	7.6%
1983	30.9%	15.6%	53.5%	77.2%	16.6%	6.3%
1984	31.4%	15.7%	52.9%	77.6%	16.5%	5.9%
1985	29.1%	13.9%	57.0%	77.6%	16.3%	6.0%
1986	28.8%	13.6%	57.6%	76.5%	17.7%	5.8%
1987	29.2%	13.3%	54.1%	76.2%	17.7%	6.2%
1988	28.2%	11.2%	60.6%	75.6%	17.5%	6.9%
1989	28.3%	11.8%	59.9%	75.7%	16.5%	7.7%
1990	27.8%	11.9%	60.3%	75.6%	16.3%	8.1%
1991	26.3%	10.8%	63.0%	74.5%	17.2%	8.4%
1992	26.6%	10.0%	63.5%	73.6%	18.0%	8.4%
U.S. Department of Energy, <i>Coal Production</i> , various years.						

CHAPTER 3

STATE PATTERNS OF CONSUMPTION AND PRODUCTION FROM 1960 TO 1992

Introduction

Between 1960 and 1991, the coal industry experienced a number of both supply and demand side phenomena that altered production and consumption patterns. The development of any industry, including coal, is influenced by both endogenous and exogenous forces. Factors that are inherent to the coal industry can affect both consumption and production. Two of those affecting consumption are environmental restrictions on sulfur emissions and proximity to the source of coal production, as transportation rates are a significant portion of the cost of consuming coal. Examples of endogenous forces influencing production and development are technological advances, mining costs, notably labor, and environmental restrictions on strip mining. Exogenous factors to the coal industry can influence demand. The prices of alternate fuels, such as oil and natural gas, affect demand for coal, as does the demand for electricity and the development of the nuclear power industry. The goal of the present chapter is not to explain how these forces and others have resulted in demand and supply shifts. This chapter simply attempts to identify, at a state level, changes in location and end-uses in consumption, and changes in location of production, and establish a relationship between the two. Thus, in a descriptive fashion, it considers both the changing role of states as consumers and the changing role of producing areas as suppliers.

The next section analyses the changing role of states as coal consumers. The objective is to determine the locational changes in coal consumption and subsequently analyze the composition of the demand shifts by studying consumption changes by end-use. The consumption trends are supported with coal distribution data, reporting state purchases by end-use. Then, another section considers output developments by first identifying locational changes in coal production by state, and then attempting to determine what accounted for the changes in the role of producing areas as suppliers using data on coal shipments.

Four data sets are used in the analysis. The first contains annual consumption data by state. The consumption data were extracted from *State Energy Data Reports* issued by the Department of Energy. The reports separate consumption figures into five end-use categories--residential, commercial, industrial, transportation, and electric utility coal use (with the last also consumed by the first four sectors); coverage starts with 1960. The second data set of production data by state from 1947 to 1976 were extracted from either the coal chapters of different editions of the U. S. Bureau of Mines (USBM) *Minerals Yearbook* publication or the separate USBM publication on bituminous coal and lignite output. In 1977, the production report became the responsibility of the Energy Information Administration (EIA) of the Department of Energy and is issued under the title *Coal Production*.³ The third data set indicates annual flows of US. coal from producing districts to market. These data were supplied by the USBM in its *Bituminous Coal and Lignite Distribution* annual reports from 1957 to 1977, and its Department of Energy successor, *Coal Distribution*. As part of a depression era regulatory program, the USBM divided the country into coal producing districts. When distribution reports were established long after the program for which the districts were designed had vanished, these districts were chosen as the origin of shipments reported in the distribution data. Most of the districts do not coincide with state boundaries (see table 3.1).

³ EIA announced that the issue covering 1992 would be the last and an undetermined replacement publication would be introduced. As of December 1994, the nature of this new report has not been announced. (RLG)

(As table 3.1 attempts to indicate, using production districts as origins precludes directly determining the role of critical individual states such as West Virginia as suppliers of specific regions. RLG)

In 1990, the Department of Energy changed from districts of origin to states of origin; thus the analysis of coal flows only cover the period from 1960 to 1989. (After the 1991 issue, the *Coal Distribution* report was discontinued, but some of the information is contained in the EIA's *Quarterly Coal Report*).⁴ The coal flow data set has been arranged into two forms: a time series showing distribution of coal by district of origin (that is, district sales to individual states) and a time series showing coal distribution by destination (that is, state purchases from the various districts). The principal destinations were individual states, Canada, Mexico (until EIA aggregated it into other exports), and overseas. The emphasis here is on domestic shipment patterns. The state destination data has been separated into deliveries to four end-use groupings: electric utilities, coke plants, retail outlets (renamed residential and commercial by EIA), and Other (other industry by EIA). A fourth set is one constructed from multiple sources on electricity generation by source by state.

The Changing Role of States as Coal Consumers

This section initially presents and compares coal consumption by state for 1960 and 1991 to determine the location of coal consumption changes. Once the changing demand patterns have been established, the focus turns to analyzing the composition of the demand shifts. As noted, coal consumption for each state is subdivided into residential and commercial, industrial, and electric utility consumption. However, the emphasis is on the last two sectors, particularly the role of electric utility coal consumption. The last is the primary factor explaining the changing role of individual states as coal consumers. Total industrial use (coking and other) dropped prior to 1960 and fell sharply (43 percent) during the period 1960 to 1991.

Since, in 1960, the industrial coal markets were important in specific consuming states, the declines most severely affected such states and their coal suppliers. Consideration of the transportation and residential and commercial sectors is not necessary as consumption levels in each of these sectors were already relatively insignificant in 1960, and use continued steadily to decline between 1960 and 1991. In 1960, the combined residential and commercial sectors only accounted for 10 percent of total coal consumption, and transportation represented less than 1 percent. Between 1960 and 1991, coal consumption on a national level virtually was wiped out in the transportation sector, and an 85 percent decrease in use occurred in the residential and commercial sectors. On the state level, residential and commercial consumption decreased sharply for virtually every state. Any increases were negligible in absolute terms.

Coal Consumption of Individual States From 1960 to 1991

Table 3.2 shows total U.S. coal consumption for 1960 and 1991 for the fifty states, plus the District of Columbia. To facilitate identifying states where coal consumption has either decreased, stagnated, or grown, the states are arranged into groups based on how their coal consumption growth compared to the national rate of growth in coal use between 1960 and 1991. Although presentation of state coal consumption data in this format is most

⁴ This information is limited to totals of shipments by end use by sector to individual states from all origins and of shipments from individual states by sector to all destination. Breakdowns of transportation methods used are given (RLG)

Table 3.1**United States Coal Producing Districts and Consuming Regions**

PRODUCING REGIONS	PRODUCING STATES	DISTRICTS
Northern Appalachia	Pennsylvania, part northern West Virginia	1,2
	Maryland	
	rest northern West Virginia	3,6
	Ohio	4
Southern Appalachia	Southern West Virginia, Virginia	7,8
	East Kentucky, northern Tennessee,	
	Alabama, Georgia, Southern Tennessee	13
Midwest	Western Kentucky	9
	Illinois	10
	Indiana	11
West North Central	Iowa	12
	North Dakota	21
West South Central	Texas, Kansas, Oklahoma, Louisiana, Arkansas, Missouri	14,15
Mountain	Colorado, New Mexico, Arizona,	16,17,18
	Wyoming	19
	Utah	20
	Montana	22
Pacific	Washington, Alaska	23

Table 3.1**United States Coal Producing Districts and Consuming Regions****CONSUMING REGIONS****EAST:**

New England:
Connecticut
Maine
Massachusetts
New Hampshire
Rhode Island
Vermont

Middle Atlantic:
New Jersey
New York
Pennsylvania

East North Central:
Illinois
Indiana
Michigan
Ohio
Wisconsin

East South Central:
Alabama
Kentucky
Mississippi
Tennessee

South Atlantic:
Delaware
District of Columbia
Florida
Georgia
Maryland
North Carolina
South Carolina
Virginia
West Virginia

WEST:

West North
Central:
Iowa
Kansas
Minnesota
Missouri
Nebraska
North Dakota
South Dakota

West South
Central:
Arkansas
Louisiana
Oklahoma
Texas

Mountain:
Arizona
Colorado
Idaho
Montana
Nevada
New Mexico
Utah
Wyoming

Pacific:
Alaska
California
Hawaii
Oregon
Washington

Notes:

District 2 consists only of the western counties of Pennsylvania

District 7 has parts of Virginia and West Virginia

District 8 has parts of Virginia and West Virginia, all of eastern Kentucky, and northern Tennessee

District 14 is all of Arkansas and part of Oklahoma

District 15 is all of Texas, Missouri, Louisiana, Kansas, and the rest of Oklahoma

District 16 consists only of a part of Colorado

District 17 is the rest of Colorado and part of New Mexico

District 18 is the rest of New Mexico plus all of Arizona and California

suitable for identifying trends, a few relevant consumption features in table 3.2 are notable, but not clearly evident without some tabulation. These are indicated before looking at the different groupings.

Although the majority of the growth in coal consumption came from the West, as discussed, nine of the ten largest consumers in 1991 were still eastern states. The ten largest by rank of 1991 consumption were: Ohio, Pennsylvania, Indiana, Texas, Kentucky, West Virginia, Michigan, Illinois, Alabama, and Georgia. New York, Tennessee, and Virginia were among the ten largest consumers in 1960 but were replaced in 1991 by Texas, Kentucky, and Georgia.

In 1960, the ten largest consumers accounted for 74 percent of U.S. consumption, while in 1991 the ten largest users only consumed 53 percent of all coal consumed in the U.S. Similarly, in 1991, seventeen states had greater than a 2 percent share of U.S. consumption, while fifteen did in 1960; in 1991, thirty one states had greater than a 1 percent share of national consumption, while only twenty states did in 1960. These trends, coupled with the fact that total U.S. consumption increased 91 percent between 1960 and 1991, indicates that coal consumption has become less regionally concentrated.

The first group in table 3.2 consists of states that have been large consumers since 1960 but have grown at a rate below the national increase (91 percent) in coal consumption, comparing 1960 with 1991 (and in the worst cases showed declines). The states in this group are arranged in order of the worst percent growth performance to the best. All eleven states in this relatively poor growth group are from the East. Consumption for three states in this group--New York, Illinois, and Pennsylvania--actually decreased, although Pennsylvania remained the second largest coal consumer in the U.S. in 1991. Although Indiana's growth rate was below the national level, it did have the fourth largest absolute increase in coal consumption in the U.S. New York had the largest percent drop in consumption of all fifty states, using less than half the coal in 1991 as it did in 1960. This also resulted in New York registering the largest absolute decrease in coal use in the U.S. (Examination of the details shows that the New York decline arose with the shift to oil in the era of cheap oil in the 1960s and that most of the lost was not recovered. RLG) Even though eight states increased consumption, every state in this group necessarily decreased its share of total U.S. consumption. Pennsylvania registered the largest decline in the country as its share of U.S. consumption fell from 16 percent in 1960 to 7 percent in 1991.

The next groups consist of the states that showed greater than the national growth rate in coal consumption, ranked in order of the greatest growth to the least. One group of seven states have been relatively large consumers since 1960, and a second group of sixteen states were relatively small consumers in 1960 but were significant consumers by 1991. The selection of the dividing line was subjective. Of all these states, seventeen of the twenty three states are western; however, of the group that were relatively small consumers in 1960, fourteen of the sixteen states are western, primarily Mountain and southwestern states. The fourteen western states in this group only accounted for 3 percent of 1960 U.S. consumption. By 1991, their combined share of national consumption had risen to 25 percent.

Although other states had greater percentage increases (because of even lower initial levels), Texas had by the far the largest absolute increase in coal consumption in the U.S. between 1960 and 1991. Texas alone accounted for approximately 15 percent of the total

Table 3.2							
Growth in U.S. Coal Consumption by State, 1960-1991							
	Total Consumption Trillion Btus		Change	Percent Change	State Share U.S.		Change in U.S. Share
State	1960	1991			1960	1991	
United States	9,830.5	18,753.6	8,923.1	90.8%	100.0%	100.0%	
<i>a) Relatively Large Coal Consumers With Below National Growth Rate</i>							
New York (M.ATL)	691.6	344.4	(347.2)	-50.2%	7.0%	1.8%	-5.2%
Illinois (ENC)	914.7	757.7	(157.0)	-17.2%	9.3%	4.0%	-5.3%
Pennsylvania (M.ATL)	1,529.9	1,364.8	(165.1)	-10.8%	15.6%	7.3%	-8.3%
Ohio (ENC)	1,269.4	1,413.0	143.7	11.3%	12.9%	7.5%	-5.4%
Virginia (S.ATL)	316.4	356.6	40.1	12.7%	3.2%	1.9%	-1.3%
Michigan (ENC)	653.2	759.8	106.6	16.3%	6.6%	4.1%	-2.6%
Maryland (S.ATL)	226.6	274.8	48.1	21.2%	2.3%	1.5%	-0.8%
Wisconsin (ENC)	304.7	407.9	103.2	33.9%	3.1%	2.2%	-0.9%
Tennessee (ESC)	374.4	565.5	191.0	51.0%	3.8%	3.0%	-0.8%
Indiana (ENC)	795.1	1,340.1	545.0	68.5%	8.1%	7.1%	-0.9%
Alabama (ESC)	395.4	719.8	324.3	82.0%	4.0%	3.8%	-0.2%
Total	7,471.5	8,304.4	832.8	11.1%	76.0%	44.3%	-31.7%
<i>b) Relatively Large Coal Consumers With Above National Growth Rate</i>							
Missouri (WNC)	170.9	534.5	363.5	212.7%	1.7%	2.8%	1.1%
South Carolina (S.ATL)	96.4	290.9	194.5	201.8%	1.0%	1.6%	0.6%
Iowa (WNC)	115.9	346.4	230.5	198.9%	1.2%	1.8%	0.7%
Kentucky (ESC)	286.6	804.6	518.0	180.7%	2.9%	4.3%	1.4%
Minnesota (WNC)	131.3	300.6	169.3	128.9%	1.3%	1.6%	0.3%
North Carolina (S.ATL)	231.4	522.5	291.1	125.8%	2.4%	2.8%	0.4%
West Virginia (S.ATL)	354.5	799.7	445.3	125.6%	3.6%	4.3%	0.7%
Total	1,387.0	3,599.1	2,212.1	159.5%	14.1%	19.2%	5.1%

Table 3.2
Growth in U.S. Coal Consumption by State, 1960-1991

State	Total Consumption Trillion Btus		Change	Percent Change	State Share of U.S. Consumption		Change in U.S. Share
	1960	1991			1960	1991	
<i>c) Relatively Small Coal Consumers in 1960 With Above National Growth Rate</i>							
Arizona (MTN)	0.2	347.5	347.3	165,654.4 %	0.0%	1.9%	1.9%
Arkansas (WSC)	0.4	216.1	215.7	60,548.4 %	0.0%	1.2%	1.1%
Oklahoma (WSC)	1.8	291.6	289.8	15,865.9 %	0.0%	1.6%	1.5%
New Mexico (MTN)	4.1	234.0	229.9	5,654.7 %	0.0%	1.2%	1.2%
Texas (WSC)	25.0	1,333.1	1,308.1	5,236.8 %	0.3%	7.1%	6.9%
Nevada (MTN)	4.0	180.1	176.2	4,449.4 %	0.0%	1.0%	0.9%
Montana (MTN)	4.0	180.2	176.2	4,406.4 %	0.0%	1.0%	0.9%
Wyoming (MTN)	15.8	449.8	434.0	2,753.2 %	0.2%	2.4%	2.2%
Florida (S.ATL)	27.2	642.8	615.6	2,265.4 %	0.3%	3.4%	3.2%
Kansas (WNC)	15.7	268.7	253.0	1,609.0 %	0.2%	1.4%	1.3%
North Dakota (WNC)	30.5	379.2	348.7	1,141.9 %	0.3%	2.0%	1.7%
Nebraska (WNC)	20.0	152.0	132.0	659.4 %	0.2%	0.8%	0.6%
Georgia (S.ATL)	89.0	646.2	557.2	626.4 %	0.9%	3.4%	2.5%
Colorado (MTN)	68.2	321.8	253.6	371.7 %	0.7%	1.7%	1.0%
Utah (MTN)	91.0	345.0	254.0	279.2 %	0.9%	1.8%	0.9%
Louisiana (WSC)		214.3	214.3	#N/A	0.0%	1.1%	1.1%
Total	396.8	6,202.5	5,805.7	1,463.2 %	4.0%	33.1%	29.0%
Total Eastern States Above	8,556.5	12,011.1	3,454.6	40.4 %	87.0%	64.0%	-23.0%
Total Western States Above	698.8	6,094.9	5,396.1	772.2 %	7.1%	32.5%	25.4%

d) Insignificant Coal Consumers

Mississippi (ESC)	0.8	95.3	94.5	12,547.5 %	0.0%	0.5%	0.5%
New Hampshire (N.E.)	5.4	34.8	29.4	544.8 %	0.1%	0.2%	0.1%
Washington (PAC)	15.2	89.2	73.9	485.2 %	0.2%	0.5%	0.3%
South Dakota (WNC)	6.7	36.1	29.4	438.1 %	0.1%	0.2%	0.1%
Oregon (PAC)	8.9	32.8	23.8	266.2 %	0.1%	0.2%	0.1%
Delaware (N.E.)	20.5	56.8	36.3	177.4 %	0.2%	0.3%	0.1%
California (PAC)	35.9	64.0	28.1	78.2 %	0.4%	0.3%	0.0%
Alaska (PAC)	7.2	12.7	5.5	76.2 %	0.1%	0.1%	0.0%
Massachusetts (N.E.)	118.8	116.8	(1.9)	-1.6 %	1.2%	0.6%	-0.6%
Idaho (MTN)	16.8	12.3	(4.6)	-27.2 %	0.2%	0.1%	-0.1%
Maine (N.E.)	20.4	9.4	(11.1)	-54.2 %	0.2%	0.0%	-0.2%
New Jersey (M.ATL)	168.8	62.0	(106.8)	-63.3 %	1.7%	0.3%	-1.4%
Connecticut (N.E.)	101.7	22.6	(79.1)	-77.7 %	1.0%	0.1%	-0.9%
Vermont (N.E.)	3.5	0.3	(3.2)	-91.3 %	0.0%	0.0%	0.0%
Dist. of Columbia (M.ATL)	27.8	1.7	(26.1)	-94.1 %	0.3%	0.0%	-0.3%
Rhode Island (N.E.)	16.8	0.1	(16.7)	-99.4 %	0.2%	0.0%	-0.2%
Hawaii (PAC)		0.9	0.9	#N/A	0.0%	0.0%	0.0%
Total	575.2	647.6	72.4	12.6 %	5.9%	3.5%	-2.4%

Source: U.S. Department of Energy, *State Energy Data Report 1991*, disk version.

U.S. increase in coal consumption over the 31 years. Texas increased its share of U.S. consumption from .25 percent in 1960 to over 7 percent in 1991, a greater increase than any other state in the country. In the entire group of twenty three states, the four states that followed Texas in absolute increases in coal consumption over the thirty one year period were Florida, Georgia, Kentucky, and Wyoming. Kentucky had the largest absolute increase in coal use of traditionally large eastern consumers. Georgia climbed from the twenty third largest consumer in 1960 to the tenth largest in 1991, while Florida rose from the twenty eight to the eleventh largest. (While shown to maintain consistency, the growth ratios for states with low 1960 levels only show that a rise from a negligible level necessarily is a large percent change. RLG)

The last group of sixteen states and the District of Columbia are relatively insignificant coal consumers. Among others, this last group includes all six New England states--Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont, and all the Pacific states--California, Oregon, and Washington. (Stringent environmental regulation in California led utilities in the state to secure new generating capacity from coal and nuclear plants in the Mountain states. RLG)

Consumption patterns can be further analyzed using table 3.2 and the regional breakdown of states into consumption groups as displayed in table 3.1. Looking first at the East from a regional viewpoint, the New England states are all insignificant consumers with declining coal use, except New Hampshire experienced some growth, though negligible in absolute terms. The three Middle Atlantic states all showed declining coal consumption. New York and Pennsylvania had smaller percent changes, but larger absolute drops than New Jersey. (New Jersey also made a shift from coal in the 60s that was not reversed. RLG) The East North Central states, comprised entirely of traditionally large consumers, all registered slow consumption growth, with declining coal use in Illinois. The East South Central group of states showed lower than national growth rates from two of the three traditionally large consumers, Alabama and Tennessee. The exception was Kentucky. Mississippi showed strong growth, and in 1991 was one of the larger insignificant consumers.

As a whole, the South Atlantic states considerably increased their use of coal. They were led by large increases in Florida, Georgia, West Virginia, and North and South Carolina. In Maryland and Virginia, the other large consumers in the South Atlantic, consumption rose positive, but more slowly than the national rate. Recall from table 3.2 that the first group of large underperforming states were all eastern and included all five East North Central states, the only two significant consumers in the Middle Atlantic group (Pennsylvania and New York), two of the three significant consumers in the East South Central group (Alabama and Tennessee, but not Kentucky), and two of seven large consumers in the South Atlantic.

In summary, the New England states consume insignificant amounts of coal, the East North Central, Middle Atlantic, and the East South Central states, except for Kentucky and Mississippi experienced slow growth, while the South Atlantic states generally had strong growth, except in Maryland and Virginia. (The last underwent but reversed a shift to oil. RLG) The majority of the growth in coal consumption occurred in the West. Increases in western consumption accounted for 60 percent of the national increase in coal consumption from 1960 to 1991.

On a western regional level, all the Mountain states, with the exception of Idaho, an insignificant consumer with declining coal use, were small consumers in 1960 but increased their coal use at rates significantly greater than the national rate. This was also the case for the four West South Central states. The seven West North Central states all had greater than the national rate of consumption, three of these--Kansas, North Dakota, and

Nebraska--were small consumers in 1960. The Pacific states are all insignificant consumers.

Now that the locational changes in consumption have been identified, the end-use changes can be established and related to the locational consumption changes.

Declining Industrial Coal Consumption

Industrial coal consumption in the U.S. is centered in the East North Central states and Pennsylvania (in the Middle Atlantic region), the largest individual consumer in both 1960 and 1991. West Virginia and Virginia in the South Atlantic region are also relatively large industrial coal consumers. Table 3.3 presents industrial coal consumption by state, with the states arranged in the same groupings as table 3.2, less the insignificant coal consuming states. Within each group, the states are arranged first in descending order of the change in the industrial share of state coal consumption and then in descending order of absolute change. Nationally, industrial consumption accounted for 46 percent of total coal use in 1960. By 1991, it accounted for just 14 percent. The emphasis in this section is on coking coal consumption as it represents the largest single industrial use of coal. Coal used in making coke represented 48 percent of total industrial use in 1960. However, coking use fell by 58 percent between 1960 and 1991, reducing its share of total industrial consumption to 35 percent in 1991. Coke, manufactured from mixing various coals, then heating them in coke ovens, is an input in steel making. Thus, its consumption fluctuations reflect fluctuations in steel output.

Steel Market Developments

Traditionally steel production involves three steps: 1) charging iron ore and coke in blast furnaces to reduce the iron ore to pig iron, 2) steel making--molten pig iron, and other inputs are turned to steel in an oxygen furnace, and 3) steel finishing--casting the liquid steel into the shapes in which it is sold. Traditional producers that employ all of these steps are called integrated producers. As a primary step in steel production, most integrated producers manufacture their own coke.

Production of steel reached a peak in the U.S. in 1973. In subsequent years, until 1986, steel output fell at an average annual rate of five million tons (Lima 1989, p. 29). There was a corresponding drop in coking coal consumption. Prior to the early 1970s, coal consumed by coke plants had not exhibited any significant trends. However, coking coal consumption was 60 percent lower in 1986 than in 1973. A number of economic developments underlay the reduction in steel output, but coking coal demand was additionally affected by technological advances in steel production. The reasons for the decline in steel output are considered first.

U.S. integrated producers were faced with declining domestic demand for steel after 1973. U.S. apparent steel consumption dropped by four million tons annually between 1973 and 1983 (Lima, 1989, p. 27). Substitution of other materials for steel and the more efficient use of steel were two of the factors behind the diminished demand.

Import competition, a third factor underlying the demand reduction, stemmed from increased international trade in both raw materials used in steel making and in steel products. Steel production capacity emerged in countries that previously were not steel producers. Countries such as South Korea, Brazil, and to a lesser extent South Africa, Mexico and Venezuela, were able to secure the inputs to steel production at prices similar to traditional producers. Moreover, these countries had labor cost advantages over industrialized country producers that outweighed capital cost disadvantages and were quicker to adopt new cost saving production technologies than the U.S. integrated producers. The result was U.S. integrated producers were faced with import competition as the U.S. became a net importer of steel. The substitution of other materials for steel,

Table 3.3
Industrial Coal Consumption for Principal Coal Consuming States, 1960
and 1991

State	Industrial Coal Consumption Trillion Btus		Change	Percent Change 1960-1991	Industrial Share of State Coal Consumption		Percent Change 1960- 1991
	1960	1991			1960	1991	
United States	4,547.9	2,600.4	(1,947.4)	-42.8%	46.3%	13.9%	-32.4%

Ranking by Change in Industrial Share in Coal

a) Relatively Large Consumers With Below National Average Growth

Maryland	135.0	52.8	(82.2)	-60.9%	59.6%	19.2%	-40.3%
Michigan	332.0	92.5	(239.5)	-72.1%	50.8%	12.2%	-38.6%
Ohio	664.3	216.8	(447.6)	-67.4%	52.3%	15.3%	-37.0%
Alabama	209.9	145.5	(64.4)	-30.7%	53.1%	20.2%	-32.9%
Pennsylvania	873.1	337.6	(535.5)	-61.3%	57.1%	24.7%	-32.3%
Indiana	431.8	321.6	(110.2)	-25.5%	54.3%	24.0%	-30.3%
Wisconsin	116.6	45.6	(71.0)	-60.9%	38.3%	11.2%	-27.1%
New York	311.9	82.2	(229.7)	-73.6%	45.1%	23.9%	-21.2%
Illinois	338.8	156.8	(182.0)	-53.7%	37.0%	20.7%	-16.3%
Tennessee	58.1	93.5	35.4	60.8%	15.5%	16.5%	1.0%
Virginia	114.9	134.3	19.4	16.9%	36.3%	37.7%	1.4%
Total	940.3	512.4	(427.9)	-45.5%	12.6%	6.2%	-6.4%

b) Relatively Large Consumers With Above National Average Growth

West Virginia	204.4	108.1	(96.3)	-47.1%	57.7%	13.5%	-44.1%
Missouri	62.2	28.7	(33.5)	-53.8%	36.4%	5.4%	-31.0%
South Carolina	44.7	55.8	11.1	24.8%	46.4%	19.2%	-27.2%
Iowa	51.7	59.3	7.6	14.8%	44.6%	17.1%	-27.5%
Kentucky	95.9	73.8	(22.1)	-23.1%	33.5%	9.2%	-24.3%
Minnesota	55.2	15.2	(40.0)	-72.5%	42.0%	5.1%	-37.0%
North Carolina	61.6	67.8	6.2	10.1%	26.6%	13.0%	-13.6%
Total	371.3	300.6	(70.6)	-19.0%	26.8%	8.4%	-18.4%

Table 3.3
Industrial Coal Consumption for Principal Coal Consuming States, 1960
and 1991

	Industrial Coal Consumption Trillion Btus		Change	Percent Change 1960-1991	Industrial Share of State Coal Consumption		Percent Change 1960- 1991
State	1960	1991			1960	1991	
<i>c) Relatively Small Consumers in 1960 With Above National Average Growth</i>							
Arkansas	0.4	6.8	6.5	1,853.3%	98.3%	3.2%	-95.1%
Arizona	0.2	13.7	13.5	6,567.1%	98.3%	4.0%	-94.3%
Texas	24.4	63.2	38.8	158.8%	97.8%	4.7%	-93.0%
Nevada	3.2	4.6	1.4	44.8%	79.6%	2.5%	-77.0%
Utah	70.5	43.7	(26.8)	-38.0%	77.5%	12.7%	-64.8%
New Mexico	2.4	0.9	(1.5)	-63.4%	59.4%	0.4%	-59.0%
Colorado	36.6	15.6	(21.1)	-57.5%	53.7%	4.8%	-48.9%
Nebraska	9.0	6.1	(2.8)	-31.6%	44.8%	4.0%	-40.7%
Oklahoma	0.6	16.1	15.5	2,395.0%	35.3%	5.5%	-29.8%
Kansas	4.0	3.6	(0.3)	-8.5%	25.2%	1.3%	-23.8%
Montana	0.8	5.2	4.4	531.6%	20.6%	2.9%	-17.7%
Georgia	13.9	52.8	38.9	279.4%	15.6%	8.2%	-7.5%
Wyoming	2.4	41.8	39.4	1,615.8%	15.5%	9.3%	-6.2%
North Dakota	7.7	84.3	76.6	992.5%	25.3%	22.2%	-3.0%
Florida	-	28.5	28.5	#N/A	0.0%	4.4%	4.4%
Louisiana	-	10.3	10.3	#N/A		4.8%	4.8%
Total	176.1	397.2	221.1	125.5%	44.4%	6.4%	-38.0%
Eastern Total	3,996.0	2,042.6	(1,953.4)	-48.9%	46.7%	17.0%	-24.6%
Western Total	342.1	442.5	100.4	29.4%	49.0%	7.3%	-41.8%

Table 3.3
Industrial Coal Consumption for Principal Coal Consuming States, 1960
and 1991

State	Industrial Coal Consumption Trillion Btus		Change	Percent Change 1960-1991	Industrial Share of State Coal Consumption		Percent Change 1960-1991
	1960	1991			1960	1991	
Ranking by Change in BTU							
<i>d) Large Consumers With Below National Average Growth</i>							
Pennsylvania	873.1	337.6	(535.5)	-61.3%	57.1%	24.7%	-32.3%
Ohio	664.3	216.8	(447.6)	-67.4%	52.3%	15.3%	-37.0%
Michigan	332.0	92.5	(239.5)	-72.1%	50.8%	12.2%	-38.6%
New York	311.9	82.2	(229.7)	-73.6%	45.1%	23.9%	-21.2%
Illinois	338.8	156.8	(182.0)	-53.7%	37.0%	20.7%	-16.3%
Indiana	431.8	321.6	(110.2)	-25.5%	54.3%	24.0%	-30.3%
Maryland	135.0	52.8	(82.2)	-60.9%	59.6%	19.2%	-40.3%
Wisconsin	116.6	45.6	(71.0)	-60.9%	38.3%	11.2%	-27.1%
Alabama	209.9	145.5	(64.4)	-30.7%	53.1%	20.2%	-32.9%
Virginia	114.9	134.3	19.4	16.9%	36.3%	37.7%	1.4%
Tennessee	58.1	93.5	35.4	60.8%	15.5%	16.5%	1.0%
<i>e) Large Consumers With Above National Average Growth</i>							
West Virginia	204.4	108.1	(96.3)	-47.1%	57.7%	13.5%	-44.1%
Minnesota	55.2	15.2	(40.0)	-72.5%	42.0%	5.1%	-37.0%
Missouri	62.2	28.7	(33.5)	-53.8%	36.4%	5.4%	-31.0%
Kentucky	95.9	73.8	(22.1)	-23.1%	33.5%	9.2%	-24.3%
North Carolina	61.6	67.8	6.2	10.1%	26.6%	13.0%	-13.6%
Iowa	51.7	59.3	7.6	14.8%	44.6%	17.1%	-27.5%
South Carolina	44.7	55.8	11.1	24.8%	46.4%	19.2%	-27.2%
<i>f) Small Consumers in 1960 With Above National Average Growth</i>							
Utah	70.5	43.7	(26.8)	-38.0%	77.5%	12.7%	-64.8%
Colorado	36.6	15.6	(21.1)	-57.5%	53.7%	4.8%	-48.9%
Nebraska	9.0	6.1	(2.8)	-31.6%	44.8%	4.0%	-40.7%
New Mexico	2.4	0.9	(1.5)	-63.4%	59.4%	0.4%	-59.0%
Kansas	4.0	3.6	(0.3)	-8.5%	25.2%	1.3%	-23.8%
Nevada	3.2	4.6	1.4	44.8%	79.6%	2.5%	-77.0%
Montana	0.8	5.2	4.4	531.6%	20.6%	2.9%	-17.7%
Arkansas	0.4	6.8	6.5	1,853.3%	98.3%	3.2%	-95.1%
Louisiana	-	10.3	10.3	#N/A	0.0%	4.8%	4.8%
Arizona	0.2	13.7	13.5	6,567.1%	98.3%	4.0%	-94.3%
Oklahoma	0.6	16.1	15.5	2,395.0%	35.3%	5.5%	-29.8%
Florida	-	28.5	28.5	#N/A	0.0%	4.4%	4.4%
Texas	24.4	63.2	38.8	158.8%	97.8%	4.7%	-93.0%
Georgia	13.9	52.8	38.9	279.4%	15.6%	8.2%	-7.5%
Wyoming	2.4	41.8	39.4	1,615.8%	15.5%	9.3%	-6.2%
North Dakota	7.7	84.3	76.6	992.5%	25.3%	22.2%	-3.0%

Source: U.S. Department of Energy, *State Energy Data Report 1991*, disk version.

more efficient use of steel, and the emergence of new steel producers resulted in excess production capacity in the U.S.

Integrated producers undertook restructuring efforts aimed at reducing both costs and capacity. Capacity at some mills was reduced, while some mills dismantled capacity. The net result was less steel produced, and consequently less coking coal was consumed. Cost reductions were made in part by technological advances and, specifically pertaining to coking coal use, the advances had the effect of reducing consumption. One such advance was the substitution of alternative fuels--such as oil, gas, and uncoked coal--for coke in the blast furnace during the iron ore reduction stage. Between 1973 and 1985, the average coke rate for a U.S. blast furnace declined from 597 to 525 kilograms (1,313 lb. to 1,155 lb.) of coke per ton of pig iron. (Lima 1989, p. 15). The substitution for each ton of coke reduces the use of coal used to produce coke by 1.4 to 1.6 tons. In addition, both the amount of pig iron produced per ton of finished steel and the amount of raw steel required to produce a given volume of finished steel fell.

Another technological advance, which actually was a reason for, not a result of restructuring by integrated producers, was the development of mini mills. Mini mills, unlike integrated producers, do not engage in the iron ore reduction stage of steel production. Rather, the development of electric furnaces provided the technology for these mills to use scrap as the main input in steel making. These mills successfully captured significant portions of the market for nonflat rolled steel products from the integrated producers. (Mini mills produce a range of products that do not require flat rolling. Flat rolling requires technologies that have been economic only on a large scale and some quality requirements of consumers precluded the use of scrap steel as the input in steel making). Obviously as the iron ore reduction stage has been eliminated, so too has the need for coking coals.

The Role of Electric in Utilities in Determining Coal Consumption Patterns

The national-level analysis of coal consumption trends in the preceding chapter indicated that the trend of increasing coal consumption between 1960 and 1991 was attributable to increasing use of coal by electric utilities. The state-level analysis identifies states where electric utility coal use has shown the largest growth. Table 3.4 identifies electric utility consumption by state, again with the states arranged in the same groupings as in table 3.2, excluding the insignificant consuming states. Within each group, the states are ranked in descending order of the change in coal's share of the total electricity generation fuel market, which is the final column in table 3.4. The groups were originally based on total coal consumption growth between 1960 and 1991 in table 3.2; however, they also hold for the growth in electric utility consumption in every case except North Carolina which had lower than the 278 percent change in coal consumed by electric utilities on a national level.

Electric utilities in every state in the first group of traditionally large, slow growing consumers increased their coal consumption at a lower rate than the national rate (see table 3.4). Furthermore, on average, the electric utilities increased their share of total state coal consumption at a level lower than the national level. More importantly, even though electric utility consumption increased, albeit at a slow rate, in all of these eleven states except Indiana, coal lost its share of the electricity generation fuel market. Thus, in the northeastern significant coal consuming states and in Alabama and Tennessee, electric utilities slowly increased their share of the coal market by increasing coal consumption at a rate greater than other end-use sectors; however, coal lost a considerable share of the electricity generation-fuel market.

Considering the group of states with above average electric-utility growth in coal consumption, the most prominent trends in electric utility coal use occurred in the sub-

group of states that were relatively small consumers in 1960. Recall that fourteen of the sixteen states are western, including all four West South Central states and seven of eight Mountain states. (Idaho, the Mountain state without growth in coal use, has relied on out-of-state capacity to meet consumption growth. RLG) Georgia and Florida are the only eastern states in the subgroup.

Looking first at the electricity share of state coal consumption, electric utilities, on average, consume 94 percent of the coal consumed by this group. (Nationally utilities accounted for 85 percent of coal use in 1991). For eleven of sixteen states in this group, over 95 percent of the coal is consumed by electric utilities. For six states, Nevada, Arizona, and all four West South Central states--Oklahoma, Texas, Arkansas and Louisiana, electric utilities did not account for any of the coal consumed in 1960, but by 1991 they accounted for over 94 percent of coal use. The electric utility share of coal consumption increased more on average in this group than any other.

The most dramatic change for this group was the extent to which coal increased its share of the electricity generation market. Nationally, between 1960 and 1991, coal gained a 2 percent share of the electricity generation fuel market, increasing its share from 52 percent in 1960 to 54 percent in 1991. In 1960, coal only had an 18 percent share of the electricity generation market, but by 1991 coal's share had jumped to 68 percent--a gain of almost 50 percentage points.

It was previously suggested that the majority of the increase in national coal consumption between 1960 and 1991 was attributable to an increase in western coal use. It is now apparent that the change in coal use from one state to another can be explained by differences in coal use by electric utilities across states. In the western states that are significant coal consumers, electric utilities greatly increased coal use and their share of the total coal consumed in each state (except Wyoming, although the share decrease from 1960 to 1991 is from 100 percent to 96 percent), so that by 1991 electric utilities consumed over 90 percent of the coal used in every principal western coal consuming state (except Utah, North Dakota, and Iowa). (Utah has a steel mill; North Dakota, a coal gasification plant. RLG)

Of significant coal users in 1991, electric utilities in western states for 93 percent of total coal consumption, while eastern utilities accounted for 82 percent of coal consumption. Of greater consequence, in the western consuming states, more electricity was being produced by using coal as a fuel source between 1960 and 1991. In the principal western consuming states, coal held a 63 share of the electric utility fuel market in 1991. This is up from a 17 percent share in 1960. Comparatively, in the large eastern consuming states, coal's share dropped from 77 in 1960 to 61 percent in 1989. (As mentioned, the national share increased from 52 percent in 1960 to 54 percent in 1991.) Moreover, more electricity is being produced (see table 3.5) as electricity gained a larger share of a growing energy market between 1960 and 1991. The electricity share of the energy market increased in every state except for Idaho, Rhode Island, the District of Columbia, and a slight decline in California. (All these four regions relied heavily on out of state capacity to meet the growth in electricity consumption). As the increase in coal's share of the electricity market was largest in the West, so too was the increase in the electricity share of the state energy market. Again considering states with significant coal consumption in the East, the electricity share of state energy increased from 23 percent in 1960 to 45 percent in 1991. The western increase, over the same period, was even greater, climbing from 17 percent to 52 percent.

Table 3.4

Electric Utility Coal Consumption in Principal Coal Consuming States, 1960 and 1991

State	Electricity Coal Consumption Trillion Btus		Percent Change 1960-1991	Electricity Share of State Coal Consumption		Change 1960- 1991	Coal Share of Electricity Generation Fuel Consumption		Change 1960- 1991
	1960	1991		1960	1991		1960	1991	
<i>United States</i>	4,226.6	16,012.4	278.8%	43.0%	85.4%	42.4%	51.6%	53.6%	2.0%
<i>a) Large Consumers With Below National Average Growth in Total Coal Consumption</i>									
Indiana	305.2	1,008.8	230.5%	38.4%	75.3%	36.9%	96.3%	98.2%	1.9%
Alabama	175.3	573.9	227.4%	44.3%	79.7%	35.4%	69.6%	66.7%	-2.9%
Ohio	512.5	1,184.4	131.1%	40.4%	83.8%	43.5%	99.1%	87.3%	-11.8%
Tennessee	291.8	467.7	60.3%	77.9%	82.7%	4.8%	74.3%	61.8%	-12.5%
Wisconsin	125.8	362.0	187.9%	41.3%	88.7%	47.5%	83.6%	70.4%	-13.3%
Michigan	256.3	660.8	157.8%	39.2%	87.0%	47.7%	86.2%	68.0%	-18.2%
Maryland	82.2	220.9	168.8%	36.3%	80.4%	44.1%	83.9%	55.6%	-28.2%
Pennsylvania	423.3	991.8	134.3%	27.7%	72.7%	45.0%	89.7%	59.7%	-30.0%
New York	326.1	255.2	-21.7%	47.1%	74.1%	27.0%	52.9%	18.8%	-34.1%
Illinois	416.9	595.1	42.7%	45.6%	78.5%	33.0%	89.2%	42.5%	-46.6%
Virginia	167.4	218.8	30.7%	52.9%	61.4%	8.5%	91.7%	43.4%	-48.3%
Total	3,082.7	6,539.3	112.1%	41.3%	78.7%	37.5%	81.9%	60.5%	-21.4%
<i>b) Large Consumers With Above National Average Growth in Total Coal Consumption</i>									
Iowa	44.0	281.8	540.6%	37.9%	81.3%	43.4%	41.6%	82.9%	41.3%
Minnesota	54.5	283.7	420.8%	41.5%	94.4%	52.9%	46.9%	61.7%	14.8%
Missouri	80.5	500.2	521.5%	47.1%	93.6%	46.5%	66.2%	79.0%	12.8%
Kentucky	171.5	726.2	323.4%	59.8%	90.3%	30.4%	84.8%	94.9%	10.1%
West Virginia	140.6	689.2	390.4%	39.6%	86.2%	46.5%	96.3%	99.2%	2.9%
South Carolina	42.7	234.6	449.6%	44.3%	80.6%	36.4%	40.7%	31.9%	-8.8%
North Carolina	144.0	452.2	214.0%	62.2%	86.5%	24.3%	71.1%	53.5%	-17.6%
Total	677.7	3,167.8	367.4%	48.9%	88.0%	39.2%	67.8%	70.8%	3.0%

Table 3.4

State	Electricity Coal Consumption Trillion Btus		Percent Change 1960-1991	Electricity Share of State Coal Consumption		Change 1960-1991	Coal Share of Electricity Generation Fuel Consumption		Change 1960-1991
	1960	1991		1960	1991		1960	1991	
c) Small Consumers in 1960 With Above National Average Growth in Total Coal Consumption									
New Mexico	0.6	232.9	35,785.9%	16.0%	99.6%	83.6%	1.8%	88.1%	86.4 %
Nevada		175.5	#N/A	.0%	97.4%	97.4%	.0%	78.0%	78.0 %
Kansas	10.3	265.1	2,463.4%	65.8%	98.6%	32.9%	10.6%	72.8%	62.3 %
Colorado	25.1	304.8	1,115.1%	36.8%	94.7%	58.0%	33.7%	92.9%	59.2 %
Oklahoma	0.0	275.5	#N/A	.1%	94.5%	94.3%	.0%	58.8%	58.8 %
Utah	12.8	294.3	2,191.8%	14.1%	85.3%	71.2%	37.3%	94.8%	57.4 %
Montana	2.5	174.2	6,808.5%	63.1%	96.7%	33.6%	3.9%	58.3%	54.4 %
Arkansas		209.2	#N/A	.0%	96.8%	96.8%	.0%	50.9%	50.9 %
Texas		1,269.6	#N/A	.0%	95.2%	95.2%	.0%	50.0%	50.0 %
Arizona		333.8	#N/A	.0%	96.0%	96.0%	.0%	47.5%	47.5 %
Nebraska	6.3	145.6	2,198.7%	31.7%	95.8%	64.2%	12.6%	59.1%	46.5 %
North Dakota	14.0	293.0	1,988.4%	45.9%	77.3%	31.3%	54.7%	92.6%	38.0 %
Wyoming	12.1	404.8	3,243.8%	76.8%	90.0%	13.2%	62.3%	98.0%	35.6 %
Louisiana		204.0	#N/A	#N/A	95.2%	95.2%	33.7%	92.9%	59.2 %
Florida	27.2	614.3	2,160.6%	100.0%	95.6%	-4.4%	13.1%	45.7%	32.6 %
Georgia	65.3	593.2	808.1%	73.4%	91.8%	18.4%	56.3%	64.3%	7.9 %
Total	176.4	5,790.0	3,182.2%	44.5%	93.3%	48.9%	11.4%	59.2%	47.8 %
Eastern Total	3,673.9	9,848.9	168.1%	42.9%	82.0%	39.1%	77.5%	61.1%	-16.4 %
Western Total	262.8	5,648.1	2,048.9%	37.6%	92.7%	55.1%	16.7%	63.2%	46.4 %

Source: U.S. Dept. of Energy, *State Energy Data Report 1991*, disk version.

Thus, in summary, increasing electricity production, coupled with coal gaining an increasing share of an expanding electricity base accounts for the national increase in coal consumption. Coal consumed by utilities increased in both eastern and western principal coal consuming states, although coal lost its share of the electricity market in the East. Furthermore, in the western principal coal consuming states more state energy is in the form of electricity than in the East, and a greater share of state electricity is produced by coal in the West than in the East. In chapter 4, factors are presented that explain the regional differences in coal's share of the electricity market. The analysis in chapter 4 identifies what method of electricity generation displaced coal in the eastern principal coal consuming states, and what methods (or fuels) coal displaced in western coal consuming states.

This material is presented after identifying regional changes in coal production in this chapter. As transportation costs greatly influence the competitive position of coal, fuels compete most effectively near centers of production (Gordon, 1975 p. 17). Thus, the discussion of electricity generation and fuel use patterns in chapter 4 is preceded by a review in this chapter of coal production developments).

Coal Shipments and Consumption Patterns

The USBM's coal distribution data are useful indicators of consumption trends, which reflect the previously mentioned end-use coal consumption changes. The analysis of the distribution data was narrowed to include only those states that were principal consumers, defined as accounting for at least 2 percent of the total domestic shipments in 1989. Eighteen states met this criterion and, in total, accounted for over 70 percent of the 1989 shipments. Shipments to the particular states are listed in table 3.6. South Dakota is listed as it was combined with North Dakota for reporting until 1974. Similarly, Mississippi was combined with Alabama, and Georgia with Florida. As individual reporting states in 1989, neither South Dakota nor Mississippi came close to meeting the 2 percent criterion.

In 1960, Texas, North Dakota, Georgia, Florida, Missouri, Wyoming, and Minnesota each accounted for less than 2 percent of total shipments. New York and Virginia did meet the cut-off in 1960, with 6 percent and 3 percent shares respectively. However, by 1989 they both accounted for approximately half a percent each. New York's share dropped because of declining coal use, while Virginia had only a small increase in consumption.

Table 3.6 also presents the changes that occurred in supplying the electric utility and coking sectors. As noted previously, the most significant development was the growth in electric utility coal use. The distribution data in table 3.6 identifies two primary points of interest, which confirm the consumption trends identified in the previous section: the large share that utilities hold of each state's total coal shipments in 1989 and the differences in growth rate in electric utility coal use across states.

Coking shipments within the U.S. dropped from 81.4 million tons in 1960 to 38.8 million tons in 1989. There were declining shipments to all states that received coking coal. However, the percent change in volume figures are significant for only five states--Pennsylvania, Indiana, Ohio, Alabama, and Michigan. These five states accounted for three quarters of the domestic coking coal receipts in 1960. Pennsylvania, Indiana, and Ohio together accounted for 58 percent of the domestic market.

Table 3.5
Electricity Energy Share Change: Principal Coal Consuming States
Between 1960 and 1991

State	Total Energy Consumption Trillion Btus		Percent Change 1960-1991	Electricity Share of State Energy		Change 1960-1991
	1960	1991		1960	1991	
United States	43,795.0	81,119.0	85.2%	18.7%	36.9%	18.2%
a) Large Consumers With Below National Average Growth						
New York	2,934.5	3,558.5	21.3%	21.0%	38.2%	17.2%
Illinois	2,490.8	3,513.0	41.0%	18.8%	39.8%	21.1%
Pennsylvania	3,210.2	3,491.6	8.8%	14.7%	47.6%	32.9%
Ohio	2,960.3	3,686.9	24.5%	17.5%	36.8%	19.3%
Virginia	793.6	1,848.4	132.9%	23.0%	27.3%	4.3%
Michigan	1,819.8	2,753.9	51.3%	16.3%	35.3%	19.0%
Maryland	674.1	1,215.3	80.3%	14.5%	32.7%	18.1%
Wisconsin	816.6	1,411.7	72.9%	18.4%	36.4%	18.0%
Tennessee	919.6	1,746.5	89.9%	42.7%	43.3%	0.6%
Indiana	1,511.5	2,421.0	60.2%	21.0%	42.4%	21.5%
Alabama	822.3	1,590.7	93.4%	30.6%	54.1%	23.5%
Total	18,953.3	27,237.4	43.7%	19.9%	39.7%	19.8%
b) Growth Relatively Large Consumers With Above National Average						
Missouri	867.2	1,512.6	74.4%	14.0%	41.9%	27.8%
South Carolina	446.9	1,209.3	170.6%	23.4%	60.7%	37.3%
Iowa	597.2	937.4	57.0%	17.7%	36.3%	18.6%
Kentucky	805.1	1,476.5	83.4%	25.1%	51.9%	26.7%
Minnesota	699.2	1,363.7	95.0%	16.6%	33.7%	17.1%
North Carolina	754.1	1,961.6	160.1%	26.9%	43.1%	16.2%
West Virginia	605.3	782.9	29.3%	24.1%	88.8%	64.7%
Total	4,775.0	9,244.2	93.6%	20.9%	48.4%	27.5%
c) Small Consumers in 1960 With Above National Average Growth						
Arizona	279.6	923.6	230.3%	31.3%	76.1%	44.8%
Arkansas	390.2	769.6	97.2%	15.3%	53.4%	38.1%
Oklahoma	572.0	1,283.0	124.3%	16.4%	36.5%	20.2%
New Mexico	322.8	588.0	82.1%	11.5%	45.0%	33.5%
Texas	4,392.9	9,785.1	122.7%	9.8%	26.0%	16.1%
Nevada	90.3	400.2	343.2%	31.0%	56.2%	25.2%
Montana	219.8	342.1	55.7%	29.7%	87.4%	57.7%
Wyoming	140.7	390.8	177.7%	13.8%	105.7%	91.9%
Florida	778.6	3,021.9	288.1%	26.6%	44.5%	17.9%
Kansas	633.5	1,038.9	64.0%	15.4%	35.0%	19.6%
North Dakota	159.3	320.3	101.1%	16.1%	98.8%	82.6%
Nebraska	305.9	522.0	70.6%	16.4%	47.2%	30.8%
Georgia	631.2	2,057.0	225.9%	18.4%	44.9%	26.5%
Colorado	419.6	964.2	129.8%	17.8%	34.0%	16.3%
Utah	300.7	566.3	88.4%	11.4%	54.8%	43.4%
Louisiana	1,468.9	3,468.9	136.2%	8.5%	17.9%	9.4%
Total	9,864.1	23,465.8	137.9%	14.0%	37.0%	23.0%
Eastern Total	22,974.5	37,746.8	64.3%	20.6%	42.7%	22.1%
Western Total	11,859.7	25,176.7	112.3%	13.3%	35.5%	22.3%

Source: U.S. Department of Energy, *State Energy Data Report 1961*, disk version.

Table 3.6

Coal Shipments to Principal States, 1960 and 1989

States	Tons Coal Purchased (Thousands)		Percent of Total U.S. Shipments		Percent Change in Volume	Electrical Utility Share of Shipments		Percent Change in Volume	Coking Share of Shipments		Percent Change in Volume
	1960	1989	1960	1989		1960	1989		1960	1989	
Texas*	1,114	91,492	0.0%	10.4%	8,112.9%	0.0%	95.6%		63.5%	0.0%	-100.0%
Ohio	49,624	63,762	13.3%	7.2%	28.5%	43.1%	82.2%	145.2%	23.9%	10.0%	-46.6%
Pennsylvania	47,283	57,838	12.6%	6.6%	22.3%	32.7%	75.4%	182.4%	46.2%	15.9%	-57.9%
Indiana	32,283	52,812	8.6%	6.0%	63.6%	42.5%	77.3%	197.6%	34.1%	13.4%	-36.0%
West Virginia	13,778	36,979	3.7%	4.2%	168.4%	43.3%	83.8%	419.3%	29.9%	8.6%	-22.7%
Kentucky	11,270	34,868	3.0%	4.0%	209.4%	64.5%	89.1%	327.2%	13.1%	4.0%	-4.7%
Michigan	25,076	32,918	6.7%	3.7%	31.3%	40.6%	84.5%	172.8%	18.0%	4.0%	-70.9%
Illinois	38,705	30,116	10.3%	3.4%	-22.2%	49.4%	83.6%	31.7%	7.6%	5.7%	-41.9%
North Dakota#	2,453	28,111	0.7%	3.2%	1,147.8%	51.2%	75.7%	1,776.1%			
South Dakota#		2,497		0.3%			91.3%				
Georgia#	4,793	27,067	1.3%	3.1%	962.2%	81.0%	93.3%	1,143.5%			
Florida#		23,845		2.7%			96.5%				
Alabama#	15,500	26,678	4.1%	3.0%	94.4%	48.3%	78.6%	224.3%	43.4%	12.6%	-49.9%
Mississippi#		3,448		0.4%			96.2%				
Missouri	7,279	25,396	1.9%	2.9%	248.9%	49.4%	93.5%	559.7%	2.9%	0.0%	-100.0%
Wyoming	1,006	24,501	0.3%	2.8%	2,335.5%	83.0%	92.9%	2,625.6%			
Tennessee	14,786	23,276	4.0%	2.6%	57.4%	79.6%	83.8%	65.7%	1.3%	0.5%	-42.1%
North Carolina	8,667	21,337	2.3%	2.4%	146.2%	61.8%	88.8%	254.1%			
Wisconsin	12,437	19,639	3.3%	2.2%	57.9%	41.4%	90.4%	245.0%	2.7%	0.0%	-100.0%
Minnesota	6,375	18,028	1.7%	2.0%	182.8%	46.2%	93.7%	472.9%	11.5%	0.0%	-100.0%
Total Above	292,429	644,608	78.1%	73.1%	120.4%	46.3%	86.1%	635.8%	22.8%	5.2%	-49.5%
Total US	374,306	882,034	100.0%	100.0%	135.6%	39.4%	86.3%	415.5%	21.7%	4.4%	-52.4%

Source: U.S. Bureau of Mines, *Bituminous Coal and Lignite Distribution, 1960*; U.S. Department of Energy, *Coal Distribution, 1989*.

- combined for reporting in 1960

*Only a combined West South Central total is available for 1960; it is assumed here that all the consumption was in Texas

The Changing Role of States as Suppliers

When considering the changing role of states as consumers, the first step was to identify where the changes in consumption had occurred. A similar approach is undertaken here. Once the changes in output location have been identified, coal shipment data is analyzed in an attempt to determine the impact of the changing composition of state consumption patterns on coal producing districts.

Coal Production of Individual States from 1960 to 1992

To facilitate analysis of coal output growth, the production by state data for 1960 and 1992 are arranged into a similar format to that for the consumption data. Again four groups are shown, arranged by growth in coal output, comparing 1960 with 1992. Large producers in 1960 with declines or below average production growth comprise the first group. The second group consists only of the single large producing state with above the national growth rate. The third consists of those states with above average growth that were relatively small producers in 1960. The fourth group consists of relatively small producers (see table 3.7).

The ten largest producers in 1992 were, in order of largest to smallest: Wyoming, West Virginia, Kentucky, Pennsylvania, Illinois, Texas, Virginia, Montana, Indiana and North Dakota. Ohio, Alabama, Tennessee and Utah were among the ten largest producers in 1960. By 1992, they were replaced by Wyoming, Texas, Montana, and North Dakota.

Production, like consumption, became less concentrated both geographically and in terms of the number of significant producers. While nine of the ten largest producers in 1960 were eastern, only six were in 1992. The ten largest in 1960 accounted in total for 97 percent of U.S. production. Five states--West Virginia, Pennsylvania, Kentucky, Illinois and Ohio--mined 81 percent of the coal in the U.S. in 1960, and only these ten states individually had greater than a 1 percent share of national production. By 1992, the share of total U.S. production for the group of ten largest producers was 85 percent, and sixteen states held greater than a 1 percent share of U.S. output.

The first group, comprised entirely of eastern producers with below the national growth rate in output, had their total share of national output decline from 78 percent in 1960 to 42 percent in 1992. Two states, Pennsylvania and Ohio, produced less in 1992 than they did in 1960. Pennsylvania's decline, in absolute term was by far the largest of any state, producing sixteen and half million tons less in 1992 than in 1960. (The Pennsylvania decline involves radically different trends in anthracite and bituminous. Anthracite had an uninterrupted decline throughout the period tabulated and indeed had begun declining long before. Bituminous had a recovery starting in 1961 but reversing with the drop in coking sales in the late 1970s. The net effect is bituminous outputs in the early 90s roughly at the 1960 level and thus below both the levels immediately after World War II and the levels of the late seventies. RLG)

Table 3.7
U.S. Coal Production by State, 1960 and 1992
(Includes Pennsylvania Anthracite)

State	Total Production Thousand Short Tons		Change 1960-1992	Percent Change 1960-1992	State Share of U.S. Production		Change in U.S. Share
	1960	1992			1960	1992	
United States	434,307	1,000,250	565,943	130.3 %	100.0%	100.0%	
a) Large Producers with Below National Output Growth Rate							
Pennsylvania	84,243	68,981	-15,262	-18.1 %	19.4%	6.9%	-12.5%
Ohio	33,957	30,403	-3,554	-10.5 %	7.8%	3.0%	-4.8%
Illinois	45,977	59,857	13,880	30.2 %	10.6%	6.0%	-4.6%
West Virginia	118,944	162,164	43,220	36.3 %	27.4%	16.2%	-11.2%
Virginia	27,838	43,024	15,186	54.6 %	6.4%	4.3%	-2.1%
Alabama	13,011	25,796	12,785	98.3 %	3.0%	2.6%	-0.4%
Indiana	15,538	30,466	14,928	96.1 %	3.6%	3.0%	-0.5%
Total	339,508	420,691	81,183	23.9 %	78.2%	42.1%	-36.1%
b) Large Producer with Above National Output Growth Rate							
Kentucky	66,846	161,068	94,222	141.0 %	15.4%	16.1%	0.7%
c) Small Producers in 1960 with Above National Output Growth Rate							
Arizona	6	12,512	12,506	226,320.6 %	0.0%	1.3%	1.2%
Montana	313	38,889	38,576	12,307.8 %	0.1%	3.9%	3.8%
Wyoming	2,024	190,172	188,148	9,294.9 %	0.5%	19.0%	18.5%
New Mexico	295	24,549	24,254	8,228.4 %	0.1%	2.5%	2.4%
Washington	228	5,251	5,023	2,201.6 %	0.1%	0.5%	0.5%
North Dakota	2,525	31,744	29,219	1,157.2 %	0.6%	3.2%	2.6%
Colorado	3,607	19,226	15,619	433.0 %	0.8%	1.9%	1.1%
Utah	4,955	21,339	16,384	330.7 %	1.1%	2.1%	1.0%
Group Total	13,953	398,753	384,800	2,757.8 %	3.2%	39.9%	36.7%
d) Small Producers							
Alaska	722	1,534	812	112.3 %	.2%	.2%	.0%
Maryland	748	3,341	2,593	346.8 %	.2%	.3%	.2%
Louisiana		3,240	3,240	#N/A	.0%	.3%	.3%
Oklahoma	1,342	1,741	399	29.8 %	.3%	.2%	-.1%
California	0	103	103	#N/A	.0%	.0%	.0%
Missouri	2,890	2,886	-4	-.1 %	.7%	.3%	-.4%
Tennessee	5,930	3,476	-2,454	-41.4 %	1.4%	.3%	-1.0%
Kansas	888	363	-525	-59.1 %	.2%	.0%	-.2%
Iowa	1,068	289	-779	-72.9 %	.2%	.0%	-.2%
Arkansas	409	58	-351	-85.8 %	.1%	.0%	-.1%
South Dakota	20	0	-20	-100.0 %	.0%	.0%	.0%
Georgia	4	0	-4	-100.0 %	.0%	.0%	.0%
Group Total	14,023	17,031	3,008	21.5 %	3.2%	1.7%	-1.5%

Source: Department of Energy, *Coal Production*, various years; U.S. Bureau of Mines, *Minerals Yearbook*, various years.

Indiana produced more than twice as much coal in 1992 than in 1960. In addition, recall that Indiana fell into this group for the consumption analysis even though it had the fourth largest absolute increase in consumption of any state between 1960 and 1991. A final point on this group is that West Virginia increased output by forty six million tons, the fourth largest absolute increase in the country, behind Wyoming, Kentucky, and Texas.

Kentucky was the only large producer in 1960 that increased output at greater than the national rate between 1960 and 1992. This enabled Kentucky to maintain its position as the third largest producer in the country. (In this state, the expansion was predominantly in the eastern, Appalachian portion of the state. The western, Illinois basin part of the state grew during the period of nation decline to 1961 and continued growth to the middle 1970s when decline set in. Eastern output starting rising after 1961 and has sharply increased since. Thus, by 1961, eastern output had fallen to 31.4 million tons; western, risen to 30.6 million. Western output peaked at 56 million in 1975. In 1993, eastern output was 129 million; western, 35 million. RLG)

Geographically, the growth in production largely paralleled the growth in consumption. The group of nine relatively small producers in 1960 with better than the national rate of production growth were all western states, six from the Mountain region. As a whole, this group increased its share of U.S. output, from just over 3 percent in 1960 to almost forty percent in 1992. Wyoming had the largest absolute increase in production, raising output by over 188 million tons. Wyoming alone accounted for just over one third of the total increase in U.S. production over the 32 year period. Production in Texas commenced in 1972, and in 1992 Texas was the sixth largest producer in the country.

In summary, 68 percent of the increase in production came from the West. The increase in western production lowered the shares of eastern producers. The growth came from the Mountain states and the West South Central states, except for declining output in Arkansas, a small producer. North Dakota, the only large producer in the West North Central region, registered strong growth. The three other producing states in this region, Missouri, Kansas, and Iowa are small producers with declining output. Output from eastern states was relatively stagnant, except for the declines in Pennsylvania and Ohio and strong growth in Kentucky.

Looking at the U.S. broken into the three main producing regions, the net results between 1960 and 1992 are: Appalachian producers dropped in share of total output from 74 percent to 46 percent, with output increasing 43 percent from 321 million to 459 million tons. The Midwest (Illinois Basin) producers also lost their share of total output, falling from 21 percent to 13 percent. Output in tons increased 44 percent from 92 million to 133 million tons. Finally, western producers increased their share of production from 5 percent to 41 percent. Output rose from 21 million tons to 408 million tons, an increase of 1,771 percent. Table 3.8 summarizes percentage point consumption and production changes between 1960 and 1991/92.

Coal Shipments and Production Patterns

In determining what accounts for the changing role of producing districts as suppliers, one can look both at state purchases from individual districts and district sales to individual states. By analyzing where coal originated and where it was destined and for what use, an attempt can be made to explain how production changes are affected by changes in end use consumption. This evaluation considers, for example, how a rise in electric utility coal use in Pennsylvania affects coal production in Pennsylvania.

Table 3.8					
Summary of Percent Changes in Coal Consumption and Production in the United States Between 1960 and 1992					
	Percent Change in Share of U.S.			Percent Change in Share of U.S.	
	Consumption	Production		Consumption	Production
	1960-1991	1960-1992		1960-1991	1960-1992
EAST			WEST		
New England:			West North Central:		
Connecticut	-0.91%	#N/A	Iowa#	0.67%	-0.22%
Maine	-0.16%	#N/A	Kansas#	1.27%	-0.17%
Massachusetts	-0.59%	#N/A	Minnesota	0.27%	#N/A
New Hampshire	0.13%	#N/A	Missouri#	1.11%	-0.39%
Rhode Island	-0.17%	#N/A	Nebraska	0.61%	#N/A
Vermont	-0.03%	#N/A	North Dakota	1.71%	2.59%
			South Dakota	0.12%	#N/A
Middle Atlantic:			West South Central:		
New Jersey	-1.39%	#N/A	Arkansas#	1.15%	-0.09%
New York*	-5.20%	#N/A	Oklahoma	1.54%	-0.11%
Pennsylvania**	-8.29%	-12.64%	Louisiana	1.14%	0.32%
			Texas	6.85%	5.46%
East North Central:			Mountain:		
Illinois*	-5.26%	-4.64%	Arizona	1.85%	1.25%
Indiana	-0.94%	-0.37%	Colorado	1.02%	1.06%
Michigan	-2.59%	#N/A	Idaho	-0.11%	#N/A
Ohio#	-5.38%	-4.83%	Montana	0.92%	3.83%
Wisconsin	-0.92%	N/A	Nevada	0.92%	#N/A
			New Mexico	1.21%	2.40%
East South Central:			Utah	1.84%	0.99%
Alabama	-0.18%	-0.45%	Wyoming	2.24%	18.55
Kentucky	1.37%	0.74%			
Mississippi	0.50%	#N/A	Pacific:		
Tennessee#	-0.79%	-1.09%	Alaska	-0.01%	-0.01%
			California	-0.02%	0.01%
South Atlantic:			Hawaii	0.00%	#N/A
Delaware	0.09%	#N/A	Oregon	0.08%	#N/A
	-0.27%	#N/A	Washington	0.32%	0.47%
Florida	3.15%	#N/A			
Georgia#	2.54%	0.00%			
Maryland	-0.84%	0.16%			
North Carolina	0.43%	#N/A			
South Carolina	0.57%	#N/A			
Virginia	-1.32%	-1.92%			
West Virginia	0.66%	-10.90%			
N/A - Not Applicable					
* - Absolute decrease in consumption					
# - Absolute decrease in production					

Alternatively, the analysis examines how consumption changes in both the coal producing district and states where the coal is destined, account for production changes in the district or state. This treatment considers, for example, how much of a change in Pennsylvania production is accounted for by a decline in coking coal consumption. Thus, this section attempts to determine the impact, in terms of tons of coal shipped, of changing state coal consumption patterns on coal producing districts. As mentioned in the introduction to this chapter, the forces underlying the demand and supply shifts are presented in the next chapter. The analysis begins by looking at principal coal consuming state purchases from individual districts, comparing 1960 with 1989, this being the last year the USBM tracked coal flows using districts of origin. This is followed by a summary of district coal sales.

State Coal Purchases

Middle Atlantic (Pennsylvania)

Pennsylvania increased receipts of coal by 22 percent between 1960 and 1989; however, the share of shipments to electric utilities increased from 33 to 75 percent of the total shipments, while coking coal shipments fell from 46 to 16 percent of the total shipments (see table 3.6). Increasing electric utility consumption and declining coking coal consumption altered the relative shares of supplying districts. District 1 significantly increased its share of total shipments from 23 percent to 47 percent, as Pennsylvania increased its purchases of coal for electric utilities from this district. (The critical power plants that significantly increased purchases of local or out of state coal for each state are identified in the Appendix.) Pennsylvania did not purchase any coal from District 4 (Ohio) in 1960, but by 1989 District 4 accounted for 3.5 percent of the total shipments, almost entirely to electric utilities.

(The cost and quality report records 2.2 million tons of 1989 receipts from Ohio by Pennsylvania utilities. Of this, 2.2 million was received by the Bruce Mansfield plant, operated by the Pennsylvania Power subsidiary of Ohio Edison and jointly owned by the parent, the subsidiary, Duquesne Light, Cleveland Electric, and Toledo Edison. The plant was initially supplied mainly by a mine built especially to serve the plant. Changing economics produced shifting to other suppliers. In 1993, only 1.5 million tons came to the plant from Ohio; total Pennsylvania utility receipts from Ohio were 1.6 million. The 1991 distribution report shows that 30.2 million of 41.4 million tons to electric utilities 2.1 of 7.7 million to coke plant and 2.6 of 3.9 million to other industry was intrastate. RLG)

District 8, although still a relatively small supplier to Pennsylvania in 1989 with an 8 percent share of total shipments, was the only other district that increased its share of the Pennsylvania market. Pennsylvania increased its reliance on District 8 for supplying coking coal, at the expense of District 2. In 1989, both District 8 and District 2 each supplied just over 40 percent of coking coal shipments, whereas in 1960, the shares were 7 percent and 53 percent respectively. District 2 was left with a smaller share of a Pennsylvania coking coal base that had diminished from almost 22 million tons in 1960 to only 9.2 million tons in 1989. Total tons shipped by District 2 to Pennsylvania in 1989 were only half of what it shipped in 1960; all the losses were in supplying coking coal. District 3/6 became a slightly less important supplying district dropping in share from 22 to 17 percent of total shipments, as losses primarily in coking coal offset tons gained in supplying electric utilities. District 7, another coking coal supplier for Pennsylvania, also suffered from declining coking coal consumption.

(The 1991 data based on by state origins indicate that Pennsylvania received 14 million tons from West Virginia, 2.2 million from eastern Kentucky, and 1.1 million from Virginia. In electric power, West Virginia shipped over 10 million; eastern Kentucky, 74,000; Virginia, 18,000. Shipments to coke plants were 3 million from West Virginia, 1.5 million from eastern Kentucky, and 1.1 million from Virginia. Thus, the shift to District 8

involves some dependence on eastern Kentucky as well as West Virginia in coking but not in electric power. RLG)

East North Central

Indiana increased its purchases of coal by 64 percent between 1960 and 1989, with a trend, similar to Pennsylvania, of increased shipments to electric utilities, pushing their share from 43 to 77 percent of total shipments, and declining shipments to coke plants, dropping their share of total shipments from 34 percent in 1960 to 13 percent in 1989. Local (District 11) coal gained an increasing share of total coal consumption, (although local coal lost its share of the electric utility market) as purchases from District 11 increased from 38 percent to 46 percent of total shipments. In addition, western coal penetrated the market, gaining a 16 percent share by 1989. (In 1989, 92 percent of western coal shipped to Indiana originated in Wyoming--District 19). District 10 (Illinois) also gained market share, and by 1989 supplied slightly more coal to Indiana than District 19. In 1989, almost 90 percent of coal consumed by electric utilities came from Districts 10, 11, and further west, mostly Wyoming.

In contrast, District 7 not only suffered from shrinking coking coal consumption, but also Indiana increased coking coal purchases from Districts 8 and 10. This resulted in a reduction of the District 7 share of coking shipments from 38 percent to 16 percent, and, with a shrinking coking coal base, its share of total shipments to Indiana dropped from 14 to 2 percent. District 8 also suffered from declining coking coal consumption and accounted for less absolute tons shipped to Indiana in 1989 than 1960. Less coal for electric utility use was purchased from District 9 (western Kentucky), which eroded its market share of total shipments.

(In this case, West Virginia supplied almost 3 million tons of coking coal receipts in 1991, eastern Kentucky provided 1.6 million, and Virginia, 1.3 million so that the shrinkage may have been felt in all parts of the affected districts. RLG)

Ohio also greatly increased both total receipts and receipts of local coal over the same period. Although local coal (District 4) experienced a slight loss of market share, from 44 to 41 percent of total shipments, tons shipped to local markets increased from 21.8 million tons in 1960 to 26.1 million in 1989. In particular, the loss of share for local coal in supplying the electric utilities was more substantial, falling from 64 percent in 1960 to 46 percent in 1989. Ohio also continued to rely on District 8, which supplied 37 percent of the coal market in 1989, up from 27 percent in 1960. Purchases from Districts 2 and 7 declined as these districts principally supplied the coking sector which received 11.9 million tons in 1960, but only 6.3 million tons in 1989. Reliance on District 8 for coking coal increased.

(Of 1991 shipments to Ohio electric utilities, 13.5 million came from West Virginia, 7.4 million from eastern Kentucky, and 3.1 million from Pennsylvania. Coke plant shipments were comprised entirely of 2 million tons from West Virginia, 822,000 from eastern Kentucky, and 743,000 from Virginia. Thus, West Virginia and eastern Kentucky seem to have participated in the electric utility shift to low sulfur eastern coal. RLG)

Illinois received less coal in 1989 than in 1960, primarily because the other sector received approximately 7 million tons less in 1989 than in 1960. The other sector was largely supplied with local coal (District 10). District 10 not only suffered from a declining other sector base, but also lost market share in this sector. In addition, the share of local coal in supplying electric utilities dropped from 78 percent to 59 percent as District 10 sales to an expanded electric utility market were approximately the same volume in 1960 as 1989. Districts 19 (Wyoming) and 22-23 in total had a 21 percent of total shipments to Illinois in 1989, all to electric utilities. (District 22--Montana and District 23--Washington and Alaska were combined for reporting purposes, although it is known that all

Washington and Alaska coal is used by power plants within the state. Thus, except in dealing with the use in Washington, shipments are regarded as coming from Montana).

District 10 did increase its share of the coking market, by shipping approximately the same volume in 1989 as in 1960 to a market that received only 1.7 million tons in 1989, down from 2.9 million in 1960. By 1989, District 8 was the other main supplier to the coking coal market. Coking shipments received from District 7, which shipped 25 percent of the coal to the coking sector in 1960, were negligible in 1989. (In 1991, 51 percent of slightly less than 1.5 million tons shipped to Illinois coke plans came from West Virginia. 380,000 came from Virginia, and 277,000 from eastern Kentucky. No intrastate shipments were reported. RLG) The end result was that shipments of local coal fell from 26.8 million tons, or 69 percent of total shipments in 1960, to 17.6 million tons, or 59 percent of total shipments in 1989. District 8 increased its share of a declining coking market, and, similar to the Mountain Districts 19 and 22 commenced sales to the electric utility market. District 7 again lost market share and shipped fewer tons because of reduced coking coal use and a shift, like that in Indiana of buying more coking coal from the Illinois Basis, specifically District 10.

The two other principal East North Central consuming states, Michigan and Wisconsin, made large increases of purchases of western coal, specifically coal from the Mountain states. Michigan did not receive any western shipments in 1960; however, 37 percent of its coal came from the West in 1989, with over 90 percent of its western purchases originating in Montana (District 22). (Subsequently, the role of Wyoming has increased nearly to match Montana. RLG) District 8 was the other major supplying district, accounting for 53 percent of total shipments. The increase in purchases from District 8 and the west were almost entirely for electric utility consumption. Electric utilities increased their share of total shipments to the state from 41 percent in 1960 to 84 percent in 1989 (see Table 3.5). Again, District 7 suffered from declining coking coal use in Michigan. District 8 held its share of Michigan's coking coal market, and District 2 gained share.

(In 1991, 6.7 millions tons of eastern Kentucky coal and 6.3 million tons of West Virginia coal were shipped to Michigan electric utilities. Shipments to coke ovens were 322,000 tons with 243,000 from West Virginia. Thus, the two states supply seems to have shared in the electric utility shift to eastern low-sulfur coal. RLG.)

Wisconsin had negligible western coal purchases in 1960, but in 1989, 67 percent of coal receipts were western, chiefly from Wyoming (83 percent). As in Michigan, electric utilities in Wisconsin greatly increased their share of total shipments from 41 percent in 1960 to 90 percent in 1989. For both states, 97 percent of the western coal was for electric utility consumption.

West North Central

As a group, the West North Central group of states displayed strong growth in coal use between 1960 and 1989 (except South Dakota, which remains an insignificant user). These states have tended to fuel their strong growth in coal use by purchasing Mountain region coal. The exception is North Dakota, which relied on local coal. (Another noteworthy aspect of North Dakota's consumption is the significant increase of shipments to the other sector. Shipments rose from just under one half a million tons in 1960 to 6.6 million tons in 1989, making North Dakota the state with the largest consumption in this sector. This is due mostly to a coal gasification project.)

Minnesota in 1960 received 75 percent of its shipments from Districts 4 (Ohio), 8, and 10 (Illinois), and no Mountain region coal. By 1989, Minnesota was purchasing 45 percent of its coal from District 19 (Wyoming) and 52 percent from District 22 (Montana).

Similarly, Iowa received 77 percent of its coal from Districts 10 and 12 (Iowa) in 1960, while in 1989, 72 percent of shipments to Iowa were from District 19. District 10

was still supplying about the same number of tons to Iowa in 1989 as in 1960, but its share of Iowa's expanding coal market dropped from 56 percent to 14 percent.

Kansas and Nebraska were combined for reporting in 1960, and as relatively small consumers in 1960, 73 percent of their combined purchases were from District 15 (presumably mostly Missouri and some Kansas). In 1989, Nebraska was receiving 99 percent of its shipments from District 19, and Kansas 92 percent. Wyoming coal had also captured 25 percent of the Missouri market by 1989. However, Missouri continued to rely on District 10 for the majority of its shipments. District 10 only dropped in market share from 60 to 55 percent, and, with increasing coal use, the tons supplied by District 10 increased from 4.3 million to almost 14 million tons.

South Atlantic

In the South Atlantic region, West Virginia relied on Districts 1, 3/6, and 8 (in all cases presumably mainly the West Virginia portion of the districts) to supply the considerable increase in electric utility coal consumption. District 1 supplied a negligible quantity in 1960, but by 1989 supplied over 4.5 million tons, or 13 percent of the West Virginia market. District 3/6 shipped 14.3 million tons in 1989, increasing its market share from 26 percent in 1960 to 31 percent in 1989. District 8 increased its market share from 39 percent to 42, shipping 15.3 million tons to West Virginia in 1989. Although the shipments to electric utilities jumped from 6 to 31 million tons, District 4 (Ohio) shipped fewer tons to utilities in 1989 than it did in 1960, and its share of total shipments dropped from 12 percent in 1960 to 3 percent in 1989. Shipments of coking coal dropped 23 percent, which in relative terms is less than the drop in coking coal shipments to Pennsylvania, Ohio, Indiana and Illinois over the same time. However, a significant change occurred in supplying districts. District 2 had its share of coking coal shipments cut from 73 percent in 1960 to just 2 percent in 1989, while District 8 increased its share from 7 percent to 80 percent over the same time.

(The 1991 data indicate that 24.1 out of 28.4 million tons of shipments to West Virginia electric utilities were intrastate with 15.1 million from the southern half that includes district 8. The next largest suppliers were Maryland with 2.1 million and Pennsylvania with 1.1 million. 1.5 million of 2.4 million of shipments to coke plants also were intrastate with the rest from Virginia. Total shipments from eastern Kentucky were 845,000 tons. Thus, shipments from districts including West Virginia do seem to come mainly from within the state, and Maryland was a major element in the District 1 supplies to West Virginia. RLG)

Virginia received 82 percent of its shipments from district 8 in 1960, and nearly all the remainder from District 7. By 1989 District 8 was supplying 89 percent of the shipments to Virginia, and again District 7 supplied the majority of the remainder, although District 7 was shipping fewer tons in 1989 than in 1960.

(This case proves an extreme example of what the use of USBM districts hides. The by state origin data for 1991 show that shipments to Virginia electric utilities were fairly evenly split among eastern Kentucky--just under 3 million, Virginia--3.5 million, and West Virginia--3.3 million with a bit more than 3 million coming from the southern part of the last state. All of the 973,000 shipped to coke plants was intrastate. The 4.2 million tons to other industry came mainly from eastern Kentucky--1.9 million, Virginia--998,000, and West Virginia 1.3 million. RLG)

During the period under study, the Carolinas have always relied on District 8 for virtually all of their coal. In both states, all shipments to electric utilities were from District 8. Using data from an EIA publication, *The Cost and Quality of Fuels for Electric Utility Plants*, it is possible to determine from which state in District 8 the shipments to the electric utilities in the Carolinas came from in 1989. In North Carolina, shipments to electric

utilities from District 8 had the following state of origin breakdown: eastern Kentucky 50 percent, West Virginia 26 percent, Virginia 23 percent, and Tennessee 1 percent. In South Carolina, the breakdown was: eastern Kentucky 87 percent, Virginia 12 percent, and Tennessee 1 percent.

(The 1991 by state distribution data show a similar mix for shipments to North Carolina and South Carolina utilities. For North Carolina, 9.7 million tons came from eastern Kentucky; 4.1 million from Virginia, and 5.5 million from West Virginia--all in the southern part. For South Carolina, 8.2 million came from eastern Kentucky, 907,000 from Virginia, and 81,000 from West Virginia. No other states provided supplies to Carolina utilities. For North Carolina other industry, 1.7 million came from eastern Kentucky, 365,000 from Virginia, and 486,000 from West Virginia. For other industry in South Carolina, of 2.2 million total shipments, 1.4 was from eastern Kentucky, 615,000 from Virginia, and 96,000 from West Virginia. Other states also supplied the sector in both North and South Carolina. RLG)

Georgia and Florida have also relied on District 8 for the majority of their coal. In both states, over 90 percent of the coal was shipped to electric utilities in 1989. In 1989, Georgia received 71 percent of its electric utility shipments from District 8 and Florida received 58 percent of utility shipments from this district. Again, using the EIA cost and quality of fuel report, the states of origin for District 8 shipments to electric utilities in Georgia and Florida can be identified. District 8 shipments to utilities in Georgia originated in the following state shares: eastern Kentucky 68 percent, Virginia 18 percent, West Virginia 8 percent, and Tennessee 6 percent. In Florida the shares were: eastern Kentucky 81 percent, West Virginia 11 percent, Virginia 7 percent, and Tennessee 1 percent.

District 10 (Illinois) coal has also penetrated Georgia and Florida. Neither of these states purchased any coal from District 10 in 1960. By 1989, Georgia bought 19 percent of its coal from District 10, and Florida purchased 16 percent of its total coal shipments from District 10. District 13, which supplied 20 percent of the relatively small combined Georgia/Florida market in 1960, was supplying negligible quantities to each individual market in 1989.

East South Central

In the East South Central region, Kentucky increased its coal receipts by over 200 percent. This was attributable to increasing consumption by electric utilities, which accounted for 89 percent of consumption in 1989. The principal supplying districts in 1989 were District 8 and District 9 (western Kentucky), with 42 and 50 percent of total coal shipments respectively. District 8 seems to have replaced District 10 (Illinois), which supplied 28 percent of the shipments in 1960, but only 1 percent in 1989.

(The 1991 distribution report indicates that 6.9 million tons was shipped to Kentucky utilities by eastern Kentucky mines, 2.8 million from West Virginia, and 433,000 from Tennessee. 787,000 out of 895,000 received by coke plants was from West Virginia; the rest from eastern Kentucky. Of a bit more than 2 million shipped to other industry, 1.4 million came from eastern Kentucky and 504,000 from West Virginia. Total shipments from West Virginia were a bit over 4 million compared to a total of 8.6 million from eastern Kentucky and 16.3 million from western Kentucky. Thus, West Virginia has a significant minority share of shipments to Kentucky. RLG)

Tennessee increased its shipment receipts by over 50 percent. However, not much change arose in the relative shares of end users or supplying districts. District 8 increased its share of shipments from 52 in 1960 to 55 percent in 1989, while District 9 dropped from supplying 45 percent to 34 percent, in part losing share to District 10. Electric utilities increased their share of shipments from 80 to 84 percent, and the other segment rose from 12 to 15 percent.

(The 1991 distribution report shows that 4 million shipped to Tennessee electric utilities 5.5 million came from eastern Kentucky, 1.6 million from Tennessee, 1.3 million from Virginia, and 999,000 from West Virginia. Thus, most but not all District 8 shipments were from eastern Kentucky. The biggest supplier was western Kentucky with 9.6 million. Of 3.2 million shipped to other industry, 1.3 million came from eastern Kentucky, 1.2 million from Virginia 269,000 from Tennessee, 80,000 from West Virginia, and 286,000 from western Kentucky. RLG)

Alabama, grouped with Mississippi until 1974, relied primarily on District 13 in both 1960 and 1989, although less so in 1989 as the District 13 share of total shipments dropped from 85 percent in 1960 to 72 percent in 1989. Three other districts, 4, 8, and 9, with fairly equal shares accounted for the remainder of the shipments to Alabama in 1989. (In 1991, 17.1 of 23.3 million tons shipped to Alabama electric utilities was intrastate, 697,000 came from Tennessee, 2.0 million from eastern Kentucky, 26,000 from Virginia, and 1.1 million from West Virginia. Thus, Alabama was the main District 13 supplier, and eastern Kentucky was the main but not dominant supplier from District 8. In coking, however, of 3 million tons, 1.4 was intrastate 1.1 from West Virginia, and 523,000 from Virginia; no other suppliers were reported. With other industry, 1.7 of 2.4 million was intrastate; the next largest supplier was Tennessee at 231,000. RLG)

West South Central

The West South Central states of Arkansas, Louisiana, Oklahoma, and Texas, all significantly increased their coal consumption between 1960 and 1989 chiefly using coal shipped from District 19 (Wyoming) and District 15 (the principal producer in District 15 is Texas). In 1989 the breakdown of shipments was: Arkansas 100 percent District 19; Oklahoma 92 percent District 19 and 5 percent District 15; Louisiana 72 percent District 19 and 25 percent District 15; and Texas 39 percent District 19 and 59 percent District 15. For Oklahoma, Louisiana, and Texas, EIA's *The Cost and Quality of Fuels for Electric Utility Plants* report for 1989 indicated that District 15 shipments to electric utilities in each of these states originated within each state. In other words, utilities in these states received either Wyoming coal or coal shipped from within the state.

Mountain

The growth in production in most Mountain states was paralleled by increasing consumption of state produced coal. (Nevada and Idaho are not producing states. However, Nevada did considerably increase coal use between 1960 and 1989). Virtually all the coal consumed (99 percent) in Montana was shipped from within District 22 (Montana). Likewise, Wyoming received 99 percent of its coal from District 19 (Wyoming) in 1989.

Arizona and New Mexico bought 93 percent and 99 percent of their coal respectively from District 18 (Arizona and New Mexico). In both these states, almost all coal is consumed by electric utilities, and using *The Cost and Quality of Fuels for Electric Utility Plants* report, we can identify which state in District 18 supplied the coal to the utilities. In Arizona, 54 percent of the shipments to utilities from District 18 came from Arizona and 46 percent came from New Mexico. (Further examination of the details for 1989 and 1993 shows that intrastate shipments were entirely to the Navajo plant, a joint venture operated by the Salt River District. Similarly, all Arizona shipments to Nevada were to another joint venture--the Mohave plant operated by Southern California Edison. These latter shipments employ the only coal slurry pipeline operating in the United States. Thus, the coal industry of Arizona has only two electric utility customers. RLG) District 18 shipments to utilities in New Mexico came entirely from within the state.

Utah uses 85 percent local coal (District 20), and Colorado consumes 65 percent local coal (Districts 16-17), and 34 percent District 19 coal. Nevada, a non-producer, receives 58 percent of its coal from District 18, and 34 percent from District 20. Nevada's

receipts from District 18 in 1989 were all electric utility receipts, and *The Cost and Quality of Fuels for Electric Utility Plants* report indicated that they all originated in Arizona.

District Sales

District 1

District 1 shipped 16 million tons more tons of coal in 1989 than in 1960, an increase of 58 percent (see table 3.9) largely by increasing shipments to electric utilities in Pennsylvania, West Virginia, and Maryland. Nevertheless, District 1 still lost its market share of total U.S. shipments, including losses in both the electric utility and coking coal sectors. This was attributable to three factors in particular. First, there was the loss of the New England market, and considerable declines in New York and New Jersey (see table 3.10) as these areas moved to fuel oil and nuclear power. District 1 shipped 8.1 million fewer tons of coal to these areas in 1989 than in 1960. Second, supplying coal to electric utilities in the South Atlantic region, particularly West Virginia, is limited for District 1, as District 8, and to a lesser extent, District 3/6 are better positioned to increase sales to South Atlantic states. These districts, as discussed below, did in fact have strong growth in their sales to electric utilities in the South Atlantic region during the period under study. Third, and least importantly for District 1, was the decline in coking coal consumption. Shipments to the coking sector dropped by 2.5 million tons between 1960 and 1989, however, this decline was offset by an increase in export sales.

The pattern of District 1 sales illustrates quite clearly that production growth is tied to increasing electric utility coal use. Electric utility coal consumption fell significantly in the New England states and New Jersey, tons shipped to New York electric utilities were stagnant. As previously discussed, although Pennsylvania utilities increased consumption, their rate of increase was lower than the national rate of increase. (In both New York and Pennsylvania coal lost a considerable share of the electricity market to nuclear power between 1960 and 1991. Coal's share loss was from approximately 90 percent to 60 percent in Pennsylvania, and 53 percent to 19 percent in New York. In 1960, the nuclear share of the electricity market in Pennsylvania was less than 1 percent and there was no nuclear power in New York. By 1991, nuclear held a 37 percent share of Pennsylvania's electricity production and 23 percent of New York's.)

District 2

District 2 not only lost market share of total U.S. shipments, but also was shipping 35 percent fewer tons (12.1 million tons less) in 1989 than in 1960 (see table 3.9). The reduction of tons shipped was a result of declining coking coal demand. This sharply affected District 2, which shipped 59 percent of its domestic shipments to coke plants in 1960 (see Table 3.11). District 2's market share was lost primarily to District 8. Again, the trend to a single use fuel has impeded production growth in districts that were dependent upon end uses other than electricity generation.

(The 1991 data indicate that the consequences for the main component of Districts 1 and 2, Pennsylvania is heavy reliance on intrastate sales particularly to electric utilities. Of 58.2 million tons of shipments, 36.3 million were intrastate and 30.2 million of those were to electric utilities. Other sales were mainly to surrounding states. RLG)

District 3/6

District 3/6 had a relatively small increase in tons shipped between 1969 and 1989, and lost overall market share of shipments, including share losses in both the electric utility and coking markets. District 3/6, like District 1, suffered from reduced demand in New York and New Jersey. However, as table 3.10 indicates, sales to South Atlantic states became a greater percentage of total sales as shipments increased to electric utilities, notably in West Virginia. Sales to electric utilities in Pennsylvania also increased, but this gain was

largely offset by a virtual elimination of coking shipments to Pennsylvania by 1989. Coking shipments to Maryland were negligible by 1989. The result was that in 1989 District 3/6 was no longer shipping coking coal. In 1960, it had supplied almost 9 percent of a 81.4 million ton domestic coking coal market.

In short, although District 3/6 made advances into the West Virginia electric utility market, output growth was restricted, both by being located close to markets that have essentially discontinued coal consumption (New England), and by the heavy dependence in 1960 on east coast markets that have since had declining electric utility consumption (New York and New Jersey), or slow growth in electric utility consumption (Maryland), or the latter coupled with sharply falling coking coal use (Pennsylvania).

District 4 (Ohio)

District 4 (Ohio) lost overall market share between 1960 and 1989, as tons shipped increased negligibly in a growing coal market. Table 3.10 indicates a drop from 90 to 82 percent in sales to the East North Central region. What is not evident from the table is that the decline was mostly attributable to reduced shipments to Michigan, and smaller losses to Wisconsin and Minnesota. By 1989, all three of these states were making significant purchases of western coal. Within the East North Central region, losses to these states more than offset gains in local (Ohio) shipments. Shipments within the district accounted for 66 percent of total district shipments in 1960, but, by 1989, local shipments were 80 percent of total shipments. District 4 did manage to increase sales to Pennsylvania and Alabama electric utilities from virtually nothing to over 2 million tons to each state, which together with the rise in local shipments approximately equaled the losses to Michigan, Wisconsin, and Minnesota.

Table 3.9
Domestic District Coal Shipments, 1960 and 1989

Districts	Tons Coal Shipped (Thousands)		Percent of Total U.S. Shipments		Percent Change in Volume	Percent of U.S. Electrical Utility Shipments		Percent Change in Volume	Percent of U.S. Coking Coal Shipments		Percent Change in Volume
	1960	1989	1960	1989		1960	1989		1960	1989	
1	27,849	43,886	7.5%	5.0%	57.6%	10.6%	5.1%	146.7%	4.4%	2.7%	-70.4%
2	34,685	22,542	9.3%	2.6%	-35.0%	5.0%	2.0%	110.5%	25.4%	13.0%	-75.4%
3/6	37,829	44,193	10.2%	5.0%	16.8%	15.1%	5.3%	79.9%	9.0%	0.0%	-99.8%
4	32,653	32,658	8.8%	3.7%	.0%	13.7%	3.9%	47.2%	0.0%	0.0%	180.0%
7	22,834	7,139	6.1%	0.8%	-68.7%	1.3%	0.1%	-70.9%	17.3%	15.2%	-57.5%
8	92,042	195,673	24.7%	22.3%	112.6%	18.4%	19.1%	437.8%	29.8%	56.2%	-9.2%
13	14,583	21,490	3.9%	2.4%	47.4%	0.6%	2.1%	1,764.0%	8.1%	5.6%	-66.9%
Total Appalachia	262,475	367,581	70.5%	41.8%	40.0%	64.8%	37.5%	199.6%	94.0%	92.7%	-52.5%
9	30,032	41,219	8.1%	4.7%	37.3%	7.5%	5.1%	252.2%	0.0%	0.0%	-100.0%
10	45,614	58,976	12.3%	6.7%	29.3%	15.8%	7.0%	130.0%	0.8%	4.0%	141.9%
11	15,454	33,546	4.2%	3.8%	117.1%	6.6%	3.7%	192.0%	0.0%	0.0%	
Total Illinois Basin	91,100	133,741	24.5%	15.2%	46.8%	29.9%	15.9%	174.4%	0.8%	4.0%	138.5%
15	4,367	63,007	1.2%	7.2%	1,342.8%	1.9%	7.8%	2,048.6%	0.2%	0.0%	-100.0%
16-17	3,788	17,296	1.0%	2.0%	356.6%	0.8%	1.9%	1,093.6%	2.0%	2.2%	-45.8%
18	172	34,181	0.0%	3.9%	19,772.7%	0.0%	4.4%	99,111.8%			
19	1,839	171,487	0.5%	19.5%	9,225.0%	0.7%	22.0%	15,817.8%			
20	4,858	18,402	1.3%	2.1%	278.8%	0.3%	1.9%	2,723.8%	0.0%	0.9%	
21	2,475	29,860	0.7%	3.4%	1,106.5%	0.9%	3.1%	1,606.8%	3.0%	0.0%	-100.0%
22-23	1,228	42,779	0.3%	4.9%	3,383.6%	0.4%	5.4%	6,697.2%			
Total Western	18,727	377,012	5.0%	42.9%	1,913.2%	5.6%	46.7%	4,249.9%	6.3%	3.3%	-74.7%
Total Domestic	372,302	878,334	100.0%	100.0%	135.9%	100.0%	100.0%	417.3%	100.0%	100.0%	-51.9%
Eastern Total	353,575	501,322	95.0%	57.1%	41.8%	94.7%	53.4%	191.7%	94.8%	96.7%	-50.9%

Source: U.S. Bureau of Mines, *Bituminous Coal and Lignite Distribution, 1960*;

U.S. Department of Energy, *Coal Distribution 1989*.

Districts 12 and 14 excluded as they had relatively small shipments in 1960 and negligible shipments in 1989

Table 3.10

Regional Distribution of District Shipments, 1960 and 1989

Share of 1960 Shipments

District	New England	Mid-Atlantic	ENC	ESC	South Atlantic	WNC	WSC	Mountain	Pacific
1	10.9%	72.9%	2.3%	0.0%	13.7%	0.0%	0.0%	0.0%	0.0%
2	0.3%	71.9%	18.2%	0.0%	9.3%	0.0%	0.0%	0.0%	0.0%
3/6	4.4%	61.4%	13.8%	0.4%	19.9%	0.0%	0.0%	0.0%	0.0%
4	0.0%	1.4%	90.5%	2.8%	5.1%	0.0%	0.0%	0.0%	0.0%
7	5.8%	13.8%	53.2%	2.5%	20.2%	3.5%	0.0%	0.0%	0.0%
8	3.4%	4.4%	45.9%	3.0%	32.0%	10.9%	0.0%	0.0%	0.0%
13	0.0%	0.0%	0.0%	0.0%	6.5%	92.7%	0.3%	0.0%	0.0%
Appalachia	3.5%	29.0%	36.6%	1.7%	19.5%	9.3%	0.0%	0.0%	0.0%
9	0.0%	0.0%	44.9%	3.5%	4.4%	46.7%	0.1%	0.0%	0.0%
10	0.0%	0.0%	73.2%	19.2%	0.0%	7.0%	0.0%	0.0%	0.0%
11	0.0%	0.0%	98.3%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%
Illinois Basin	0.0%	0.0%	68.1%	11.0%	1.4%	18.9%	0.1%	0.0%	0.0%
15	0.0%	0.0%	0.0%	88.9%	0.0%	0.0%	9.9%	0.0%	0.0%
16-17	0.0%	0.0%	0.0%	4.5%	0.0%	0.0%	0.0%	89.0%	5.5%
18	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	99.4%	0.6%
19	0.0%	0.0%	0.0%	25.3%	0.0%	0.0%	0.0%	71.2%	3.4%
20	0.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	65.7%	33.8%
21	0.0%	0.0%	0.0%	99.7%	0.0%	0.0%	0.2%	0.2%	0.0%
22-23	0.0%	0.0%	0.0%	1.5%	0.0%	0.0%	0.0%	23.0%	16.9%
West	0.0%	0.0%	0.0%	39.1%	0.0%	0.0%	4.9%	41.2%	10.9%
Total U.S.	2.5%	20.4%	42.2%	6.0%	14.0%	11.1%	0.3%	2.3%	0.6%

Table 3.10
Regional Distribution of District Shipments, 1960 and 1989
Share of District's 1989 Shipments

District	New England	Mid-Atlantic	ENC	ESC	South Atlantic	WNC	WSC	Mountain	Pacific
1	1.0%	70.8%	2.9%	0.0%	24.2%	0.0%	0.0%	0.0%	0.0%
2	2.6%	66.1%	25.4%	0.1%	3.6%	0.1%	0.0%	0.0%	0.0%
3/6	5.0%	33.5%	15.7%	0.1%	42.8%	0.0%	0.5%	0.0%	0.0%
4	0.1%	6.5%	82.3%	0.0%	3.6%	7.1%	0.0%	0.0%	0.0%
7	0.8%	20.1%	43.6%	0.0%	28.8%	3.5%	0.0%	0.0%	0.0%
8	1.6%	4.2%	26.3%	0.4%	50.2%	15.9%	0.1%	0.0%	0.0%
13	0.0%	0.0%	1.2%	0.0%	2.5%	92.4%	0.0%	0.0%	0.0%
Appalachia	1.7%	19.7%	26.0%	0.3%	36.0%	14.6%	0.1%	0.0%	0.0%
9	0.0%	0.0%	12.6%	2.7%	15.7%	67.6%	0.7%	0.0%	0.0%
10	0.0%	0.0%	48.7%	28.8%	15.4%	6.8%	0.2%	0.0%	0.0%
11	0.0%	0.0%	86.7%	3.7%	1.6%	7.8%	0.0%	0.0%	0.0%
Illinois Basin	0.0%	0.0%	47.1%	14.5%	12.0%	25.8%	0.3%	0.0%	0.0%
15	0.0%	0.0%	0.0%	7.1%	0.0%	0.0%	92.8%	0.0%	0.0%
16-17	0.0%	0.0%	2.0%	1.3%	0.0%	0.0%	13.6%	81.6%	1.4%
18	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	99.8%	0.2%
19	0.0%	0.0%	13.8%	28.3%	0.1%	0.0%	39.3%	18.0%	0.5%
20	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	1.3%	85.0%	13.4%
21	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
22-23	0.0%	0.0%	38.6%	22.9%	0.1%	0.0%	0.0%	24.9%	13.5%
West	0.0%	0.0%	10.7%	24.7%	0.1%	0.0%	34.1%	27.9%	2.5%
Total U.S.	0.7%	8.5%	22.6%	12.9%	16.9%	10.0%	14.7%	12.0%	1.1%

Table 3.10
Regional Distribution of District Shipments, 1960 and 1989

District	New England	Mid-Atlantic	ENC	ESC	South Atlantic	WNC	WSC	Mountain	Pacific
Change in Share 1960-1989									
1	-9.9%	-2.2%	0.6%	0.0%	10.5%	0.0%	0.0%	0.0%	0.0%
2	2.3%	-5.8%	7.1%	0.1%	-5.7%	0.1%	0.0%	0.0%	0.0%
3/6	0.6%	-27.9%	1.9%	-0.4%	22.9%	0.0%	0.5%	0.0%	0.0%
4	0.1%	5.1%	-8.2%	-2.8%	-1.5%	7.1%	0.0%	0.0%	0.0%
7	-5.0%	6.3%	-9.5%	-2.5%	8.5%	0.0%	0.0%	0.0%	0.0%
8	-1.9%	-0.3%	-19.5%	-2.5%	18.2%	5.1%	0.1%	0.0%	0.0%
13	0.0%	0.0%	1.2%	0.0%	-4.0%	-0.3%	-0.2%	0.0%	0.0%
Appalachia	-1.8%	-9.3%	-10.6%	-1.4%	16.5%	5.3%	0.1%	0.0%	0.0%
9	0.0%	0.0%	-32.3%	-0.7%	11.3%	20.9%	0.6%	0.0%	0.0%
10	0.0%	0.0%	-24.5%	9.5%	15.4%	-0.2%	0.1%	0.0%	0.0%
11	0.0%	0.0%	-11.6%	2.2%	1.6%	7.8%	0.0%	0.0%	0.0%
Illinois Basin	0.0%	0.0%	-21.0%	3.4%	10.6%	6.9%	0.2%	0.0%	0.0%
15	0.0%	0.0%	0.0%	-81.7%	0.0%	0.0%	82.9%	0.0%	0.0%
16-17	0.0%	0.0%	2.0%	-3.1%	0.0%	0.0%	13.6%	-7.4%	-4.1%
18	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	-0.4%
19	0.0%	0.0%	13.8%	3.0%	0.1%	0.0%	39.3%	-53.2%	-3.0%
20	0.0%	0.0%	0.0%	-0.3%	0.0%	0.0%	1.3%	19.3%	-20.4%
21	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	-0.2%	-0.2%	0.0%
22-23	0.0%	0.0%	38.6%	21.4%	0.1%	0.0%	0.0%	1.8%	-3.4%
West	0.0%	0.0%	10.7%	-14.4%	0.1%	0.0%	29.1%	-13.3%	-8.4%
Total U.S.	-1.8%	-11.9%	-19.7%	6.9%	2.8%	-1.1%	14.4%	9.7%	0.5%

Source: U.S. Bureau of Mines, *Bituminous Coal and Lignite Distribution, 1960*;
U.S. Department of Energy, *Coal Distribution, 1989*.

Table 3.11
Share of District Shipments by End-Use Sector, 1960 and 1989

Districts	Percent to Electric Utilities		Percent to Coking Sector		Percent to Other Sector		Percent to Retail Sector	
	1960	1989	1960	1989	1960	1989	1960	1989
1	56.3%	88.1%	12.8%	2.4%	27.4%	7.4%	3.5%	1.0%
2	21.2%	68.7%	58.9%	22.3%	18.6%	5.8%	2.1%	1.2%
3/6	58.8%	90.6%	19.2%	0.0%	19.5%	6.6%	2.6%	0.5%
4	61.7%	90.9%	0.0%	0.0%	32.2%	7.4%	5.9%	1.2%
7	8.7%	8.1%	60.9%	82.8%	14.5%	6.2%	16.2%	0.8%
8	29.3%	74.2%	26.0%	11.1%	26.0%	12.9%	12.5%	0.6%
13	5.8%	73.3%	44.9%	10.1%	8.1%	13.6%	2.5%	0.3%
Total Appalachia	36.3%	77.6%	28.8%	9.8%	23.0%	10.5%	7.7%	0.7%
9	36.8%	94.5%	0.0%	0.0%	16.4%	4.3%	9.3%	0.5%
10	50.9%	90.5%	1.4%	2.6%	30.5%	6.0%	10.3%	0.8%
11	62.6%	84.2%	0.0%	0.0%	31.0%	13.7%	6.4%	1.9%
Total Illinois Basin	48.3%	90.2%	0.7%	1.2%	25.9%	7.4%	9.3%	1.0%
15	63.2%	94.1%	3.7%	0.0%	25.6%	5.8%	12.6%	0.0%
16-17	31.9%	83.3%	42.2%	5.0%	14.1%	11.2%	11.8%	0.5%
18	19.8%	98.7%	0.0%	0.0%	63.4%	1.3%	16.9%	0.0%
19	57.2%	97.6%	0.0%	0.0%	31.4%	2.2%	11.4%	0.2%
20	10.4%	77.5%	50.1%	2.0%	18.1%	15.0%	21.4%	2.2%
21	55.2%	78.0%	0.0%	0.0%	23.8%	19.9%	21.2%	0.6%
22-23	48.9%	95.5%	0.0%	0.0%	40.6%	2.6%	10.4%	0.1%
West	39.3%	93.7%	24.4%	0.3%	22.9%	5.2%	14.7%	0.3%
USA	39.4%	86.3%	21.7%	4.4%	23.7%	7.9%	8.5%	0.7%
East	39.4%	81.0%	21.6%	7.5%	23.8%	9.6%	8.1%	0.8%

Source: U.S. Bureau of Mines, *Bituminous Coal and Lignite Distribution, 1960*;
U.S. Department of Energy, *Coal Distribution, 1989*.

District 7

Declining domestic consumption of coking coal is the primary reason for District 7's fall in absolute output and market share. District 7 is primarily a coking coal district and did not fare any better in shipments to all other sectors. Although table 3.9 indicates a 68.5 percent decrease in absolute tons shipped (22.8 to 7.1 million tons) domestically, the district's overall performance was not quite so poor, as exports climbed from 1.3 million tons in 1960 to 13.6 million tons in 1989. Overall tons shipped fell only by 14 percent. (A major consideration must have been that exports were more remunerative than sales to electric utilities. RLG)

District 8

Although its market share fell 2.5 percent, District 8 still accounted for 22 percent of total domestic coal shipments, which made it the largest supplying district in 1989 (see table 3.8). When exports are included, District 8 shipped a total of 248 million tons in 1989. This was 76 million tons more than District 19 (Wyoming). District 8 was one of only two eastern districts to increase electric utility market share (the other was District 13), and one of only two eastern districts to increase coking coal market share (the other was District 10).

As table 3.10 reveals, proportionately more tons were shipped to the East South Central and South Atlantic states and proportionately less to the East North Central states in 1989 than in 1960. Tons shipped to all three regions were greater in 1989 than 1960. However, the growth in shipments to both the South Atlantic and East South Central regions exceeded 200 percent, compared with 22 percent growth for shipments to the East North Central states. By 1989, District 8 was supplying 66 percent of the total shipments to the South Atlantic region, and 35 percent of the shipments to the East South Central region. In 1960, the shares were 56 percent and 24 percent respectively.

Considerably larger volumes were shipped to electric utilities in all three regions. However, coking coal shipped to the East North Central states declined 6 million tons. In addition, total exports grew from just 4 million tons in 1960 to almost 52 million tons in 1989. The strong performance of District 8, relative to other eastern districts, particularly in supplying electric utilities stems from being better located to take advantage of the remarkable increase in demand for coal by utilities in the East South Central states (especially Kentucky) and South Atlantic states (especially West Virginia, North and South Carolina, Georgia, and Florida).

(Having looked at all the districts that contain West Virginia, Virginia, eastern Kentucky, and Tennessee, it is desirable to look at these states as a whole. At 165 million tons of total shipments in 1991 West Virginia was second only to Wyoming--at 194 million. However, while less than a million tons of Wyoming coal was exported, West Virginia had 54 million in exports so domestic U.S. shipments were only 122 million.⁵ At 117 million, eastern Kentucky was by far the larger part of the number three state; the Kentucky total was 158 million. The eastern Kentucky domestic component was 102 million out of 142 million for the whole state; exports were 15 million. Total U.S. exports were 108 million. Virginia had 43 million tons of total shipments of which 25 million were domestic and 16.7 million foreign. This made Virginia number seven in total shipments. Tennessee at 4 million is a small producer.

⁵ Given the interregional nature of this study, it should be noted that here exports here refer only to shipments to other countries. In regional economics, shipments to other regions that may all be in the same country are termed exports.

West Virginia domestic distribution in 1991 was heavily electric utility oriented--88.8 million tons. It also supplied 12.9 of the 29.9 million tons shipped to coke plants and 9.8 million of 69.4 million to other industry. These shipments are spread among many states. Intrastate shipments at 27.2 million exceeded shipments to any other single state. Ohio at 16.6 million and Pennsylvania at just under 14 million were the next largest customers. Six states received shipments in the 4 to 7 million ton range.

Eastern Kentucky sold 80.1 million to electric utilities, 4.4 million to coke plants, and 15.3 million to other industry. Georgia, at 12.3 million--almost 11 million of which went to electric utilities, had the largest receipts. North Carolina at 11.3 million--9.7 to utilities. Florida was a close third with the 32,000 ton difference disappearing in rounding. 10.8 million went to utilities. Then the sales are scattered among many states.

Virginia has an even higher relative dependence on coke plants than West Virginia. 14.7 million tons went to utilities, 6.2 to coke plants, and 4.0 to other industry. Intrastate shipments at 5.5 million are the largest to any state followed by 4.5 million to North Carolina and 3.2 million to Georgia.

Tennessee sales also are scattered with 1.9 million intrastate of which 1.6 million went to utilities. The next largest recipient was Alabama at 934,000. In sum, these Appalachian states have diverse supply areas none of which dominate. RLG)

District 9 (Western Kentucky)

By 1989, District 9's (western Kentucky) share of total U.S. coal shipments had fallen 42 percent from its 1960 level (see table 3.9). In 1989, it only accounted for 4.7 percent of total shipments. This is primarily because the East North Central states, which accounted for 45 percent of District 9's shipments in 1960 (see table 3.10) started buying western coal. In 1960, District 9 shipped 13.4 million tons to the East North Central states; by 1989, only 5.1 million tons were shipped. Illinois represented the largest loss in this region, as shipments in 1989 were less than half a million tons, compared with 5.4 million in 1960. (In Illinois, coal significantly lost its share of the electricity market to nuclear power.)

With the decline of East North Central sales, district 9 became more dependent on sales to the East South Central and South Atlantic regions (see table 3.10). Shipments to electric utilities in Kentucky, Tennessee, Florida, and Georgia accounted for the increase in tons shipped from District 9. Kentucky receipts rose from 5.4 to 17.4 million tons; Tennessee from 6.7 to 8 million; Georgia and Florida a combined 1.3 million tons in 1960, to 1.5 million to Georgia and 5.9 million to Florida in 1989.

District 10 (Illinois)

District 10 (Illinois) dropped from its position as the second largest supplying district in the country in 1960 (District 8 was the largest) to being the fourth largest in 1989 (behind Districts 8, 19, and 15). This was due to a relatively small increase in tons shipped. Similarly, in 1960, District 10 held the second largest share of the electric utility market, but, by 1989, its share was the fourth largest. Again Districts 8, 19, and 15 had larger shares. The coking sector also received a greater proportion of shipments in 1989. In fact, District 10 increased its share of the coking market and was the only district significantly to increase tons shipped and thus necessarily share in the shrinking coking sector. However, with 1.5 million tons shipped in 1989, District 10 only held approximately 4 percent of coking sales. (Table 3.9 also shows District 4 with increased volume shipped to the coking customers; however, the tons were negligible.)

Table 3.10 shows that proportionately less coal was shipped to the East North Central states in 1989 than in 1960. In fact, absolute tons sold to this region were less in 1989. Illinois itself was consuming less coal in 1989 than 1960. Although the electricity

share of state energy had increased from 19 percent to 40 percent, tons shipped to electric utilities in Illinois were the same in 1989 as they were in 1960. Coal had lost its share of the electricity market to nuclear power. Not only was Illinois using less coal, but it was also buying less local coal. In 1960, Illinois was purchasing 69 percent of its coal locally, but, by 1989, local purchases only represented 58 percent of the total, while western coal, which had not entered the Illinois market in 1960, accounted for 21 percent of total shipments in 1989. Shipments to Wisconsin also declined, as this state greatly increased its reliance on western coal. In the East North Central region, market losses in Illinois (dropping from 26.8 to 17.6 million tons from District 10) and Wisconsin (4 million to 2.3 million tons) were partially offset by increasing shipments to Indiana from 1.6 to 9.5 million tons. (Indiana is a smaller producer and had greater growth in coal consumption than Illinois.)

Sales to the West North Central became proportionately larger, due to increasing shipments to Missouri from 4.3 to 13.9 million tons. Sales to Minnesota declined, as Minnesota turned to western coal. District 10 also entered the Georgia and Florida electric utility markets, shipping 5.2 and 3.8 million tons respectively in 1989.

District 11 (Indiana)

District 11 (Indiana) had the greatest rate of increase of tons shipped of any eastern district (see table 3.9) between 1960 and 1989. This enabled District 11 to move from the position of the ninth largest of ten eastern supplying districts in 1960 to the sixth largest in 1989. District 11's share of total shipments fell, although slightly, relative to the average eastern district. In 1960, District 11 coal was almost entirely shipped to states in the East North Central region (see table 3.10). Indiana alone received 80 percent of 1960 shipments. By 1989, sales remained heavily concentrated in the East North Central region, with 72 percent (24 million tons) of the shipments used locally.

Wisconsin and Illinois were the two other principal East North Central users of Indiana coal, each receiving approximately 2.3 million tons in 1989. Kentucky, in the East South Central region, represented the largest expansion, receiving 2.2 million tons. Half a million tons were shipped to Florida in the South Atlantic, and shipments to Iowa in the West North Central region grew tenfold, to one million tons in 1989.

Western Districts 15-23

The western districts (Districts 15-23) only accounted for 5.5 percent of total domestic shipments in 1960. (Districts 12 and 14 are excluded as they shipped negligible amounts in 1989) In 1989, the western share had risen to 43 percent of the domestic total, with 94 percent of western shipments going to electric utilities. Furthermore, by 1989, almost 8 percent of shipments received by eastern states originated in the West. The East North Central region, in particular, purchased 20 percent of its 1989 shipments from western districts.

Although some western districts ship a large proportion of their production within the district, other western districts, notably 19 (Wyoming) and 22 (Montana), have had much more extensive distribution of their coal. In Districts 15, 18, and 21 at least 85 percent of the coal is shipped within the district. In 1989, Texas received 86 percent (54.4 million tons) of the shipments from District 15 (probably all from the Texas portion of the district). Of the remaining shipments from District 15, Missouri received 3.7 million, Louisiana 3, and Oklahoma 1. Shipments within District 18 were split fairly evenly with New Mexico receiving 44 percent of the shipments (15.1 million tons) and Arizona receiving 43.5 percent (14.8 million tons). Nevada received the bulk of the remainder (4.1 million tons). District 21 (North Dakota) sent 93 percent of its shipments to North Dakota (27.8 million tons) and virtually all the remainder to South Dakota (2 million tons).

Districts 16-17, 19, 20 and 22-23 had broader based shipping patterns. Colorado consumed 62 percent, or 10.8 million tons of District 16-17 coal. Texas and Utah split nearly all the remainder, each receiving about 13 percent of the shipments (2.3 and 2.2 million tons respectively). District 20 (Utah) sent 20 percent (12.9 million tons) to consumers within the state, 13 percent (2.4 million tons) to Nevada, 12.6 percent (2.3 million tons) to California and exported 1 million tons. District 19 (Wyoming) had the broadest based developments. In 1989, it was shipping coal to every East North Central state. The breakdown was as follows: Wisconsin 10 million tons, Indiana 7.6, Illinois 3.4, Ohio 1.4 and Michigan 1. In the West North Central region, Kansas received 14 million tons, Iowa 11.9, Minnesota 8.1, Nebraska 7.4, Missouri 6.4, and just under a half million tons was shipped to South Dakota. All West South Central states were also buyers of Wyoming coal. Texas purchased 34.5 million tons, Oklahoma 12.5, Arkansas 11.4, and Louisiana 8.9. In the Mountain region, Wyoming was the principal consumer, receiving 24.2 million tons. Colorado received 5.6 million tons. Nevada and Idaho each received less than a million tons. In the Pacific region, Washington purchased just less than three quarters of a million tons of Wyoming coal.

(Viewing the 1991 data indicates that 10.9 million of 17.1 million tons of total shipments and 10.2 million of 15.3 million of electric utility shipments from Colorado mines were intrastate. The next largest shipments were 2.2 million total and 1.7 million utilities to Texas. All Arizona shipments were to electric utilities. Of 22.4 million tons from New Mexico 21.7 went to electric utilities. All but 8,000 of the 13.1 million shipped intrastate went to electric utilities. Most of the rest--8.8 million of which 8.4 million went to utilities--was to Arizona. RLG)

District 22 (Montana) also diversified its shipping base. In the East North Central region, Indiana was the largest buyer, receiving 11.2 million tons. Illinois received 2.9 million tons, and Wisconsin 2.1. Minnesota was the only significant buyer in the West North Central region, purchasing 9.4 million tons. In the Mountain region, Montana received 24 percent of the districts' shipments (10.4 million tons). As noted, District 23 is combined with District 22 in the data. The data for the combined districts show Washington in the Pacific region purchased of 5 million tons of coal. The cost and quality reports indicate this was coal produced in Washington.

Summary and Conclusions

Between 1960 and 1991 coal consumption in the United States grew by 91 percent. Although nine of the ten largest consumers were still eastern states in 1991, consumption became less regionally concentrated as most of the growth in coal use came from the western states. (Texas was the sole western state among the top 10.) Regionally, three of the five eastern region--the Middle Atlantic, East South Central (except Kentucky and Mississippi), and East North Central--experienced relatively slow growth in coal consumption. The South Atlantic region, except Virginia and Maryland generally had strong consumption growth. The New England region does not consume significant amounts of coal. In the West, three of the four regions, the West North Central, West South Central, and Mountain had strong growth in coal use. All the West South Central states and Mountain states (except Idaho, an insignificant consumer) were small coal users in 1960 but increased their coal use at rates significantly greater than the national rate. The Pacific region states are insignificant coal consumers.

The consumption analysis indicated that the change in coal use across states can be explained by differences in coal use by electric utilities from one state to another. Examining the role of electric utilities in determining coal consumption patterns between 1960 and 1991 resulted in the following observations:

- 1) The rate of rise in coal use by electric utilities in principal coal consuming states was greater in the West than in the East.

- 2) The expansion in the electricity share of total coal consumption for principal coal consuming states was greater in the West than in the East.
- 3) In the West, the coal share of the electricity market increased significantly, while in the East coal lost its share of the electricity market.
- 4) The growth in the electricity share of an expanding energy market in principal coal consuming states was greater in the West than in the East.

Nationally, the growth of electric utilities, together with a rising coal share of that expanding electricity base accounted for the increase in coal consumption. When regionally considering the principal coal consuming states, more state energy in the West is in the form of electricity than in the East, and a greater proportion of state energy is generated by coal in the West than in the East.

Regionally, the growth in coal output was analogous to consumption growth. The western states accounted for the majority of the rise in coal production. Wyoming and Texas had by far the largest absolute increases in western output between 1960 and 1992. These two states, along with Montana and North Dakota, were among the ten largest producers in 1992. In contrast, Utah was the only western state in the top ten in 1960. In summary, the Appalachian share of total coal consumption dropped from 73 percent in 1960 to 48 percent in 1992, the Illinois Basin share dropped from 22 percent to 12 percent, while the share of the West rose from 5 percent to 40 percent.

The pattern of district coal shipments clearly indicates that production growth is tied to increasing electric utility coal use. Those districts, especially District 2 and 7, that were dependent on coking coal shipments have suffered. While most of the growth in western production was used to fuel utilities in the West, some states, notably Wyoming and Montana, have had particularly broad based coal distribution developments. As coal from these states is low in sulfur content and relatively inexpensive to mine, it has captured markets in the East North Central region and made further advances into states in the West North Central region.

CHAPTER 4

FACTORS EXPLAINING THE DIFFERENTIAL USE OF COAL BY ELECTRIC UTILITIES ACROSS STATES FROM 1947 TO 1992

Introduction

In looking at the principal coal consuming states, we saw that coal lost its share of the electricity generation fuel market in the East, while gaining in the West. The discussion now turns to explaining what underlies the regional shifts from one fuel source, or one method of generation, to another. In particular, what fuel or method of electricity generation displaced coal in the East, and conversely, what fuel or method did coal displace in the West? Although the focus is on the major coal consuming states since 1960, it is interesting at this stage to include the New England and Pacific states in the analysis. New England produced 59 percent of its electricity in 1947 using coal as a fuel source, a much larger proportion than in 1991.

Electricity Generation by Method--National Overview

Before discussing regional patterns of fuel use, an overview of the national share of electricity generation by method in the U.S. since 1947 is presented. Shares are shown in table 4.1. In every year since 1947, coal has held the largest share of the electricity generation market. Coal lost the majority share in the late 1940s and the early 1950s, and again between 1969 and 1979. In both cases, coal losses were to oil gains. However, from 1980 through 1992, coal maintained over a 50 percent share of the electricity market. Middle East and Venezuelan oil was an economically attractive alternative to coal in the late 1940s as a fuel for the post war reconstruction effort. In 1966, with the freeing of residual oil import quotas, oil again became the fuel of choice for most electric plants with easy access to water. The share of oil peaked in 1977, at 16.9 percent, and subsequently declined to a low of 3.2 percent in 1992.

The share of gas rose steadily from 9 percent in 1947 to a high of 24.3 percent in 1970. However, rising gas prices in the late 1960s eroded the share of gas, and since 1970, its share has generally trended downward. Gas's share in 1992 was not significantly different from that in 1947.

Between 1947 and 1958, waterpower held the second largest share of electricity generation, behind coal. In the late 1940s, approximately 30 percent of electricity was produced by waterpower. However, due to a limited supply of economic generation sites, waterpower generation has not kept pace with the growth in electricity. Consequently, its share of electricity production declined in most years since 1947, and in 1992 was less than a third of the 1947 level.

It was 1969 before nuclear power gained a 1 percent share of the electricity market. Since its commencement, the share of electricity produced by nuclear power has increased in virtually every year. In 1992 its share stood at 22.1 percent, its highest level.

Table 4.1

U.S. Electricity Generation by Method, 1946-1992

a. million kilowatt hours

Year	Total	Coal	Fuel Oil	Gas	Nuclear	Hydro
1946	233,178	111,654	14,082	18,820		78,406
1947	255,739	136,985	16,925	23,073		78,426
1948	282,698	152,910	16,762	30,123		82,470
1949	291,100	135,451	28,547	36,967		89,748
1950	329,141	154,520	33,734	43,879		95,938
1951	370,673	184,204	28,712	56,616		99,750
1952	399,224	195,437	29,750	68,453		105,103
1953	442,665	218,846	38,404	79,791		105,233
1954	471,686	239,146	31,520	93,688		107,069
1955	547,038	301,363	37,138	95,285		112,975
1956	600,668	338,503	39,957	104,037		122,029
1957	631,507	346,386	40,500	114,212	10	130,232
1958	645,098	344,366	40,372	119,759	165	140,262
1959	710,006	378,424	46,840	146,619	188	137,782
1960	755,374	403,067	46,105	157,970	518	145,516
1961	794,273	421,871	47,120	169,286	1,692	151,850
1962	854,773	450,249	46,983	184,301	2,270	168,283
1963	916,793	493,927	52,001	201,602	3,212	165,755
1964	983,990	526,230	56,954	220,038	3,343	177,073
1965	1,055,052	570,926	64,801	221,559	3,657	193,851
1966	1,144,350	613,475	78,926	251,151	5,520	194,756
1967	1,214,365	630,483	89,271	264,806	7,655	221,518
1968	1,329,443	684,905	104,276	304,433	12,528	222,491
1969	1,442,182	706,001	137,847	333,279	13,928	250,193
1970	1,531,609	706,102	182,488	372,884	21,797	247,456
1971	1,612,589	714,676	218,608	374,026	38,106	266,314
1972	1,749,637	772,871	272,530	375,735	54,092	272,626
1973	1,856,216	845,704	312,805	340,449	83,334	271,634
1974	1,866,436	829,842	299,306	319,931	113,727	300,928
1975	1,917,619	852,972	288,873	299,766	172,506	300,065
1976	2,037,674	944,562	319,779	294,610	191,107	283,734
1977	2,124,166	985,465	357,866	305,444	250,882	220,446
1978	2,206,313	976,618	364,153	305,392	276,403	280,432
1979	2,247,359	1,075,595	302,948	329,486	255,155	279,790
1980	2,286,414	1,161,969	245,547	346,233	251,121	276,039
1981	2,294,812	1,203,554	206,070	345,777	272,674	260,684
1982	2,241,211	1,192,379	146,423	305,260	282,773	309,213
1983	2,310,285	1,259,424	144,499	274,098	293,677	332,130
1984	2,416,304	1,341,681	119,808	297,394	327,634	321,150
1985	2,469,841	1,402,128	100,202	291,946	383,691	281,149
1986	2,487,310	1,385,831	136,585	248,508	414,038	290,844
1987	2,572,127	1,463,781	118,493	272,621	455,270	249,695
1988	2,704,250	1,540,653	148,900	252,801	526,973	222,940
1989	2,784,304	1,553,661	158,318	266,598	529,355	265,063
1990	2,808,151	1,559,606	117,017	264,089	576,862	279,926
1991	2,825,023	1,551,167	111,463	264,172	612,565	275,519
1992	2,797,219	1,575,895	88,916	263,872	618,776	239,559

**Table
4.1
U.S. Electricity Generation by Method, 1946-1992**

Year	b. percent of total						Total
	Coal	Fuel Oil	Gas	Nuclear	Hydro	Other**	
1946	47.9%	6.0%	8.1%	0.0%	33.6%	0.0%	95.6%
1947	53.6%	6.6%	9.0%	0.0%	30.7%	0.0%	99.9%
1948	54.1%	5.9%	10.7%	0.0%	29.2%	0.0%	99.8%
1949	46.5%	9.8%	12.7%	0.0%	30.8%	0.0%	99.9%
1950	46.9%	10.2%	13.3%	0.0%	29.1%	0.0%	99.7%
1951	49.7%	7.7%	15.3%	0.0%	26.9%	0.0%	99.6%
1952	49.0%	7.5%	17.1%	0.0%	26.3%	0.0%	99.9%
1953	49.4%	8.7%	18.0%	0.0%	23.8%	0.0%	99.9%
1954	50.7%	6.7%	19.9%	0.0%	22.7%	0.0%	99.9%
1955	55.1%	6.8%	17.4%	0.0%	20.7%	0.0%	99.9%
1956	56.4%	6.7%	17.3%	0.0%	20.3%	0.0%	100.6%
1957	54.9%	6.4%	18.1%	0.0%	20.6%	0.0%	100.0%
1958	53.4%	6.3%	18.6%	0.0%	21.7%	0.0%	100.0%
1959	53.3%	6.6%	20.7%	0.0%	19.4%	0.0%	100.0%
1960	53.4%	6.1%	20.9%	0.1%	19.3%	0.0%	99.7%
1961	53.1%	5.9%	21.3%	0.2%	19.1%	0.0%	99.7%
1962	52.7%	5.5%	21.6%	0.3%	19.7%	0.0%	99.7%
1963	53.9%	5.7%	22.0%	0.4%	18.1%	0.0%	100.0%
1964	53.5%	5.8%	22.4%	0.3%	18.0%	0.0%	100.0%
1965	54.1%	6.1%	21.0%	0.3%	18.4%	0.0%	100.0%
1966	53.6%	6.9%	21.9%	0.5%	17.0%	0.0%	100.0%
1967	51.9%	7.4%	21.8%	0.6%	18.2%	0.1%	100.0%
1968	51.5%	7.8%	22.9%	0.9%	16.7%	0.1%	100.0%
1969	49.0%	9.6%	23.1%	1.0%	17.3%	0.1%	100.0%
1970	46.1%	11.9%	24.3%	1.4%	16.2%	0.1%	100.0%
1971	44.3%	13.6%	23.2%	2.4%	16.5%	0.1%	100.0%
1972	44.2%	15.6%	21.5%	3.1%	15.6%	0.1%	100.0%
1973	45.6%	16.9%	18.3%	4.5%	14.6%	0.1%	100.0%
1974	44.5%	16.0%	17.1%	6.1%	16.1%	0.1%	100.0%
1975	44.5%	15.1%	15.6%	9.0%	15.6%	0.2%	100.0%
1976	46.4%	15.7%	14.5%	9.4%	13.9%	0.2%	100.0%
1977	46.4%	16.8%	14.4%	11.8%	10.4%	0.2%	100.0%
1978	44.3%	16.5%	13.8%	12.5%	12.7%	0.2%	100.0%
1979	47.9%	13.5%	14.7%	11.4%	12.4%	0.2%	100.0%
1980	50.8%	10.7%	15.1%	11.0%	12.1%	0.2%	100.0%
1981	52.4%	9.0%	15.1%	11.9%	11.4%	0.3%	100.0%
1982	53.2%	6.5%	13.6%	12.6%	13.8%	0.2%	100.0%
1983	54.5%	6.3%	11.9%	12.7%	14.4%	0.3%	100.0%
1984	55.5%	5.0%	12.3%	13.6%	13.3%	0.4%	100.0%
1985	56.8%	4.1%	11.8%	15.5%	11.4%	0.4%	100.0%
1986	55.7%	5.5%	10.0%	16.6%	11.7%	0.5%	100.0%
1987	56.9%	4.6%	10.6%	17.7%	9.7%	0.5%	100.0%
1988	57.0%	5.5%	9.3%	19.5%	8.2%	0.4%	100.0%
1989	55.8%	5.7%	9.6%	19.0%	9.5%	0.4%	100.0%
1990	55.5%	4.2%	9.4%	20.5%	10.0%	0.4%	100.0%
1991	54.9%	3.9%	9.4%	21.7%	9.8%	0.4%	100.0%
1992	56.3%	3.2%	9.4%	22.1%	8.6%	0.4%	100.0%

Sources: National Coal Association, *Trends in Electric Utility Industry Experience, 1946-1958*, Washington, 1960; Edison Electric Institute, annual, *Statistical Yearbook of the Electric Utility Industry*; U.S. Department of Energy, Energy Information Administration, annual, *Electric Power Annual*.

Electricity Generation by Method--Regional Analysis

Four factors appear critical to the differential growth in electric utility coal consumption across states after 1960: 1) the emergence of nuclear power, 2) increasing natural gas prices, 3) limited waterpower resources, and 4) a shift in the New England states from coal to oil. These factors are considered below in a regional overview of changes in electricity generation by fossil fuel and method.

Three tables on the following pages highlight the trends in electricity generation by method and fuel, and are referred to in the regional overview below. To indicate alterations in electric utility fuel use and methods of electricity generation in the principal coal consuming states, the change in share of electricity generation from 1960 to 1992 for coal, oil, gas, hydropower, and nuclear power are shown in table 4.2. Table 4.2 has been arranged using the same groups that were used to identify state coal consumption and production growth patterns. Within each group, the states are arranged by their geographic regions.

In short, it is evident from table 4.2 that coal share losses of the electricity generation market in the traditionally large and laggard eastern coal consuming states were to nuclear gains. In contrast, the western growth in coal use was at the expense of gas and waterpower. To determine when the shifts occurred, table 4.2 can be used in conjunction with table 4.3 which indicates, for selected years between 1947 and 1992, the share of electricity produced by fuel and method in each region. Finally, in table 4.4 the actual share of electricity generation by fuel and method is shown for every state, comparing 1960 and 1992.

The regional developments in electricity generation since 1947 are as follows:

New England

Coal and oil competed in Connecticut, Massachusetts, New Hampshire, and Rhode Island from 1947 until 1966. When oil import controls were lifted in 1966 these states, except New Hampshire, favored oil over coal. Coal and oil competed in New Hampshire until 1990, when nuclear reduced their shares. Massachusetts and Rhode Island have continued to rely heavily on oil. In fact, coal has not been used by Rhode Island electric utilities since 1974. By 1976, nuclear accounted for over half the electricity generated in Connecticut.

Maine, which relied heavily on waterpower in the late 1940s, also turned to oil. However, by the mid 1970s, the majority of electricity in Maine was generated by nuclear power. Hydropower also had a dominant role in Vermont from 1947 until 1973, except in 1948 and 1949 and the period from 1951 to 1956, when oil use increased. The removal of the oil import controls in 1966 had relatively little impact in Vermont. Nuclear power has made the largest gains in Vermont. (In both Maine and Vermont, only a single nuclear unit

Table 4.2			
Change in Share of Electricity Generation by Method			
For Principal Coal Consuming States, 1960-1992			

State	Coal Share of Electricity Generation Utility Fuel Consumption		Change in Share of Electricity 1960-1992				
	1960	1992	Coal	Nuclear	Gas	Oil	Hydro
United States	53.5%	56.3%	2.8%	22.1%	-11.5%	-4.0%	-10.8%
a) Relatively Large Consumers With Below National Average Growth							
New York	58.5%	22.2%	-36.3%	21.5%	7.9%	6.7%	0.2%
Pennsylvania	89.8%	61.6%	-28.3%	36.2%	-1.0%	-3.0%	-3.5%
Illinois	89.6%	39.9%	-49.7%	59.1%	-8.4%	-0.1%	-0.3%
Indiana	96.4%	98.4%	2.0%	0.0%	-2.2%	-0.1%	0.3%
Michigan	90.9%	74.3%	-16.6%	22.8%	-0.5%	-0.2%	-5.5%
Ohio	99.4%	88.4%	-11.0%	10.9%	-0.2%	-0.1%	0.2%
Wisconsin	83.9%	70.5%	-13.5%	24.1%	-0.6%	-0.1%	-10.3%
Maryland	84.3%	59.7%	-24.7%	26.9%	2.1%	3.7%	-10.1%
Virginia	92.5%	46.3%	-46.2%	47.7%	1.8%	2.5%	-5.8%
Alabama	71.6%	66.8%	-4.7%	21.4%	-2.8%	0.1%	-14.0%
Tennessee	76.5%	66.3%	-10.2%	20.8%	-1.8%	0.2%	-8.9%
Average	84.9%	63.1%	-21.7%	26.5%	-0.5%	1.1%	-5.2%
b) Relatively Large Consumers With Above National Average Growth							
Iowa	40.9%	84.4%	43.5%	11.6%	-45.3%	-1.7%	-7.8%
Minnesota	48.7%	64.7%	16.0%	29.6%	-40.6%	-0.2%	-5.6%
Missouri	69.4%	82.7%	13.3%	14.3%	-22.0%	-1.3%	-4.3%
North Carolina	73.0%	65.1%	-7.9%	27.4%	-1.8%	0.0%	-17.7%
South Carolina	41.8%	32.2%	-9.6%	63.7%	-23.6%	0.0%	-30.5%
West Virginia	96.6%	99.1%	2.6%	0.0%	-0.5%	0.1%	-2.3%
Kentucky	85.8%	25.0%	9.2%	0.0%	-0.9%	0.1%	-8.4%
Average	65.2%	74.7%	9.6%	20.9%	-19.2%	-0.4%	-10.9%
c) Relatively Small Consumers in 1960 With Above National Average Growth							
Kansas	10.5%	69.7%	59.2%	26.7%	-83.8%	-1.9%	-0.2%
Nebraska	13.8%	55.4%	41.6%	39.1%	-60.5%	-1.8%	-17.2%
North Dakota	39.8%	94.0%	54.2%	0.0%	-0.2%	-0.3%	-53.6%
Florida	14.1%	46.0%	31.9%	18.7%	-30.1%	-19.2%	-1.4%
Georgia	58.3%	63.5%	5.1%	30.5%	-20.4%	-0.1%	-15.2%
Arkansas	0.0%	53.6%	53.6%	30.3%	-73.0%	-1.0%	-9.9%
Louisiana	0.0%	35.9%	35.9%	18.8%	-55.3%	0.6%	0.0%
Oklahoma	0.0%	60.2%	60.2%	0.0%	-58.4%	-0.3%	-1.5%
Texas	0.0%	49.5%	49.5%	10.2%	-58.1%	0.0%	-1.7%
Arizona	0.0%	49.4%	49.4%	36.5%	-60.4%	-0.2%	-25.1%
Colorado	36.5%	94.1%	57.5%	0.0%	-44.1%	-0.8%	-12.7%
Montana	3.0%	67.2%	64.2%	0.0%	-0.1%	0.1%	-64.5%
Nevada	0.0%	78.4%	78.4%	0.0%	-14.4%	0.6%	-64.6%
New Mexico	1.0%	91.5%	90.5%	0.0%	-87.3%	-1.8%	-1.3%
Utah	37.2%	95.8%	58.6%	0.0%	-7.8%	-43.1%	-8.2%
Wyoming	59.0%	98.3%	39.3%	0.0%	-2.3%	-0.2%	-36.8%
Average	17.1%	69.2%	52.2%	13.2%	-41.0%	-4.3%	-19.6%
Average Included Panel	76.7%	64.3%	-12.3%	25.7%	-5.1%	-0.5%	-7.8%
	21.2%	72.0%	50.9%	12.8%	-42.0%	-3.1%	-18.5%

Sources: National Coal Association, *Trends in Electric Utility Industry Experience, 1946-1958*. Washington, 1960; Edison Electric Institute, annual, *Statistical Yearbook of the Electric Utility Industry*; U.S. Department of Energy, Energy Information Administration, annual, *Electric Power Annual*.

Table 4.3									
Regional Percentage of Electricity Generation by Method									
Selected Years, 1947-1992									

	Percentage of Electricity Generation By Method									
	1947	1953	1959	1965	1971	1977	1983	1989	1992	
New England										
Coal	59.0%	34.2%	48.4%	38.0%	9.7%	3.3%	15.3%	17.7%	19.3%	
Oil	14.7%	46.8%	30.4%	67.9%	56.4%	41.8%	38.0%	25.2%	23.5%	
Gas	0.0%	0.1%	3.5%	2.5%	1.5%	0.4%	3.3%	5.3%	4.9%	
Hydro	26.3%	18.8%	17.5%	9.2%	6.7%	6.4%	6.0%	4.4%	4.7%	
Nuclear	0.0%	0.0%	0.0%	2.4%	14.4%	33.5%	33.6%	34.0%	45.5%	
Middle Atlantic										
Coal	77.5%	70.8%	67.3%	67.1%	45.0%	40.3%	46.8%	42.7%	42.8%	
Oil	4.2%	11.2%	11.9%	13.4%	33.3%	31.5%	19.7%	16.8%	6.8%	
Gas	0.1%	6.0%	8.5%	5.7%	5.3%	0.4%	8.3%	6.8%	7.3%	
Hydro	18.2%	12.0%	12.1%	13.1%	11.5%	10.2%	10.6%	7.6%	8.6%	
Nuclear	0.0%	0.0%	0.0%	0.7%	4.9%	17.5%	14.6%	26.1%	34.2%	
East North Central										
Coal	93.4%	89.5%	92.9%	94.6%	84.6%	80.1%	82.0%	73.7%	73.9%	
Oil	1.0%	6.6%	6.4%	0.3%	3.7%	5.0%	1.1%	6.6%	0.3%	
Gas	0.3%	6.1%	4.3%	2.9%	7.6%	8.9%	0.6%	0.3%	0.6%	
Hydro	3.3%	3.8%	2.4%	1.7%	1.3%	0.7%	1.1%	0.6%	0.1%	
Nuclear	0.0%	0.0%	0.0%	0.3%	2.7%	13.2%	15.2%	24.3%	24.3%	
West North Central										
Coal	46.4%	38.8%	38.3%	42.3%	48.1%	65.5%	77.9%	75.2%	75.3%	
Oil	37.1%	66.3%	19.9%	84.3%	99.4%	57.0%	67.1%	68.8%	10.7%	
Gas	24.8%	45.9%	45.7%	40.5%	33.5%	10.3%	2.7%	1.1%	0.9%	
Hydro	17.6%	10.5%	14.0%	16.0%	14.4%	6.8%	7.4%	4.7%	4.5%	
Nuclear	0.0%	0.0%	0.0%	0.2%	1.4%	14.2%	11.6%	18.6%	18.7%	
South Atlantic										
Coal	60.6%	63.1%	66.3%	72.4%	59.4%	54.6%	61.8%	61.3%	58.2%	
Oil	10.1%	14.0%	10.1%	11.3%	22.1%	21.2%	9.2%	7.5%	6.3%	
Gas	3.7%	9.2%	11.0%	6.6%	11.2%	3.5%	4.1%	3.8%	4.0%	
Hydro	25.8%	13.8%	12.6%	9.4%	6.1%	4.0%	3.9%	2.9%	3.1%	
Nuclear	0.0%	0.0%	0.0%	0.0%	0.9%	16.6%	21.1%	24.3%	28.4%	
East South Central										
Coal	26.9%	48.2%	74.6%	77.1%	75.7%	71.1%	68.4%	71.4%	72.7%	
Oil	0.2%	0.0%	0.0%	0.0%	0.5%	6.0%	0.2%	0.3%	0.3%	
Gas	6.6%	14.3%	6.2%	6.6%	8.5%	1.7%	2.1%	1.6%	1.7%	
Hydro	66.3%	37.4%	19.2%	16.3%	15.1%	11.7%	11.2%	12.1%	8.9%	
Nuclear	0.0%	0.0%	0.0%	0.0%	0.0%	9.5%	18.1%	14.4%	16.4%	
West South Central										
Coal	2.2%	0.5%	0.0%	0.0%	0.0%	8.1%	41.3%	49.3%	49.3%	
Oil	3.3%	0.7%	0.2%	6.1%	1.1%	9.0%	0.8%	0.4%	0.2%	
Gas	86.8%	95.1%	95.6%	97.2%	96.7%	79.2%	53.4%	39.5%	35.9%	
Hydro	7.3%	3.6%	4.2%	2.6%	2.2%	1.7%	2.2%	1.9%	2.4%	

Table 4.4									
State Share of Electricity Generation by Method, 1960 and 1992									
State	1960 Share of Electricity by Method				1992 Share of Electricity by Method				
	Coal	Oil	Gas	Hydro	Coal	Oil	Gas	Hydro	Nuclear
Connecticut	85.1%	8.2%	1.7%	5.1%	8.5%	21.1%	0.8%	1.4%	66.7%
Maine	1.3%	33.4%	0.0%	65.3%	0.0%	15.1%	0.0%	20.6%	64.3%
Massachusetts	45.8%	41.4%	6.1%	6.5%	33.3%	40.4%	11.4%	0.3%	14.4%
New Hampshire	11.0%	37.2%	0.0%	51.8%	23.7%	10.2%	0.4%	7.2%	58.5%
Rhode Island	84.2%	14.4%	0.9%	0.5%	0.0%	68.8%	32.1%	0.0%	0.0%
Vermont	3.6%	0.4%	0.0%	96.1%	0.0%	0.1%	1.3%	17.2%	79.5%
New England	50.2%	28.4%	3.3%	17.9%	19.3%	25.2%	4.9%	4.7%	45.5%
New Jersey	50.9%	34.5%	14.4%	0.2%	17.4%	3.3%	10.5%	-0.4%	69.3%
New York	58.5%	9.2%	9.7%	22.6%	22.2%	15.8%	17.6%	22.8%	21.5%
Pennsylvania	89.8%	4.3%	1.1%	4.2%	61.6%	1.3%	0.2%	0.7%	36.2%
Middle Atlantic	69.3%	11.3%	7.2%	12.1%	42.8%	6.8%	7.5%	8.6%	34.2%
Illinois	89.6%	0.4%	9.0%	0.4%	39.9%	0.3%	0.6%	0.0%	59.1%
Indiana	96.4%	0.4%	2.9%	0.3%	98.4%	0.3%	0.7%	0.6%	0.0%
Michigan	90.9%	0.8%	1.8%	6.6%	74.3%	0.6%	1.2%	1.1%	22.8%
Ohio	99.4%	0.2%	0.4%	0.0%	88.4%	0.1%	0.2%	0.2%	10.9%
Wisconsin	83.9%	0.2%	1.0%	14.8%	70.5%	0.1%	0.4%	4.6%	24.1%
East North Central	93.6%	0.4%	3.4%	2.5%	73.9%	0.3%	0.6%	0.8%	24.3%
Iowa	40.9%	1.9%	45.8%	11.1%	84.4%	0.1%	0.5%	3.3%	11.6%
Kansas	10.5%	2.0%	87.2%	0.2%	69.7%	0.1%	3.4%	0.0%	26.7%
Minnesota	48.7%	1.9%	41.6%	7.6%	64.7%	1.7%	1.0%	2.0%	29.6%
Missouri	69.4%	1.4%	22.3%	6.9%	82.7%	0.1%	0.3%	2.6%	14.3%
Nebraska	13.8%	1.9%	61.2%	22.0%	55.4%	0.0%	0.6%	4.8%	39.1%
North Dakota	39.8%	0.4%	0.2%	59.6%	94.0%	0.1%	0.0%	5.9%	0.0%
South Dakota	15.3%	1.3%	16.6%	66.8%	42.0%	0.1%	0.0%	57.8%	0.0%
West North Central	40.3%	1.7%	45.1%	12.6%	75.3%	0.4%	0.9%	4.5%	18.7%

		Table 4.4		
State Share of Electricity Generation by Method, 1960 and 1992				

[illegible]

was added. Each unit was a large portion of state capacity, and with low operating costs, operated at high rates. Heavy fuel oil is expensive to transport over land, and, therefore, cannot compete inland. Vermont, of course, is not on the east coast, and neither was the plant in New Hampshire that continued coal use. The largest utility is Rhode Island is a subsidiary of the New England Electric System and relies on power generated elsewhere in New England. RLG)

Middle Atlantic

All three states, especially New Jersey, have had significantly increasing shares of nuclear generated electricity, which has displaced coal use. To a lesser extent, gas has also displaced coal use in New York. Of the three states in this region, Pennsylvania, being a large coal producer, continued to generate the majority of its electricity from coal in 1992. New York and New Jersey had large increases in oil generated electricity from 1966 to 1972, but the oil shares have since sharply declined. Between 1960 and 1992 New York has generated from 18 to 28 percent of its electricity from hydropower. (Again, another influence is geography. While much of New Jersey and downstate New York is located where tankers and barges could deliver oil, this is true only for parts of Pennsylvania such as the Philadelphia area. RLG)

East North Central

Nuclear power captured a share of electricity generation in all but one state in this traditionally coal consuming region. The exception was Indiana, where coal held a 98 percent share of the electricity generation market in 1992. (Two nuclear units planned for Indiana were canceled although a substantial amount of construction had been completed. RLG.) The nuclear gain in Illinois was almost 60 percent. However, except in Illinois, electricity generation by burning coal remains the predominant method, as Illinois, Ohio, and Indiana are large coal producers, and coal is accessible for Michigan and Wisconsin.

West North Central

In general, substantial shifts from gas and hydro to coal and nuclear power arose. Gas, which accounted for the largest share of electricity generation in 1960, was essentially eliminated from this region when prices rose in the late 1960s. In Kansas, gas dropped in share by 84 percent. Coal gains were greater than nuclear in Kansas, Iowa, and Nebraska, while the opposite was the case for Minnesota and Missouri. In North Dakota, where there was no gas use, just coal and hydropower, the shift was from hydro to coal, resulting in 94 percent coal use by electric utilities. In 1992, South Dakota still generated the majority (58 percent) of its electricity from hydropower. The remainder was coal generated.

South Atlantic

Nuclear power has also penetrated the South Atlantic states, except Delaware and West Virginia. The nuclear gains were largest in South Carolina and Virginia. To a lesser, but still significant extent, nuclear gained shares in Georgia, North Carolina, Maryland, and Florida. In North Carolina, South Carolina, and Georgia, a declining share of waterpower was the main change associated with the nuclear rise. However, in the last two states, gas also dropped from over a 20 percent share of the electricity market in 1960 to less than 1 percent in 1992. Gas use declined steadily in both states after 1970 as prices for gas rose in the late 1960s. In Virginia, nuclear power captured approximately half of the 93 percent share of the electricity generation market that coal held in 1960. (Virginia Electric and Power, the largest electric utility in the state also built a coal-fired plant in West Virginia; the other main supplier, the Appalachian Power division of American Electric Power, also relied on capacity expansion outside the state. Conversely, Virginia Electric and Power totally reversed its coal to oil shift in its Virginia plants. RLG)

Coal was also the principal loser to nuclear gains in Maryland. In Florida, coal and nuclear gains resulted in oil and gas losses. In 1992, oil still had a 21 percent share of electricity generation in Florida, although this was down from a 40 percent share in 1960. (For most of the 1950s, oil held well over an 80 percent share in Florida). Similar to Georgia and South Carolina, gas use by Florida utilities also declined after 1969. The gas share fell from 44 percent in 1960 to 14 percent in 1992.

In 1992, coal was still the dominant fossil fuel, especially in West Virginia, one of the largest coal producers, where virtually all electricity is generated using coal. Although the Carolinas and Georgia are coastal states and thus could receive oil shipments by tanker, oil use by utilities was never significant. (The plants often were not close to tidewater. RLG) At its peak in 1974, oil gained just over a ten percent share in South Carolina and Georgia. In 1992 oil held less than a one percent share in all three of these states.

East South Central

Reliance on coal is heavy, especially in Kentucky, the third largest coal producer in the U.S. in 1992. In Alabama and Tennessee, coal accounted for approximately two-thirds of electricity generation in 1992. In both states nuclear gained about a 20 percent share, displacing both coal and hydro. (All expansion in the 1970s by the Tennessee Valley Authority, the sole producer in Tennessee and one of the main producers in Alabama, was nuclear. The other main Alabama producer, the Alabama Power division of the Southern Company, installed both coal and nuclear units. RLG) Mississippi was almost entirely a gas burning state in 1960. However, coal and nuclear power had each gained just less than a 40 percent share by 1992.

West South Central

Electricity was almost exclusively generated by gas in 1960. These states are principal gas producers. Thus gas was a relatively inexpensive fuel for utilities until prices rose (and federal regulation was extended to intrastate gas RLG) in the 1970s. Gas lost over a fifty percent share of electricity generation in Texas, Oklahoma, Louisiana, and over 70 percent in Arkansas. The losses were primarily to coal gains, although nuclear made gains in every state, except Oklahoma.

Mountain

The growth in electricity consumption was met by coal produced within this region. Hydropower and gas had significantly reduced roles, except Idaho still produced all its electricity by waterpower in 1992. (Idaho is another state in which the power companies, principally Idaho Power, relied on out of state generation. RLG)

Pacific

The role of oil, which was essentially only used by utilities in California, was sharply reduced in the late 1970s and early 1980s, and its use was negligible in 1992. Oil had accounted for a significantly growing share of electricity generation in the mid 1970s, reaching a peak of 56 percent in 1976. In California, oil and hydro losses were to nuclear gains. California is a producer of natural gas, and gas held at least a 20 percent share of the electricity market in every year between 1960 and 1992. The share of gas in California in 1992 was 47 percent, only 2 percent less than 1960. In the mid 1960s the gas share in California reached a high of just over 60 percent. Coal has never had a role in California, though California receives coal generated electricity from Nevada, Arizona, New Mexico and Utah. These coal plants were not constructed in California for environmental reasons.

(The California experience illustrates the many problems of the electric power industry. The state supplemented conventional regulation of electric utilities with creation of a separate Energy Commission with power over approval of new power plants and their sites. A combination of prior state decisions and the actions of the two state agencies

profoundly altered the nature of electric utility expansion to serve California. New plant additions in the 1980s within the state were limited to four nuclear units and the extensive nonutility capacity that the Public Service Commission encouraged. A series of coal-fired plants were built in Mountain states in the seventies and eighties in part to serve California. The idea for such plants, in turn, was a U.S. Department of Interior response to environmental objections to new dams on the Colorado River. However, the coal plants ultimately became subject of environmental criticism because the plants were believed to cause deterioration of visibility at the Grand Canyon and other scenic locations in the region. RLG)

As a whole, this region has reduced its reliance on hydropower. Hydro remains prominent in Washington and Oregon, however, its share did drop from virtually 100 percent in both states, to 80 percent in Washington and 76 percent in Oregon. In both states the waterpower losses were to coal and nuclear gains.

CHAPTER 5 SUMMARY AND CONCLUSIONS

Coal has become a predominantly single use fuel. Since the late 1940s, electricity has gradually become the primary market for coal. Electric utility use of coal represented 17 percent of total coal use in 1949 compared to 85 percent in 1991. On the other hand, coal has historically held a considerable share of an expanding electricity generation fuel market. Not only did coal use become concentrated in the electric utility sector, but also, its consumption growth is attributable to large increases in use by this sector. While utilities were consuming more coal, other end use sectors experienced declining consumption.

On a state level, differences in coal consumption growth rates can be explained by differences in electric utility coal use from one state to another. Underlying the developments in electricity coal use by states are changes in where the growth in coal consumption and output occurred. The majority of the production expansion has come from new western areas that correspond to areas of increasing electric utility coal consumption. In these western areas, coal, which is almost exclusively consumed by electric utilities, has increased its share of an expanding electricity market, while in the East coal lost share, primarily to nuclear gains. Even though coal lost its share of the electricity market in virtually every principal eastern coal consuming state, coal consumed by electric utilities still increased in these states because of the growing demand for electricity. Coal gains displaced gas as the fuel of choice for utilities in the West North Central, West South Central and Mountain regions. Coal was also favored over hydropower, in light of the rising incremental costs of expanding these projects.

While most of the growth in coal consumption is in the West, nine of the ten largest consumers are still eastern states. Some eastern demand, and demand from West North Central states close to Illinois Basin producers is being met with low sulfur western coal.

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		Table A					
Key Developments in the Location of Electric Power Plant Coal Purchases for Selected States, 1960 - 1991							
(Thousand short tons)							
Utility	Plant*		Tons	1960 Origin**	Tons	1993 Origin	
NEW ENGLAND:							
MASSACHUSETTS							
New England Electric	Brayton Point	1963			1,652	WVA	
					427	Import	
					69	EKY	
					1	MD	
					7	WYOM	
					2,163	Total	
NEW HAMPSHIRE:							
Public Service Co of NH	Merrimac	1960	30	na	662	PA	
					389	WVA	
					46	Import	
					1,096	Total	
MIDDLE ATLANTIC:							
NEW YORK:							
New York Electric and Gas	Kintigh	1984			1,467	PA	
Niagara Mohawk Power	Dunkirk	1960	866	PA-WVA	835	PA	
					310	WVA	
					16	CH	
					1,161	Total	
	Huntley	1958	1,208	PA-WVA	1,020	PA	
					195	WVA	
					1,215	Total	
PENNSYLVANIA:							
Duquesne Light	Cheswick	1970			871	PA	
					332	WVA	
					1,193	Total	
	Elrama	1952	1,145	PA	1,105	PA	
					50	WVA	
					1,155	Total	
Pennsylvania Electric	Conemaugh	1970			3,913	PA	
	Homer City	1969			4,348	PA	
	Keystone	1967			4,206	PA	
					15	WVA	
					4,221	Total	
	Shawville	1954	1,553		1,417	PA	
Pennsylvania Power	Bruce Mansfield	1975			2,333	WVA	
					1,613	PA	
					1,512	CH	
					4	KY	
					5,481	Total	
Pennsylvania Power and Light	Brunner Island	1961			2,723	PA	
					75	WVA	
					2,798	Total	
	Moutour	1971			3,284	PA	
					54	WVA	
					3,338	Total	
	Sunbury	1949	1,347	PA	813	PA	
					10	WVA	
					823	Total	
West Penn Power	Hatfield	1969			2,745	WVA	
					347	PA	
					3,092	Total	

EAST NORTH CENTRAL:						
ILLINOIS:						
Central Illinois Light	Duck Creek	1976			965	IL
					36	EKY
					1,001	Total
Central Illinois Light	Edwards	1960	230	IL	877	EKY
					114	WVA
					212	IL
					1,203	Total
Central Illinois Public Service	Coffeen	1965			1,667	IL
Central Illinois Public Service	Newton	1977			1,275	IL
					814	CO
					333	IN
					13	WYOM
					11	UT
					2,446	Total
Commonwealth Edison	Joliet	1965	1,383	IL-KY	1,362	MT
					405	WYOM
					1,767	Total
	Kincaid	1967			1,761	IL
	Powerton	1972	740	IL	2,424	WYOM
					116	MT
					2,540	Total
	Waukegan	1968	859	IL-IN-KY	673	WYOM
					311	MT
					984	Total
	Will County	1955			1,511	WYOM
					481	MT
					1,992	Total
Electric Energy	Joppa	1953	3,256	IL-IN-KY	1,713	IL
					1,621	WYOM
					105	IN
					100	WKY
					3,539	Total
Illinois Power	Baldwin	1970			2,526	IL
					750	WYOM
					447	IN
					173	WKY
					3,895	Total

INDIANA:						
Hoosier Energy REC	Merom	1981			2,434	IN
Indiana Michigan Power	Rockport	1984			8,968	WYOM
	Tanners Creek	1951	1,182	WV	538	WKY
					70	EKY
					172	KY
					556	IN
					240	WVA
					1,575	Total
Indiana-Kentucky Electric Corp	Clifty Creek	1954	4,179	IN-KY	2,774	WKY
					731	IN
					136	WYOM
					47	VA
					3,668	Total
Indianapolis Power and Light	Petersburg	1967			4,427	IN
	Stout	1958	490	IN	963	IN
Northern Indiana Public Service	Bailly	1962			837	IL
					201	OH
					177	IN
					90	WYOM
					1,305	Total
	Michigan City	1974	266	IL-IN	830	WYOM
					171	IL
					138	IN
					55	VA
					40	UT
					1,234	Total
	Mitchell	1956	869	IL-IN	794	WYOM
					178	WVA
					973	Total
	Rollin Schahfer	1976			917	CO
					866	IL
					840	WYOM
					163	UT
					67	IN
					53	OH
					2,907	Total
Public Service Co of Indiana	Cayuga	1970			2,046	IN
					10	IL
					10	WKY
					2,066	Total
	Gallagher	1958			467	IN
					174	PA
					48	EKY
					12	IL
					10	WKY
					11	Import
					721	Total
	Gibson Station	1975			4,443	IL
					1,684	IN
					160	EKY
					16	WKY
					27	KY
					191	WVA
					753	WYOM
					7,275	Total
	Wabush River	1953	1,299	IN	1,202	IN
Southern Indiana Gas and Electric	AB Brown	1978			604	IN
	Culley	1955	129	IN	1,009	IN
					10	WKY
					1,019	Total

MICHIGAN:						
Consumers Power	Campbell	1962			2,004	EKY
					888	WVA
					57	WYOM
					2,949	Total
	Karn	1959	605	KY-OH-WV	697	WVA
					358	EKY
					1,055	Total
	Weadock Sandusky	1955			145	EKY
					133	MT
					451	WVA
					417	WYOM
					1,146	Total
Detroit Edison Co.	Belle River	1984			3,606	MT
	Monroe	1971			1,656	EKY
					3,194	WYOM
					734	MT
					1,345	PA
					478	WVA
					7,417	Total
	River Rouge	1957	1,810	OH	479	WVA
					399	WYOM
					359	EKY
					11	CO
					10	VA
					1,258	Total
	St Clair	1953	2,064	OH	4,081	MT
					193	PA
					36	WYOM
					20	WVA
					4,330	Total
	Trenton Channel	1949	609	KY-VA-WV	703	EKY
					683	MT
					40	WVA
					10	VA
					1,455	Total
Wisconsin Electric Power	Presque Isle	1955	57	WV	834	MT
					502	WVA
					35	WYOM
					1,372	Total

OHIO:						
Cardinal Operating Co. (AEP)	Cardinal	1966			2,884	WVA
					886	OH
					3,769	Total
Cincinnati Gas and Electric Co.	Beckjord	1952	1,353	KY-OH-WV	1,302	EKY
					16	WKY
					375	OH
					34	PA
					130	WVA
					1,857	Total
	Miami Fort	1949	689	KY-OH-WV	630	EKY
					111	WKY
					937	WVA
					584	OH
					116	PA
					2,387	Total
	Zimmer	1990			25	IN
					212	EKY
					6	WKY
					2,518	OH
					603	PA
					184	WVA
					3,548	Total
Cleveland Electric Illum Co	Avon Lake	1949	824	OH-WV	1,241	OH
					289	WVA
					79	EKY
					50	PA
					10	VA
					1,669	Total
	Eastlake	1953	1,450	OH-PA-WV	1,298	OH
					889	PA
					236	WVA
					2,423	Total
	Conesville	1959	800	OH	3,298	OH
Dayton Power and Light Co.	Stuart	1971			3,809	EKY
					1,965	WVA
					81	OH
					22	PA
					5,878	Total
Dayton Power and Light Co.	Killen	1982			536	EKY
					876	WVA
					1,412	Total
Ohio Edison	Burger	1944	1,343	OH-WV	1,151	OH
					100	PA
					6	EKY
					1,257	Total
	Sammis	1959	745	OH-WV	1,625	OH
					1,578	WVA
					1,220	EKY
					999	PA
					5,422	Total
Ohio Power	Gavin	1974			4,840	OH
					322	WVA
					5,162	Total
	Muskingum	1953	2,659	OH	2,529	OH
					241	WVA
					40	VA
					1	PA
					2,813	Total
Ohio Valley Electric Corp.	Kyger Creek	1955	3,084	OH-WV	1,452	OH
					996	WVA
					77	EKY
					2,525	Total
Toledo Edison Co.	Bay Shore	1955	688	OH-PA-WV	1,113	WVA

WISCONSIN:						
Dairyland Power Cooperative	Alma-Madgett	1947	339	IL-KY	1,256	WYOM
					162	IL
					6	WVA
					1,425	Total
Wisconsin Electric Power	Pleasant Prairie	1980			4,315	WYOM
					11	NM
					4,326	Total
	Oak Creek	1959	1,747	IL-KY	1,381	NM
					275	WVA
					238	CO
					1,893	Total
Wisconsin Power and Light	Columbia	1975			2,119	WYOM
					1,205	MT
					3,323	Total
	Edgewater	1951	138	KY	2,109	WYOM
					401	IN
					14	EKY
					61	VA
					2,584	Total
Wisconsin Public Service Corp	Weston	1954	136	IL-IN-MN	1,643	WYOM
WEST NORTH CENTRAL:						
IOWA:						
Midwest Power	Council Bluffs	1954	91	MO-OK	2,259	WYOM
Midwest Power	George Neal 1/4	1964			5,354	WYOM
Iowa Southern Utilities	Ottumwa	1981	20	IOWA	2,458	WYOM
Iowa Illinois Gas and Electric	Louisa	1983			2,039	WYOM
KANSAS:						
Kansa City Bd. Public Utilities	Nearman	1981			772	WYOM
Kansas City Power and Light	La Cygne	1973			4,568	WYOM
					122	MO
					157	IL
					4,847	Total
Western Resources	Jeffery Energy Cnt	1978			7,679	WYOM
	Lawrence	1939	66	MO	804	WYOM
					7	CO
					811	Total
Sunflower Electric Power Corp	Holcomb Unit 1	1983			1,244	WYOM

MINNESOTA:						
Minnesota Power and Light	Boswell	1958	291	KY-PA-WV	3,527	MT
Northern States Power	King	1968			1,220	WYOM
					369	MT
					1,589	Total
	Riverside	1964	107	IL	959	WYOM
	Sherburne County	1976			3,813	MT
					4,068	WYOM
					7,881	Total
MISSOURI:						
Associated Electric Coop	Thomas Hill	1966			174	MO
					11	WYOM
					185	Total
	Madrid	1972			677	IL
					65	WKY
					568	IN
					1,445	WYOM
					2,756	Total
Kansas City Power and Light	Hawthorne	1969	495	KA-MO	1,140	WYOM
	Iatan	1980			2,034	WYOM
	Montrose	1958	856	MO	1,601	WYOM
Union Electric	Labadie	1970			1,184	IL
					2,706	WYOM
					410	CO
					4,300	Total
	Rush Island	1976			1,046	WYOM
					967	IL
					2,013	Total
	Sioux	1967			854	IL
					184	WYOM
					1,038	Total
Utilicorp	Sibley	1960	66	MO	722	WYOM
					198	UT
					102	IL
					9	CO
					1,032	Total
NEBRASKA:						
Nebraska Public Power System	Gerald Gentleman	1979			3,677	WYOM
Omaha Public Power District	Nebraska City	1979			1,957	WYOM
	North Omaha	1954	173	KA-MO	1,624	WYOM

NORTH DAKOTA:						
Basin Electric Power Coop	Antelope Valley	1983			5,507	ND
	Leland Olds	1965			2,281	ND
Cooperative Power Association	Coal Creek	1979			7,617	ND
Minnkota Power Coop	Young	1970			4,146	ND
Montana-Dakota Utilities	Coyote	1981			2,179	ND
United Power Association	Stanton	1966			914	ND
					5	WYOM
					919	Total
SOUTH DAKOTA:						
Otter Tail Power	Big Stone	1975			2,152	ND
SOUTH ATLANTIC:						
DELAWARE						
Delmarva Pwer & Light	Indian River	1957	328	na	45	MD
					216	PA
					14	VA
					1,291	WVA
					1,566	Total
FLORIDA:						
Florida Power Corp.	Crystal River	1982			2,709	EKY
					834	VA
					3,543	Total
Gulf Power	Crist	1959	166	ALA	1,490	IL
					515	Import
					72	AL
					55	WKY
					13	WVA
					2,146	Total
	Smith	1965			705	IL
					198	Import
					16	WKY
					919	Total
Jacksonville Electric Authority	St. Johns River	1986			2,291	Import
					1,300	EKY
					243	WVA
					3,835	Total
Orlando Utilities Commission	Stanton	1987			1,194	EKY
Seminole Electric Corp	Seminole	1983			1,689	EKY
					1,821	IL
					45	IN
					3,555	Total
Tampa Electric	Davant Transfer	1970			1,733	WKY
					1,346	IL
					1,051	EKY
					728	WVA
					305	TN
					284	Import
					187	UT
					19	IN
					5,651	Total

GEORGIA:						
Georgia Power (Southern Co)	Atkinson-McDonough	1963	264	KY-TN	632	EKY
					373	VA
					36	IL
					153	IN
					6	WVA
					1,200	Total
	Bowen	1971			7,320	EKY
					119	WVA
					7,440	Total
	Hammond	1954	783	KY-TN	430	VA
	Harlee Branch	1965			2,324	EKY
					278	VA
					2,760	Total
	Scherer	1981			2,664	WVA
					1,275	EKY
					700	WYOM
					640	VA
					44	CO
					5,323	Total
	Wansley	1976			2,778	IL
					635	EKY
					298	WVA
					128	VA
					3,839	Total
	Yates	1950	754	KY-TN	903	VA
					531	IL
					80	WVA
					79	EKY
MARYLAND					1,593	Total
Baltimore Gas and Electric	Brandon Shores	1984			841	EKY
					1,583	WVA
					224	Imports
					2,648	Total
Potomac Electric Power	Chalk	1964			167	MD
					974	PA
					7	WVA
					1,148	Total
	Dickerson	1959	784	MD-PA-WVA	1,183	WVA
	Morgantown	1970			744	MD
					1,129	PA
					52	WVA
					1,925	Total

NORTH CAROLINA:						
Carolina Power and Light	Mayo	1982			1,753	WVA
					92	EKY
					1,846	Total
	Roxboro	1966			2,630	WVA
					2,026	EKY
					340	VA
					4,996	Total
Duke Power	Allen	1949	1,375	KY-TN-VA-WVA	1,364	VA
	Belews Creek	1974			4,049	EKY
					144	VA
					565	WVA
					4,758	Total
	Marshall	1965			1,997	VA
					926	EKY
					729	WVA
					3,652	Total
SOUTH CAROLINA:						
S. C. Electric and Gas	Waterloo (Richland)	1970			1,200	EKY
					418	VA
					1,618	Total
	Williams	1973			1,491	EKY
S. C. Public Service Authority	Cross	1984			1,368	EKY
	Winyah	1974			2,195	EKY
VIRGINIA:						
Appalachian Power (AEP)	Clinch River	1958			1,426	VA
Virginia Electric and Power	Chesapeake Ch Cr	1953			1,178	VA
					236	WVA
					16	EKY
					1,431	Total
	Chesterfield	1952	642	VA-WV	2,088	EKY
					280	WVA
					407	VA
					2,775	Total
WEST VIRGINIA:						
Appalachian Power (AEP)	Amos	1971			3,306	WVA
	Mountaineer	1980			1,816	WVA
Central Operating Co. (AEP)	Sporn	1949	1,646	OH-WV	967	WVA
Monongahela Power (APS)	Pt. Martin	1967			1,388	WVA
					496	EKY
					494	MD
					18	PA
					2,396	Total
	Harrison	1972			3,356	WVA
					51	PA
					3,407	Total
	Pleasants	1978			1,187	PA
					986	WVA
					652	OH
					7	EKY
					2,832	Total
Ohio Power (AEP)	Kanawha	1958	1,175	WV	1,528	WVA
					220	OH
					1,749	Total
	Mitchell	1971			2,205	WVA
Virginia Electric and Power	Mount Storm	1965			2,413	WVA
					1,633	MD
					154	PA
					4,201	Total

EAST SOUTH CENTRAL						
ALABAMA:						
Alabama Power Co (SC)	Gaston	1960			2,726	AL
					1,656	WVA
					4,382	Total
	Gorgas 2 and 3	1951	1,761	AL	6,153	AL
	Greene	1965			642	AI
					80	WVA
					737	EKY
					1,458	Total
	James Miller	1978			4,982	AL
Alabama Electric Coop	Lowman				1,184	AL
Tennessee Valley Authority	Colbert	1954	1,696	IL-KY	931	EKY
					692	WVA
					575	IL
					469	WKY
					57	TN
					46	PA
					2,770	Total
	Widows Creek	1952	897	AL-KY-TN	1,554	EKY
					1,331	WKY
					449	TN
					231	WVA
					188	IL
					177	OH
					51	CO
					30	PA
					10	IN
					4,019	Total

KENTUCKY:						
Big Rivers Electric Corp	Coleman	1969			#REF!	WKY
					323	IN
					59	EKY
					48	CH
					38	PA
					9	IL
					1,319	Total
	DB Wilson	1984			1,257	WKY
	RD Green	1979			1,365	WKY
Cincinnati Gas and Electric Co	East Bend	1980			#REF!	EKY
					429	CH
					90	WVA
					60	WKY
					47	PA
					1,073	Total
East Kentucky Power Coop	Spurlock	1977			1,149	EKY
					889	WVA
					23	PA
					2,061	Total
Kentucky Power (AEP)	Big Sandy	1962			2,247	EKY
Kentucky Utilities	Brown	1957	206	KY	1,061	EKY
					227	TN
					1,288	Total
	Ghent	1973			1,650	WVA
					1,179	EKY
					814	WKY
					311	PA
					280	IN
					26	CH
					4,260	Total
Louisville Gas and Electric	Cane Run				1,113	WKY
	Mill Creek	1972			2,706	WKY
					195	IN
					75	EKY
					16	CH
					12	WVA
					3,004	Total
	Trimble County	1990			610	WKY
					212	EKY
					372	IN
					66	CH
					94	WVA
					1,354	Total
Tennessee Valley Authority	Paradise	1963			6,431	WKY
					273	IL
					101	WVA
					248	WYOM
					7,054	Total
	Shawnee	1953	4,945	IL-KY	1,191	EKY
					795	WKY
					1,438	WVA
					298	CO
					5	TN
					2	VA
					3,729	Total

MISSISSIPPI:						
Mississippi Power (Southern Co.)	Jackson Ct. Daniel	1977			775	EKY
					178	MT
					159	CO
					68	Import
					1,178	Total
	Watson	1968			1,080	IL
					215	EKY
					32	AL
					1,396	Total
TENNESSEE:						
Tennessee Valley Authority	Allen	1958	855	KY	760	WKY
					906	IL
					155	WVA
					7	PA
					1,828	Total
	Bull Run	1966			2,041	EKY
	Cumberland	1972			1,421	EKY
					3,061	WKY
					1,370	IL
					165	CO
					55	OH
					45	PA
					506	WVA
					6,606	Total
	Gallatin	1956	2,568	KY	530	EKY
					1,933	WKY
					322	IL
					2,784	Total
	Johnsonville A and B	1951	2,915	IL-KY	1,174	IL
					315	EKY
					1,489	WKY
					9	PA
					358	WVA
					3,345	Total
	Kingston	1954	3,841	KY-TN	3,022	EKY
					908	TN
					8	WVA
					3,938	Total
	Sevier	1955	1,744	KY-TN-VA-WV	1,399	VA
					549	EKY
					1,948	Total

WEST SOUTH CENTRAL						
ARKANSAS:						
Arkansas Power and Light (MSU)	Independence	1982			3,808	WYOM
	White Bluff	1980			5,020	WYOM
Southwestern Electric Power (CSW)	Flint Creek	1978			1,926	WYOM
LOUISIANA:						
Cajun Electric Power Coop	Big Cajun No 2	1981			5,701	WYOM
Central Louisiana Electric	Dolet Hills	1985			3,103	LA
	Rodemacher	1982			1,933	WYOM
Gulf States Utilities	Nelson	1982			2,336	WYOM
OKLAHOMA:						
Grand River Dam Authority	GRDA 1	1981			3,269	WYOM
					8	OK
					3,277	Total
Oklahoma Gas and Electric	Muskogee	1977			4,689	WYOM
					27	OK
					4,715	Total
	Sooner	1979			3,642	WYOM
Public Service Co of Oklahoma	Northeastern	1979			3,265	WYOM
Western Farmers Electric Coop	Hugo	1982			1,534	WYOM
TEXAS:						
Central Power and Light	Coletto Creek	1980			1,778	CO
					122	Imports
					1,900	Total
City Public Service-San Antonio	JT Deely	1977			5,286	WYOM
Houston Lighting and Power	Limestone	1985			8,403	TX
	Parish	1977			9,653	WYOM
Lower Colorado River Authority	S. Seymore Fayette	1979			5,841	WYOM
					35	TX
					5,876	Total
San Miguel Electric	San Miguel	1981			3,121	TX
Southwestern Electric Power	Pirkey	1984			3,461	TX
	Welsh Station	1977			4,490	WYOM
Southwestern Public Service	Harrington	1976			4,461	WYOM
	Tolk	1982			4,318	WYOM
Texas Municipal Power	Gibbons Creek	1982			3,541	TX
Texas New Mexico Power Co.	TNP One	1990			1,784	TX
Texas Utilities Power Company	Big Brown	1971			5,124	TX
	Martin Lake	1977			12,558	TX
	Monticello	1974			9,969	TX
	Sandow No. 4	1981			3,811	TX
West Texas Utilities (CSW)	Oklaunion	1986			2,953	WYOM

MOUNTAIN						
ARIZONA:						
Arizona Public Service	Cholla (Navajo)	1962			3,742	NM
Arizona Electric Power Coop	Apache	1978			1,221	NM
Century Power Corp	Springerville	1985			2,996	NM
Salt River Project	Coronado	1979			2,609	NM
	Navajo	1974			7,567	AZ
COLORADO:						
Platte River Authority	Rawhide	1983			1,221	WYOM
Public Service Co. of Colorado	Cherokee	1957	405	CO-WY	1,908	CO
	Comanche	1973			2,111	WYOM
	Hayden	1965			1,332	CO
	Pawnee	1981			2,144	WYOM
Tri-State G&T Assoc.	Craig	1979			4,422	CO
MONTANA:						
Montana Power Co.	Colstrip	1975			7,895	MT
NEVADA:						
Nevada Power	Gardner	1965			858	UT
					513	CO
					1,371	Total
Sierra Pacific Power	North Valmy	1981			696	UT
					754	WYOM
					1,450	Total
Southern California Edison	Mohave	1970			4,555	AZ
NEW MEXICO:						
Arizona Public Service	Four Corners	1963			8,501	NM
Public Service Co of New Mexico	San Juan	1976			5,512	NM
UTAH:						
	Bonanza	1985			1,501	CO
Los Angeles Dept of Wtr. and Pwr	Intermountain	1986			5,049	UT
PacifiCorp	Emery-Hunter	1978			4,112	UT
	Huntington	1977			2,679	UT
WYOMING:						
Basin Electric Power Corp	Laramie River	1980			6,616	WYOM
PacifiCorp	Jim Bridger	1974			8,285	WYOM
	Johnston	1958	508	WY	4,199	WYOM
	Naughton	1963			2,935	WYOM
	Wyodak	1978	45	WY	2,085	WYOM

Notes (by RLG from the EIA *Inventory of Power Plants*): Company shown is the operator of plant.

Public Service of New Hampshire is a subsidiary of Northeast Utilities.

Pennsylvania Electric is a subsidiary of General Public Utilities.

Pennsylvania Power is a subsidiary of Ohio Edison.

West Penn Power and Monongahela Power are subsidiaries of the Allegheny Power System.

Electric Energy Inc. is jointly owned by Union Electric, Illinois Power, Kentucky Utilities, and Central Illinois Public Service.

Appalachian Power, Columbus Southern Power, Indiana Michigan Power, Kentucky Power, and Ohio Power are subsidiaries of American Electric Power.

Indiana Kentucky Power is a subsidiary of Ohio Valley Electric Company--a joint venture of which American Electric Power is the operating partner.

Cardinal Operating Company is operated by American Electric Power for Buckeye Power Cleveland Electric Illuminating and Toledo Edison are subsidiaries of Centerior Energy.

Iowa Southern Utilities is a subsidiary of IES Industries as is IES Energy, the former Iowa Electric Light and Power.

Alabama Power, Georgia Power, Gulf Power, and Mississippi Power are subsidiaries of the Southern Company

Arkansas Power and Gulf States Utilities are subsidiaries of Entergy (formerly Middle South Utilities)

Central Power and Light, Southwestern Electric Power, West Texas Utilities, and Public Service Company of Oklahoma are subsidiaries of Central and Southwest

Conemaugh and Keystone are joint ventures in which several other East Coast Utilities participate; Homer City is half owned by General Public Utilities and by New State Electric and Gas.

Bruce Mansfield is a joint venture of Ohio Edison, Duquesne Light, Cleveland Electric Illuminating, and Toledo Edison.

Unit five of Gibson is jointly owned with Wabash Valley Power Association and the Indiana Municipal Power Agency.

Michigan Public Power Agency owns 4.8 percent of Campbell 3, and Wolverine Power Supply Coop has 1.89 percent.

Michigan Public Supply Agency has 18.61 percent of Belle River.

Beckjord, Zimmer, Conesville, and Stuart are joint ventures of Cincinnati Gas and Electric, Dayton Power and Light, and Columbus Southern; Cincinnati and Dayton are also partners in Miami Fort, Killen, and East Bend.

Duquesne Light owns 31.2 percent of Eastlake 5 and 31.4 percent of Sammis 7.

The Cooperative Power Association owns half of Genoa 3.

Columbia is a joint venture of Wisconsin Power and Light, Wisconsin Public Service, and Madison Gas and Electric.

Edgewater 4 is a joint venture of Wisconsin Power and Light and Wisconsin Public Service; Edgewater 5 is a joint venture of Wisconsin Power and Light and Wisconsin Electric.

Council Bluffs 3 is 46.7 percent Midwest Power, 32.4 percent Iowa Illinois Gas and Electric, and the rest owned by cooperatives and municipals.

Neal 3 is 29 percent Iowa Illinois; 28 percent Iowa Southern (IES); and 43 percent Midwest Power; Neal 4 is 40.57 percent Midwest Power, 21.53 percent Interstate Power, and the rest owned by cooperatives and municipals.

IES has 48 percent of Ottumwa; Midwest, 33.5; Iowa-Illinois 18.5 percent.

Louisa is 43 percent Iowa-Illinois, 45 percent Midwest, and the rest cooperatives and municipals

La Cygne is a joint venture of Western Resources and Kansas City Power and Light.

Jeffrey is 84 percent Western Resources and 16 percent UtiliCorp.

Minnesota Public Power owns 20 percent of Boswell 4.

Southern Minnesota Municipal Power Agency owns 41 percent of Sherburne County 4.
 Iatan is 70 percent Kansas City Power and Light, 18 percent St. Josephs Light and Power, and 12 percent Empire District Electric
 Half of Coal Creek is owned by United Power Association.
 Young 2 is 70 percent Minnesota Power and 30 percent Minnkota.
 Coyote is 25 percent Montana-Dakota, 35 percent Otter Tail Power, 30 percent Northern Municipal Power Agency, and 10 percent Northwestern Public Service.
 Big Stone is 53.9 percent Otter Tail, 23.4 percent Northwestern Public Service, and 22.7 percent Montana-Dakota.
 Jacksonville and Florida Power and Light each own half of St. Johns River.
 Stanton is 68.55 percent Orlando, 26.63 percent Florida Municipal Power Agency, and 4.82 percent Kissimmee Utility Authority.
 Georgia Power has sold parts of Scherer to power agencies in Georgia, Gulf Power, Florida Power and Light, and Jacksonville and parts of Wansley to the same Georgia agencies.
 Carolina Power and Light 16.16 percent of Mayo and 12.94 percent of Roxboro 4 to North Carolina MPA.
 Duquesne Light and the Allegheny Power System each own half of Fort Martin 1.
 Entergy owns 56.5 percent of Independence; 35 percent belongs to Arkansas Electric Coop; the rest to municipals.
 Entergy owns 57 percent of White Bluff; 35 percent belongs to Arkansas Electric Coop; the rest to municipals.
 Flint Creek is 50 percent Central and Southwest and 50 percent Arkansas Electric Coop.
 PacifiCorp owns all of Cholla 4.
 Big Cajun 2-3 is 58 percent Cajun and 42 percent Entergy.
 Dolet Hills is half each by Central and Southwest and Central Louisiana.
 Rodemacher is 30 percent Central Louisiana and 70 percent Louisiana power agencies.
 Grand River Dam Authority owns 62 percent and KAMO Electric Coop 38 percent of GRDA 2.
 Sam Seymour is 50 percent each to the Lower Colorado River Authority and Austin.
 San Miguel is half Brazos Electric Power Coop and half South Texas Electric Coop.
 Pirkey is 85.94 percent Central and Southwest, 11.72 percent Northeast Texas Electric Coop, and 2.34 percent Oklahoma Municipal Power Authority.
 Subsidiaries of Central and Southwest own 78.12 percent of Oklaunion, the Oklahoma Municipal Power Authority, 11.72 percent, and Brownsville, 10.16 percent.
 Tucson Electric Power owns all of Springerville 2.
 Navajo is a joint venture of Salt River, Arizona Public Service, Tucson Electric, Los Angeles, Nevada Power, and the U.S. Bureau of Reclamation.
 Hayden 1 is 75.5 percent Public Service of Colorado and 24.5 percent PacifiCorp; Hayden 2 is 50 percent Salt River, 37.4 percent Public Service Colorado, and 12.6 percent PacifiCorp.
 Tri-State has 24 percent of Craig, Salt River 29 percent, Platte River Power 18 percent, PacifiCorp 19.28; and Public Service Colorado, 9.72 percent.
 Colstrip 1 and 2 are half owned by Montana Power and Puget Sound Power and Light; Colstrip 3 and 4 are 30 percent Montana Power, 25 percent Puget, 20 percent Portland General Electric, 15 percent Washington Water Power, and 10 percent PacifiCorp.
 California Department of Water Resources owns 67.8 percent of Reid Gardner 4; Nevada Power, 32.2 percent.
 Idaho Power and Sierra Pacific each own half of North Valmy.
 Mohave is 56 percent Southern California Edison, 20 percent Los Angeles, 14 percent Nevada Power, and 10 percent Salt River.
 Four Corners 4 and 5 are Southern California Edison 48 percent, Arizona Public Service 15 percent, Public Service of New Mexico 13 percent, Salt River 10 percent, El Paso Electric 7 percent, and Tucson Electric 7 percent.

Public Service of New Mexico owns half of units 1-3 and 55.52 percent of unit 4 of San Juan; Tucson owns the other half of unit 1 and 2, Century Power has half of unit 3; the rest of unit 4 is owned by a power agency and municipals.

Shell Leasing owns 88.46 percent of Bonanza; Deseret 9.97 percent; Utah Municipal Power Agency 9.79 percent

Hunter 1 is 93.5 percent PacifiCorp and 6.25 percent Provo; Unit 2 60.31 percent PacifiCorp and 36.69 percent Deseret.

Laramie River is 42.27 percent Basin, 24.12 percent Tri-State, 16.47 percent Missouri Basin Municipal Power Agency, and 12.76 Lincoln Electric System.

Jim Bridger is two third PacifiCorp and one third Idaho Power.

Wyodak is 80 percent PacifiCorp and 20 percent Black Hills

Boardman is 65 percent Portland General Electric, 10 percent Idaho Power, 10 percent Pacific Northwest Generating, and 15 percent General Electric Credit.

Centralia is 47.5 percent PacifiCorp, 15 percent Washington Water Power, 2.5 percent Portland General Electric, and the rest city and county power agencies in Washington.

Appendix B
Notes on the Data Sources
By Richard L. Gordon

The main data sets used here were constructed by me and my students over an extended period. For various reasons, none of these series are available in one single document or even in different issues of exactly the same publication. The primary cause of this difficulty is the 1977 transfer of responsibility for energy data from the U.S. Bureau of Mines (USBM) to the Energy Information Administration (EIA) of the U.S. Department of Energy. The minimum change made necessary by this transfer was to devise new energy-oriented publications to assume the role of USBM's main publication surveying all the extractive industries. In addition, EIA rethought both the gathering and presentation of the data. This reappraisal proved a continuing process. EIA publications appear, disappear, and get redesigned with considerable frequency. USBM practice was more stable, but periodic changes did arise.

Another problem is that no public or private organization has continuously published the data used here on electric power for the entire time period covered. The Federal Power Commission (the predecessor of the present Federal Energy Regulatory Commission) long allowed the Edison Electric Institute (EEI) to remain as compiler of summary data on electric utility activities. EEI began such work before the FPC assumed a major role in electric power. Even so, the reports had major omissions including the data by energy source by state until a major expansion of the report that occurred in the 1950s. A one-time National Coal Association report is the only data source of which I am aware on these earlier years. In the early seventies, EEI repeated the same year's data in three successive yearbooks; the series here relies on incomplete printouts secured from EIA for those years.

Coal production data come from a combination of USBM and EIA reports. The main compilation problem is that of assembling the data. However, for a few years in the 1940s, data giving the breakdowns between surface and underground mining for the eastern and western parts of Kentucky were not tabulated. However, by county data existed and was summed to produce the totals.

The single most convenient EIA compendium of annual energy data is the *Annual Energy Review*; where they exist, data back to 1949 are reported. The data are available on disk albeit in an inconvenient form. Each series is assigned a seven character code name (with the characters dominantly being letters but with some numerals). The data files list the series in the order of their code names in enormous columns. These files are longer than the conventional spreadsheet, and until recently I resorted to opening the data in a word processor and pasting to a spreadsheet. The spreadsheet program that I use was modified to import parts of such tables directly, and this was done.

The USBM-EIA coal distribution reports usually covered only a single year; the exceptions were that for the first 10 or so years of reporting, USBM prepared a series of follow up reports in which revised data for several years were presented. Both USBM and EIA used formats in which the data for each year were spread over many pages. The substance of the data changed several times. Among the most notable changes was one for the years after 1974 in which the practice of showing combined figures for some groups of states was replaced by presentation of data for each state, a reappraisal by EIA that recognized that it was incorrect to assume that retail dealers sold only to residential and commercial users, a later EIA incorporation of anthracite into the reports, the shift for the data for 1990 and 1991 to states as origins, and the subsequent termination of the report. A further problem was that under USBM, in many years, figures for some destinations, end users, or both were combined to conceal data that were considered confidential. Often, the aggregation was insufficient to produce true concealment. Enough detail was provided to

deduce the numbers. Time pressures precluded our undertaking as complete an effort at filling in these blanks as were desired.

Our efforts began by entering the data for each year into a spreadsheet file. Each file contains five matrices of flows with the origins in the columns and the destinations in the rows. The first matrix covered the totals; the other four the four end use types identified. Then an effort was made generate tabulations of the shipments by destinations and end use in each year covered for each origin and of receipts by origins and end use for each destination. Some problems rose in this process, and an (incomplete) effort was made to correct the errors that became evident. In principle, the data files could have extended to 1991 for those districts composed of separate states. This was more effort than seemed useful. However, since the total receipts by state by end use are still reported, the 1990-1993 numbers were added.

Starting with the year 1973, the Federal Power Commission began a survey of electric utility fuel receipts. These data are vastly more detailed than those from the old coal distribution survey. The FPC survey was not subject to the confidentiality restrictions under which USBM operated. Thus, the FPC reports gave summary data on individual plants and companies. The full details were available on disk, and various consulting firms and the National Coal Association reports these details. This situation persisted after EIA took over responsibility for the survey. For the present study, the need was for a matrix of origin to destination flows for each year; the various reports from FPC and EIA have always provided at least the data needed for such a matrix; for some years, a matrix was presented. For most of the period of the survey, both the state and USBM production district of origin was reported so that the role of states in each district could be determined. These data were eliminated around 1990. This was less serious a loss than the elimination of the breakdown of state totals between eastern and western Kentucky. (The report provides almost all the data needed for calculating these figures. However, the implementation is onerous. What is supplied are tabulations of the receipts by county of origin by every included power plant. Thus, by summing shipments from individual Kentucky counties to individual plants, the totals could be determined.)

The *State Energy Data Report* on disk provides anew every year all the data for each year since 1960. The disks present the data in a form such that, in principle, the data can be converted to neat spreadsheets using a "macro" provided. In practice I have found it easier to produce my own macro. This process produces 104 separate files--two each for each state, the District of Colombia, and the U.S. as a whole. For this study, I aggregated the 52 files that presented Btu data and separated and rearranged the data relevant to coal use. However, when new data appeared in 1994, I only generated the separate 104 files. In addition, I devised a format in which the files giving data in Btu all contained both a summary of 1992 consumption and graphs of the behavior of key series.

To facilitate viewing the patterns over time of the many time series of relevance here, several series of graphs were created. For the supply districts, at least two graphs were created--one showing the amounts to each consuming sector (in all destinations) and the other presenting total shipments to every state that was a major destination (pragmatically defined as one whose consumption was discernable when the data were plotted on area graphs). For producing states, charts also were made of the division by states of receipts by electric utilities.

For consuming states, analagous charts were created of the end use breakdown of all receipt, totals from each state, and electric receipts from all important states. In addition, the breakdown of Btu coal consumption by end use from the *State Energy Data* report was plotted. By the time this work was done, more than 200 charts had been generated. This seemed more than any reader could absorb, and so none are presented here.

Appendix C
Notes on the Timing of Consumption Trends
by Richard L. Gordon

Cromby's decision to stress comparisons between 1960 and 1991 proved to conceal much of interest. The limitation is less serious with the producing and consuming states that showed strong growth. As Cromby made clear, the growth was in electric power. His tabulation of where plants were added well covers one main difference in expansion--when it started. The main neglect is of the cases of growth cessation. In some of the states that are newcomers to coal use, utilities only installed a few units before backing away from continued addition of large units.

A more serious neglect is major differences in the movements between 1960 and 1991 in many of the more established producing and consuming areas. The simplest examples are the trio of users--New York, Virginia, and Maryland--that retreated from coal use in the cheap oil period of the late 1960s and only incompletely reversed the process when oil became expensive. Elsewhere, timing differences and their causes were more diverse. Among the forces at work were opening of nuclear power plants, shifts to western (and in some cases, most notably Michigan, to low sulfur coal from central Appalachia), and the restructuring of the steel industry. The last had a particularly pronounced effect on Pennsylvania. A halving of use of coal for coking was concentrated in a few years in the 1980s.

To view these differences, many charts were embedded in the spreadsheet files, printed out, and viewed. I looked at the Btu data and the tonnages from both the comprehensive distribution survey and the electric utility receipts figures. Given the unwieldy mass of material generated, selective qualitative observations are given here.

As Crombie noted, a major element in differential consumption trends and their timing was the downturn in coking coal consumption. That decline was concentrated in the 1974-1984 period. This decline is the net effect of many different experiences in terms of both timing and magnitude of retrenchments. Ten states accounted for the great bulk of coal use for coking from 1957 to 1993. Pennsylvania was the largest single coking-coal consuming state for most years of this period. The history is one of sharp recession and recovery between 1957 and 1964, a gentle decline to 1979, a sharp (well over 50 percent) drop in the next three years, and subsequent trendless fluctuation. The next two most important states are Indiana and Ohio. Their record is of much flatter levels than Pennsylvania up to 1978 and sharp declines with rates and timing similar to those in Pennsylvania. The end result for the entire period is that Ohio levels have declined at a rate similar to those in Pennsylvania but Indiana has declined proportionally less. Up to about 1980, Indiana and Ohio levels of coking-coal consumption were similar to each other and around half of those in Pennsylvania. Indiana levels have moved closer (and indeed in some years in the middle 1980s exceed) those in Pennsylvania while Ohio levels are consistently below the two other states.

Decline is observable in the seven most important coking states, but the differences are too great to treat readily.

As noted, New York, Virginia, and Maryland are special cases among the major consumers with lower consumption in 1991 than in 1960. Each had a concentrated period of decline that started in the 1960s and ended in the early seventies. The declines involved both electric utility shifts to oil and falling industrial use. Each state had somewhat different post decline experiences. A slower decline prevailed in New York from 1973 to 1986 as modest electric power gains were offset by industrial losses; a subsequent speedup in electric utility coal use growth then produced a net rise in total use, albeit to levels below those of the 1960s.

Virginia consumption started sustained growth in 1979 with both electric power and industrial use rising, the former more than the latter. The recovery consisted entirely of Virginia Electric and Power reversing its total conversion from coal to oil. The recovery in

Maryland was less vigorous in rate and duration than that in Virginia (but considerably better than in New York). From 1972, Maryland had regularly rising electric power use involving the addition of new units and falling industrial use.

Peculiarities prevail among the other large consuming states with declines or slow growth. Illinois coal has trended down from 1967. While the sharpest drops were between 1967 and 1971, declines persisted. Up to 1982, the problem was that expansion of electric utility use was too slow to offset falling industry use. Then, industrial use rose but by less than the falls that emerged in electric power as nuclear capacity was added. Mines in Illinois then were hit by a combination of lower consumption and the introduction starting around 1970 of western coals to meet air pollution standards. As discussed by Crombie, this displacement by western coals was even greater in out of state markets for Illinois coal. A further key detail is that initially Montana was the main western supplier but ultimately was displaced by Wyoming. (Data on electric utility receipts through 1993 indicate this displacement persisted.)

In contrast, the Pennsylvania decline is dominated by the sharp fall, discussed above, of coking coal. As Crombie notes, District 2, entirely in Pennsylvania, was the prime loser. Ohio's pattern was moderate growth to 1979, four years of sharp declines, and then slow growth. However, in the period of severe Ohio declines, the drop in coking use coincided with a brief period of falling electric power use and continuation of the trend of falling other industry use.

The Michigan pattern is more complex. Coal use declined through most of the 1970s with flat use in electric utilities and coking and steadily falling other industry use. Subsequently, coking and industry use had persistent declines. Electric use grew but only to 1987. The net is a total a bit above 1960 but below the peak in 1969. A further key change was in fuel suppliers. District 8 has been the main supplier throughout. Until the middle 1970s, Ohio was the next most important supplier. Moreover, through the 1960s, Ohio gained at the expense of District 8. Starting in the 1970s, use of Ohio coal was curtailed. The shift involved both increased use of District 8 coal and the introduction of Montana (and in the 1990s Wyoming) coal. The data on electric utility receipts indicate that the shift to District 8 coal involved important shifts between Southern West Virginia and Eastern Kentucky. These changes were complex with Kentucky increasing sales from 1974 to 1984 and then showing a declines. West Virginia varied more. In any case, by 1993, Kentucky was a bit above 1973, and West Virginia, a bit below.

Wisconsin coal use declined in the first half of the 1970s as flat electric sales interacted with falls elsewhere. Then, resumed rises in electric power use produced a trend to steady growth. By 1987, consumption recovered to the 1970 level. Subsequently new highs were recorded. Wisconsin is one of the states that shifted to western coal starting (modestly) in 1970. The West, mostly Wyoming with Montana a poor second, steadily assumed dominance. Previously, supplies came in roughly equal portions from the Illinois basin and Appalachia. Both of the last two regions show declining shipments to Wisconsin since the emergence of purchases from the West. Moreover, Indiana and Western Kentucky shifted roles as suppliers. Prior to the middle 1980s, Western Kentucky had large sales to Wisconsin while those of Indiana were negligible. Subsequently, Western Kentucky sales nearly vanished while those of Indiana rose. This rise combined with falling Illinois shipments to Wisconsin made Indiana and Illinois roughly equal to each other as Wisconsin suppliers.

The key characteristics of Tennessee coal use are a persistently greater role of electricity in coal use than in the other slow growth states and the stagnation (after persistent growth) of electric utility (consisting solely of the U.S. government's Tennessee Valley Authority) use since 1976. A small rise in industrial use produced a small increase in total coal use. The coal supply situation is complex. Kentucky (both parts) appears to be the dominant supplier with more coming from Western Kentucky.

Indiana displayed steady growth resulting from electricity use offsetting declines elsewhere. Indiana has been the main supply source throughout and shipments steadily

increased. Purchases from Illinois rose as did those from Wyoming. Purchases from Western Kentucky fell. All the changes except the use of western coal prevailed from 1957 to 1993. Western coal use did not start until the early 1970s.

Finally, for this group, Alabama growth stopped in 1974 and the period in the early eighties of sharp declines in coking use coincided with a year of sharp falls in electric power. Alabama coal seems the dominant supply source throughout. However, other areas increased their importance. Western Kentucky sales rose steadily from 1957 to 1975 and then started a steady decline. Purchases from District 8 began in the middle 1960s and have risen since.

The behavior among the states classified as established consumers with above average growth shows considerably less variation over time than the patterns in the states discussed in the prior paragraphs of this appendix. The key timing issues relate to when the West North Central states in the group shifted towards western coal. The differences in timing of total coal use of most interest are the peaks well before 1991 of coal use in Georgia (1984), Missouri (1983), and North Carolina (1981).

Missouri effected its move towards Wyoming coal gradually. It was not until the 1990s that Wyoming became the largest supplier. Total and electric utility purchases from Illinois rose through 1984. Even more strikingly, use of Missouri coal fell. No electric utility purchases were reported in 1993.

From 1957 to the introduction of Wyoming coal in 1969, Illinois was the largest supplier of Iowa and gained share and levels of sales. Iowa itself was a poor second. Illinois sales peaked in 1972 and declined since. Iowa sales to Iowa declined throughout the period. Wyoming sales grew steadily from 1969, passed Illinois as the main supplier in 1976, and with a growing market far outstripped other current or past suppliers.

Prior to 1970, Minnesota coal supplies came mainly from eastern sources. In early years, more came from Appalachia (predominantly District 8) than from the Illinois basin (principally Illinois itself). The rest came from North Dakota. Purchases from Montana began in 1970 and trended up until 1984. In 1968, purchases from Illinois and the Illinois basin peaked and began a decline leading to near disappearance. Purchases from Appalachia and District 8 declined from 1960 but ended up above the Illinois basin. Moreover, at least from the 1970s, District 8 did better than other Appalachian districts. From 1983 on, almost all Appalachian coal to Minnesota came from District 8. Purchases from Wyoming began in 1986 and at the end of the old DOE system with the report for 1989 were close to those from Montana. In electricity, this situation persisted to 1993.

The major newcomers display several key timing differences. A few peaked before 1991, major differences prevail in when the first coal using electric power plant was completed, the roles of nonutility markets differ, and some variations in fuel suppliers arose. The early stops are Arkansas (1985) and Kansas (1984). Electric utility coal use began (for states not using coal in 1960) as follows:

State	Year of first coal unit
Arizona	1962
New Mexico	1964
Nevada	1965
Oklahoma	1976
Arkansas	1978
Louisiana	1981

Arizona receipts at electric utilities were entirely intrastate in 1973. Purchases from New Mexico began in 1974. A large jump in 1979 made New Mexico a more important supplier. Subsequently, intrastate supplies have been flat while purchases from New Mexico rose. With rising consumption, New Mexico became the larger supplier.

The first coal fired units in Texas used local lignite. In 1978, purchases from Wisconsin began. The latter grew more rapidly than those from Texas, but in 1993, Texas lignite still accounted for more of the tonnage. In 1973, about three quarters of Nevada electric utility supply came from Arizona; the rest from Utah. Subsequently, Utah has

become a more important supplier. Purchases from Arizona fluctuated considerably from 1977 to 1993 with little increase.

Georgia-Florida combined have obtained most of their coal from District 8 with rest coming from the Illinois basin. From 1957 to the middle 1970s, Illinois basin, mainly Western Kentucky, shipments grew more rapidly than those from District 8. This situation then reversed, and by 1989 District 8 was supplying about 80 percent of coal to the two states. Moreover, purchases from Western Kentucky fell and Illinois became the second largest supplier. The data on electric utility receipts suggest major differences between the two consuming states in their patterns. In 1973, Georgia electric utilities received more than 10 million tons of coal; those in Florida, about 6 million. For Georgia, Eastern Kentucky, Western Kentucky, and Indiana were the main suppliers. Eastern Kentucky supplies rose until the 1984 consumption peak; Western Kentucky shipments fell. Purchases from Illinois began in 1978 and around 1980 began to exceed those from Western Kentucky. Indiana faded as a supplier around 1988. Purchases from Virginia began in 1976 increased in the 1980s. Purchases from West Virginia began only in 1984 but also grew. While neither of the last two matches Illinois as a supplier, their combined sales do.

Florida receipts in 1973 came dominantly (five million tons) from Western Kentucky. Purchases from eastern Kentucky began in 1976 and steadily grew to be the largest source. Illinois also gained.

Kansas-Nebraska combined started obtaining most of their coal from District 15. As substantial coal use started in the 1970s, Wyoming became the main supplier. The electric utility receipt data indicate that Nebraska utilities moved from heavy to total dependence on Wyoming. In 1973, all the electric utility coal for Kansas came from Kansas. This shrank and ultimately vanished. Wyoming became the predominant supplier; it supplied 15.9 million of 16.5 million tons.

Among the main developments in Colorado was a gradual rise of Wyoming as a secondary supplier. Of 16.1 million received by Colorado electric utilities in 1973 10.6 million was from Colorado; 5.5 million from Wyoming. Purchases from Wyoming began in 1961 but were small until 1973 when growth began to accelerate.

Throughout, Utah has relied predominantly on intrastate supplies with most of the rest from Colorado. Colorado supplies expanded in the middle 1960s and changed little since. Most of the growth then was met by local coal. However, the data on electric utility receipts indicate that until 1986 intrastate coal supplied all power plants. Then use of Colorado coal with the growth in purchases in Colorado ending around 1990.

Finally, a notable aspect of Louisiana coal use is the emergence in 1986 of electric utility use of intrastate coal.

Turning to suppliers, the District 1 pattern is the effect of rises to 1979 and declines since. As usual, electricity growth offset declines elsewhere. The single most important decline was loss of markets in New York. District 2 has had a downward trend since 1957 with declining sales to the dominant consuming state, Pennsylvania, being the main component of the drop. The main problem is that until the 1980s the majority of sales were to coking and the District was vulnerable to declines in that sector. The fall in Pennsylvania coke use was a major part of the coke drop. This was aggravated by falling other industry use.

Districts 3-6 prove to have very variable behavior. Over the 1960-1989 period, two changes of direction occurred. The only constancies are increasing dominance of electric power as an outlet and steady growth in West Virginia consumption. However, the districts have widely distributed sales and shipments to other states varied widely. District 7 was predominantly a supplier of coking coal and had trivial amounts of electric power sales throughout the 1957-1989 period. As coke shipments fell, so did the total. Decline prevailed from 1957. Use and its decline was scattered among several largely steel producing states. In contrast, District 8 demonstrated persistent growth propelled by rising sales to electric utilities throughout the 1957-1989 period. Sales were spread over many different states.

Whatever manipulation are attempted, the data are unsuitable for untangling questions about how the outlets for West Virginia, Eastern Kentucky, and Virginia coal producers changed. In particular, none of the three so dominates the sales of all their districts to different destinations that we can allocate the changes in these districts among their component states.

Ohio shipments peaked in 1971 and headed down steadily. The initial problem was declining sales (to nearly nothing by 1989) to Michigan. A decline in intrastate sales began in 1978. The final Appalachia district, 13, grew to 1972 and then sales showed no trend. Electric utility shipments started to surpass coking coal sales in 1961 and grew through 1989. Coking sales tended down from 1957 to 1983 with accelerated declines starting in 1980. Given the production levels, Alabama clearly comprises the great bulk of the district, and the state is the main destination.

Turning the Illinois basin, Illinois started its decline after 1970 and Western Kentucky peaked in 1973. Indiana shipments grew to 1984. Illinois was the main market for Illinois coal, and the largest absolute decline was in Illinois. Interstate changes were mixed. Losses prevailed in Iowa, Minnesota, and Wisconsin; gains in Missouri, India, Georgia, and Florida. On balance, interstate shipments grew. Thus, intrastate sales went from about 60 percent of the total in 1957 to about a third in 1989. The Western Kentucky decline, in contrast, combined flat intrastate sales with net losses elsewhere. Intrastate shipments were and remained well more of the majority of sales by Indiana mines. However, interstate sales had a faster rate of growth. The largest gains were in Wisconsin and Kentucky. Sales to Illinois contracted up to about 1979 and then grew back to the earlier levels.

District 15 was the most radically transformed of those considered here. Up to the emergence of Texas lignite mining, sales to Missouri, probably mostly by Missouri mines, dominated. Subsequently, sales to Missouri shrank and those to Texas, known to be all intrastate, rose. Thus from 1957 to 1989, sales were around five million tons, about half to Missouri. In 1968, about 55 of 65 million tons of shipments were to Texas.

Wyoming became by far the largest producer. Up to 1970, sales were almost entirely intrastate and slowly growing. Then shipments began to soar. Sales were spread throughout the central states. While Texas was the largest single market, it and therefore necessarily no other state did not dominate sales.

The next most important group is the strangely combined Districts 22 and 23. As Crombie points out, the parts of District 23, Washington and Alaska, had only intrastate sales. Montana itself, Michigan, and Minnesota were the largest outlets. Montana had an inherent locational disadvantage to Wyoming in selling to the many Central states that were closer to Wyoming. The weakness was aggravated by a deliberate decisions to tax coal mining at a higher rate in Montana than in Wyoming.

Appendix D. The U.S. CGE Model

The U.S. CGE Model

Producers

The economy consists of n intermediate sectors divided into an aggregate energy sector (E) composed of r energy sub-sectors, an aggregate material sector (M) composed of m mineral/material sub-sectors, and $s = n - m - r$ other intermediate sectors. Two primary inputs, labor (L) and capital (K), are modeled as well.

Domestic producers are assumed to be profit maximizers. They utilize both domestically produced and imported intermediate inputs to produce goods for domestic use and for export. The production function has two parts -- one is for energy and material aggregates and primary inputs, which are variable in composition, and the other is for other intermediate sectors, which are characterized by fixed input-output coefficients. The output markets are perfectly competitive, with producers' equilibria occurring at the points where output prices equal their unit costs.

This can be expressed as follows (for ease of exposition, sector subscripts are omitted):

$$PX = c(AP_K, AP_L, AP_E, AP_M) + \sum_{j=1}^s P_j a_j + txPX \quad (1)$$

where

c $\equiv$ flexible functional form operator of the total unit cost function

AP $\equiv$ aggregate input price

P $\equiv$ output price to domestic consumers

PX $\equiv$ output price received by domestic producers

a $\equiv$ fixed input-output coefficient reflecting the contribution of good j to the production of good i

tx $\equiv$ sector specific ad valorem tax rate

To take account of inter-energy and inter-material substitution, a "two-tier" specification is used for the cost functions. This reflects a two-stage sequential optimization decision for producers. We also specify the energy and material aggregates with flexible functional forms.

Underlying this formulation is the assumption that labor, capital, the energy aggregate, and the material aggregate are homothetically weakly separable.

For the current application, the Generalized Leontief (GL) functional form is used for all the flexible cost functions.

$$C = XD \sum_j \sum_i \alpha_{ji} (AP_j AP_i)^{1/2} \quad (2)$$

$$\text{with } \alpha_{ji} = \alpha_{ij} \quad j, i = 1, \dots, 4$$

Domestic producers produce goods both for domestic market and for export (although some sectors are treated as producing non-traded goods, e.g., construction), and the domestically produced goods (XD) are transformed into either exports (XE) or domestic-market goods (XS), through a constant elasticity of transformation (CET) function:

$$XD = AT [\gamma XE^\delta + (1 - \gamma) XS^\delta]^{1/\delta} \quad (3)$$

where γ is the share weight, δ is the derived elasticity of transformation between exports and domestic-market goods, and AT is a shift parameter.

Domestically used good are treated as composite goods (XC) made up of domestically produced (XS) and imported goods (XM), with the goods from these two sources being less than perfect substitutes (the Armington assumption). According to this, domestically used composite goods are constant elasticity of substitution (CES) aggregates of imports and domestic-market goods.

By using Shephard's Lemma we can derive the demand for labor, capital, the aggregate quantity of energy, and the aggregate quantity of materials from equation (2). For example, for energy:

$$E = XD \left[a_{ji} + \sum_i \alpha_{ji} (AP_i / AP_j)^{1/2} \right] \quad (4)$$

$$\text{with } j = E \text{ and } i = K, L, M$$

The price of aggregate energy (AP_E) is specified in a constant-returns-to-scale GL form:

$$AP_E E = E \sum_j \sum_i (P_j P_i)^{1/2} \quad (5)$$

$$\text{with } b_{ji} = b_{ij}$$

The price of aggregate material (AP_M) is also specified in a CRS GL form.

When labor and capital are both assumed to be perfectly mobile, full employment is reached with economy-wide average prices of labor and capital services (WL and WK , respectively) adjusting accordingly. By introducing differential wage rates and prices of capital services, we have:

$$AP_L = WL \cdot fds_L \quad (6)$$

$$AP_K = WK \cdot fds_K \quad (7)$$

where fds is the factor proportionality, which determines the ratios of sector-specific wage rates and capital service prices to their economy-wide average counterparts.

Consumers

Households are assumed to be the only private consumers of the domestic use composite goods (XC). Aggregate households maximize a simplified Stone-Geary utility function leading to a system of domestic consumption functions known as the linear expenditure system (LES), which has the following form:

$$P \cdot CD = \sum_h d_h Y_h (1 - s_h)(1 - t_h) \quad (8)$$

where

CD $\equiv$ consumer demand for good i

d_h $\equiv$ the share of disposable income spent on the good by household h

s_h $\equiv$ savings rate

t_h $\equiv$ income tax rate

Government demand for the composite good i is defined as the value share of good i in the exogenously given aggregate real government spending on goods and services.

In addition to fixed investment, gross private domestic investment includes also the additions to stocks. Stocks are assumed to be kept at some proportion of domestic output.

The intermediate demands for energy and materials can be derived by using Shephard's lemma from their respective price equations. By taking the first partial derivatives of equation (5) with respect to input prices, we have the demand for energy type j by each good as follows:

$$E_j = E \left(b_i + \sum_{j=1} b_{ji} (P_i / P_j)^{1/2} \right) \quad (9)$$

with $j, i =$ energy sectors

Appendix E. Sector Definition

Sector Definition

Sector	Name	BEA Code
1	Agriculture	1-4
2	Iron Mining	5
3	Non-Iron Mining	6
4	Other Mining	9,10
5	Coal Mining	7
6	Petroleum Mining	8
7	Construction	11,12
8	Manufacturing	13-30,33,34,39-64
9	Petroleum Refining	31
10	Plastics	32
11	Glass	35
12	Stone	36
13	Steel	37
14	Metal Manufacturing	38
15	Transportation	65
16	Communication	66,67
17	Electric Utilities	68.01
18	Gas Utilities	68.02
19	Trade & Finance	69,70
20	Services (including Water & Sanitary Services)	71-79,68.03

Notes: Sectors 5, 6, 9, 17, and 18 form the energy aggregate.