A COMPREHENSIVE REVIEW OF CLEAN AIR ACT PERMITTING:

THE EFFECTS ON THE COAL INDUSTRY

by

SARA TOVA PILZER

(Under the Direction of Carl Ronald Carroll)

ABSTRACT

Historically, the Clean Air Act (CAA), a powerful piece of environmental legislation that employs consumer choice and tradable pollution permits, has been considered successful; however, the relative success of the CAA is not measured in relationship to all the potential harms that result as externalities of the law. This analysis will take a more critical look at the often-overlooked coal industry. Since coal-fired electric power is the primary industry targeted in CAA legislation and it is responsible for the majority of sulfur dioxide pollution in the United States, it is necessary to study any unintended consequences on this industry from the law. Transportation distances, eastern versus western coal disparities, and the effects of closed mines will be studied. If the program continues to be successful, it can bode very well for future pollution mitigation programs on a variety of levels.

INDEX WORDS: Clean Air Act, externality, tradable permit, pollution permit, coal, environmental economics, policy analysis

A COMPREHENSIVE REVIEW OF CLEAN AIR ACT PERMITTING:

THE EFFECTS ON THE COAL INDUSTRY

by

SARA TOVA PILZER

A.B. The University of Georgia, 2006

B.S. The University of Georgia, 2006

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2006

A COMPREHENSIVE REVIEW OF CLEAN AIR ACT PERMITTING:

THE EFFECTS ON THE COAL INDUSTRY

by

SARA TOVA PILZER

Major Professor:	Carl Ronald Carroll
Committee:	James E. Kundell Gregory Trandel

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
May 2006

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my committee for the countless drafts, edits, meetings, and advice they provided me. Next, I would like to thank my friends who knew when I needed to be left alone to work, and when I really needed to be pulled from the library or coffee shop to take a break. My family, too, has always provided me with the motivation to do what I love and to do it well. Thank you!

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

Purpose of the Study

The implications of the United States Clean Air Act (CAA) are described by Richard Schmalensee et al. as being "of interest both as a response to an important environmental issue and as a landmark experiment in environmental policy. This experiment comes at a particularly important time, since emission trading is under serious consideration, with strong U.S. backing, to deal with global climate change by curbing emissions of carbon dioxide" (1998, p.53). Since the potential success or failure of the Clean Air Act affects much more than the direct pollution reductions from the legislation, a very rigorous policy analysis must be conducted. Before using the results from the CAA as a model for similar policy initiatives in the future, noting all externalities—good and bad—is important. Although it is tempting to focus on the easily-monitored successes, a complete analysis of all the results must not be marred by overzealousness that can result from the realization of the future applications of similar tradable permit programs in other arenas.

The primary factor for this analysis will be the indirect impacts of this policy on the coal industry. There is already a tremendous amount of evidence and documentation about the overall decrease in sulfur dioxide emissions since the inception of this law, so that fact will be taken as a given (Butler, Likens, and Stunder 2001; Burtraw and Palmer

2003; Schmalensee et al. 1998; U.S. Department of Energy; U.S. Environmental Protection Agency). Since most of the studies and reports serve to highlight the nontrivial (and very substantial in most cases) reductions over time of the regulated pollutants, this report will focus on a few of the variables, industries, and impacts that are often overlooked when discussing the success of the Clean Air Act. Elucidating these unintended effects will provide a more complete assessment of the effectiveness of the Clean Air Act. The impetus for this study is the fact that about two-thirds of sulfur dioxide emissions in the United States come from electric utilities, about 90 percent of which burn coal. Thus, about 60 percent of total sulfur dioxide emissions in the nation are attributed directly to coal-fired power plants. As a result, any legislation that serves to reduce overall levels of sulfur dioxide will have a major impact on the coal industry. Some of the changes that will be addressed include the impacts on coal production, transportation, and clean-up as a result of the legislation. These factors are necessary to qualify and quantify when determining the overall success of the Clean Air Act.

Rusty Kalyoncu describes the two primary options firms have to reduce pollution to meet Clean Air Act standards. Firms can either invest in technological changes for better pollution control or they can convert to lower-sulfur coal (1998). There is a wealth of statistics and literature that indicate a shift in sulfur content of coal was an important means by which emissions were reduced. Given the different composition of coal in the eastern and western United States, western coal mining corporations that naturally produce low sulfur coal had a market advantage over the “dirtier” eastern coal mines. Firms can elect to combine eastern and western coals, but this decision still entails a shift to a greater overall use of western coal. The additional costs firms had to incur as a result oft the environmental legislation make it more cost-effective to use a larger percentage of western coal in their energy production. Although these facts are relatively widely-known within the industry and regulating bodies, little comprehensive research has been conducted to determine whether the changes in coal mining and coal burning have had other economic and environmental impacts, aside from meeting the prescribed goal of reduced emissions. The goal of this research is to examine the economic and environmental consequences that resulted from the shift to western coal and to determine effective ways to combat similar problems in the future. The distributional impacts highlighted in this analysis include the increases in transportation distances in order to convert to the lower-sulfur western coal, the changes over time in the propensity to use surface versus underground mining operations, and the effects of closing mines over time.

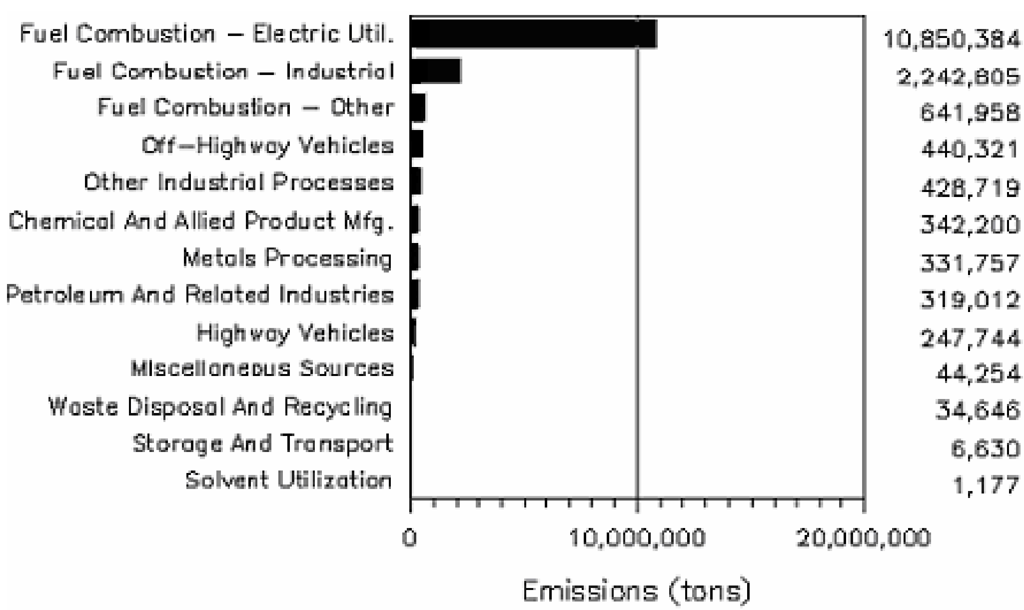
It is important to establish the extent to which the changes in firm behavior achieve the intended environmental goals—is it enough to look solely at aggregate emission levels or should other factors be considered? In particular, how does a shift, or potential shift, to lower-sulfur coal change coal transportation distances, mining type, closing of mines, and to serve as a market catalyst for western coal mining companies? Low-sulfur coal is predominantly found in the Western United States; moving coal longer distances to comply with the legislation may create new environmental problems not being assessed in the Clean Air Act regulation. Therefore, to what degree does this policy merely translate the old environmental emissions problems to a new area (such as the environmental degradation and pollution resulting from increased transportation)? If the shifts occur in a market or industry not measured under the Clean Air Act, are governmental officials and policy makers overstating the benefits of the legislation? Many of these questions have not been studied in depth, and as a result, there is limited available information on the topic. Before future analyses can be conducted, the debate must be opened regarding these changes. Thereafter, additional statistical, economic, and ecological studies may prove necessary, so that all potential harms (and benefits) can be quantified. This analysis is not intended to numerically assess and value the changes, but rather to take the first step in identifying the impacts of shifting to western, lower-sulfur, coal.

Air Pollution Background

According to the Clean Air Council, fine particle pollution causes over 45,000 premature deaths each year (2003). In addition, Jonathan M. Samet et al. (2000) report that there are hundreds of thousands of asthma attacks, cardiac problems, and upper and lower respiratory tract problems in the United States every year as a result of current air pollution. In one of her speeches to the Environmental Protection Agency, then U.S. Attorney General Janet Reno condemned the disparity in health impacts across socioeconomic classes (U.S. EPA, “Janet Reno's November 3, 1999 Speech on the Coal-Fired Power Plant Enforcement Initiative”). Koren (1995) reports that the number of Americans with Asthma is increasing, and the largest growth is in children under eighteen years. Working for the American Academy of Pediatrics Committee on Environmental Health, Kim (2004) explains that outdoor air pollutants are more harmful to children than adults. In addition to the direct health impacts such as asthma and other respiratory problems, studies are beginning to show a greater link between air pollution and "preterm birth, infant mortality, deficits in lung growth, and possibly, [the] development of asthma" (p.1699).

Sulfur dioxide (SO_2) is a primary contributor to particulate pollution, and about 68 percent of SO_2 (over 10 million tons per year) comes from electric utilities, as is illustrated in Figure 1-1. Industrial uses and fuel combustion account for about 14 percent of SO_2 emissions, while non-road engines (trains, ships, etc.) comprise less than 3 percent of the emissions. Cars and trucks account for 1.5 percent of SO_2; similarly, natural sources (such as volcanoes) are a very small percentage of total emissions.

Figure 1-1: Sulfur Dioxide Emissions by Category, 2001



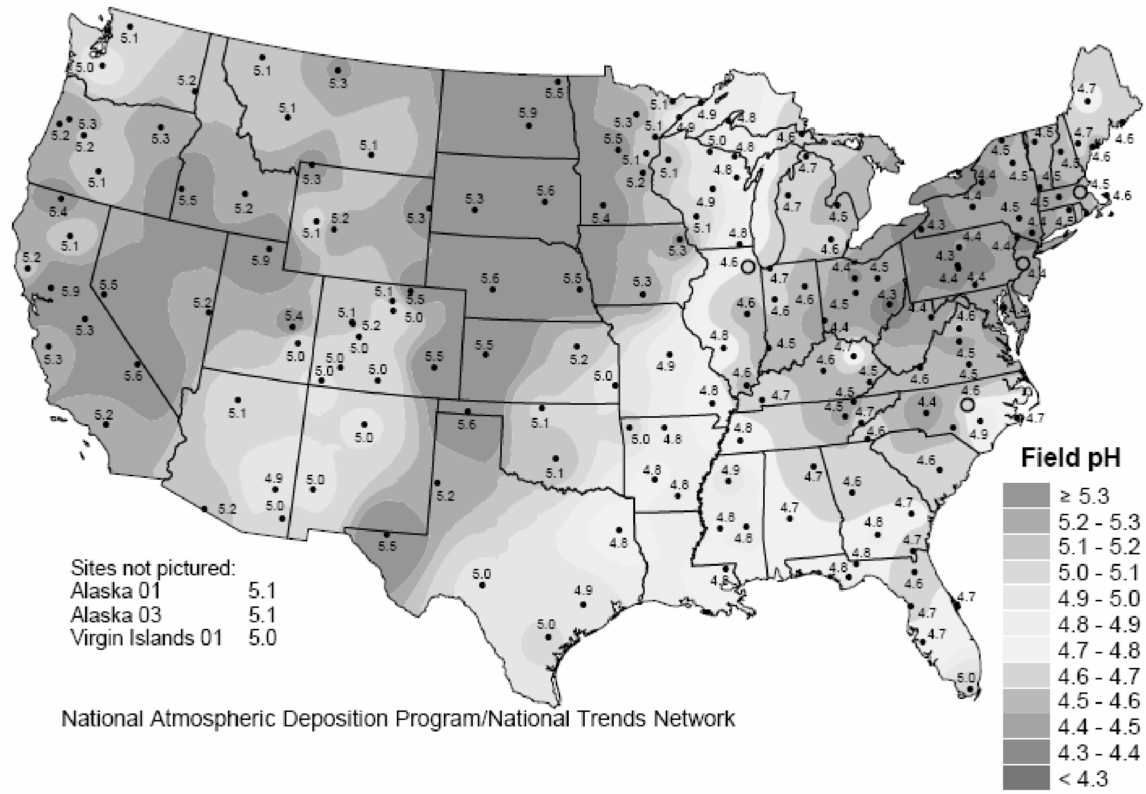
U.S. Environmental Protection Agency, Office of Air and Radiation
(http://www.epa.gov/air/data/reports.html)

The majority of sulfur dioxide emissions come from energy production. Environmental legislation aimed at curtailing pollution tends to be more effective (in monitoring and enforcement) when it is a point-source of pollution, rather than a nonpoint source. As a result, the Clean Air Act targets the primary type of polluter within the stationary (point-source) source types. While 2/3 of total sulfur dioxide pollution is already substantial, when policy designers attempt to create a policy that addresses emissions from point sources, electric utilities comprise an even larger percentage of that total.

By targeting sulfur dioxide emissions from point source, the Clean Air Act indirectly (or directly) regulates electric power plants, of which over 90 percent burn coal to provide energy. There are also other compounding influences of coal production. For example, heavy metals such as mercury are released in coal burning and mining, resulting in additional negative human health impacts and ecosystem degradation. Although important to address for both ecosystem and public health concerns, the effects of mercury pollution are not included in this analysis.

In the explanation of its Clean Air Act and Acid Rain Program monitoring and enforcement, the U.S. EPA lists the harms of numerous pollutants. Sulfur dioxide and nitrogen oxide emissions from power plants result in acid deposition ("acid rain"), thereby harming lakes, fish, trees, and other wildlife, as well as soil biota responsible for soil quality (U.S. EPA, Office of Air and Radiation, http://www.epa.gov/air/urbanair/so2/chf1.html). Acid rain from industrial emissions has traditionally been centered over the Midwest and Northeast United States. Figure 1-2 shows U.S. acid deposition is taken from field samples between 2000 and 2004; the eastern U.S., especially the Northeast, have much lower (more acidic) pHs than the West.

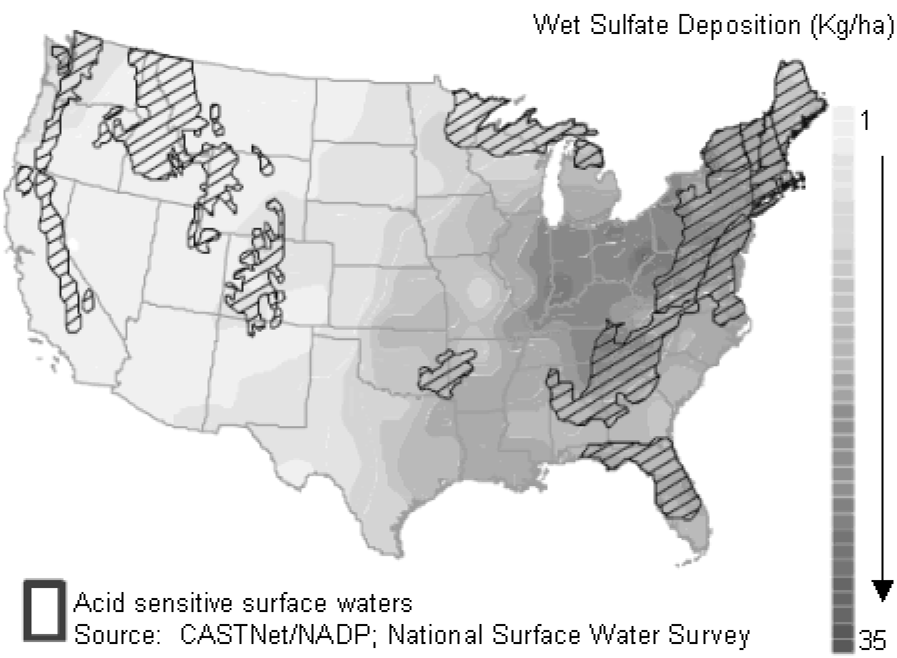
Figure 1-2: Hydrogen Ion Concentration as pH from Measurements made at the Field Laboratories, 2000-2004



National Atmospheric Deposition Program, 2004 Annual Summary (http://nadp.sws.uiuc.edu/lib/data/2004as.pdf)

Lynch (2000) explains in "Acid Rain Reduced" the importance of sulfur dioxide emissions for the health and preservation of many eastern ecosystems, especially because the crystalline bedrock in many New England locations creates much more sensitive environments to acid deposition due to a reduced buffering capacity of the soils. These areas are plagued by acidification, a process that lowers the pH of the water, stressing the ecological integrity of the aquatic ecosystem. Figure 1-3 shows sensitive surface waters to acidification highlighted on a map of sulfate deposition in the country; the eastern vulnerable areas have lower pHs (more acidic rain as a result of higher wet sulfate deposition, much of which comes from sulfur dioxide emission from power plants) than the western sensitive regions. As a result of the SO_2 limitations set by the cap-and-trade program instituted under the Clean Air Act and its amendments, many ecologically vulnerable areas saw direct and downwind emission decreases.

Figure 1-3: Acid Sensitive Areas Transposed on a Sulfate Deposition Map



(http://www.epa.gov/air/interstateairquality/aciddam.html)

Clean Air Act Background

The Clean Air Act is a key piece of environmental legislation that has been in place since the Environmental Protection Agency was first established. Initially passed in 1970, this is the comprehensive federal law that, according to the U.S. EPA, "regulates air emissions and authorizes the United States Environmental Protection Agency to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment" (U.S. EPA, http://epa.gov/enviro/html/airs/airs_law.html). It "established national air-quality standards, gave states the responsibility for developing and enforcing plans to use these standards, and set up compliance schedules. Additionally, the act made federal funding available to states to assist in their efforts" (http://encarta.msn.com/encyclopedia_761566249_4/Environment.html#p57). The Clean

Air Act aimed to address the pollution and environmental consequences that result from the emission of the “criteria” (or common) air pollutants—carbon monoxide, nitrogen oxides, particulate matter, sulfur dioxide, volatile organic compounds, and lead.

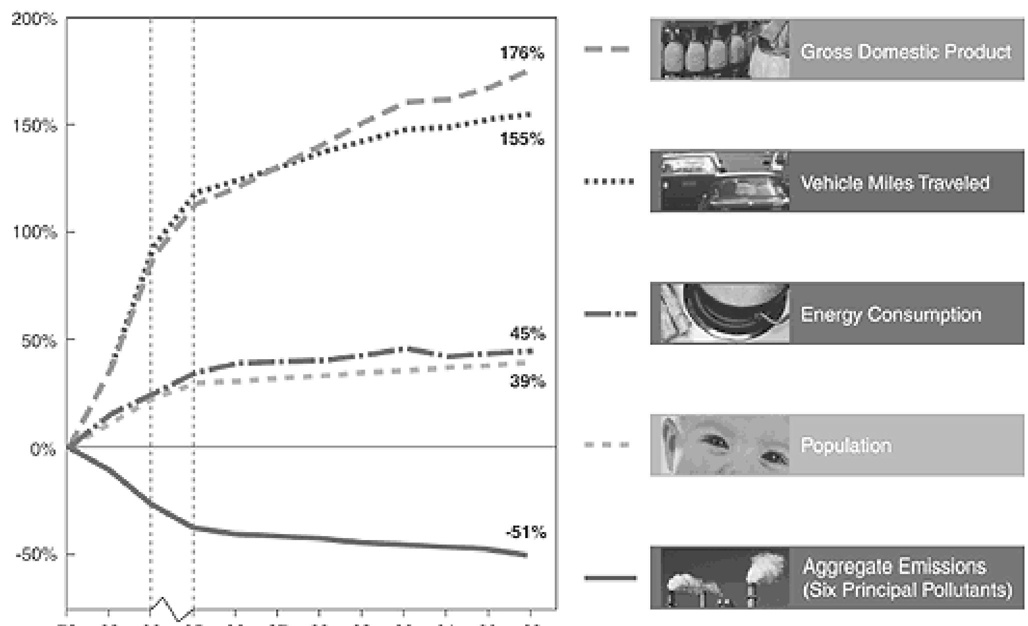
The first set of Clean Air Act amendments were passed on August 7, 1977 and are known as the Clean Air Act Public Law 95-95. These Clean Air Act amendments were technology-focused, requiring all plants to employ scrubbers as a method to clean the emitted air. This was a very controversial requirement, because the relative benefit of a scrubbing technology is much greater when a plant emits dirtier air. It therefore places an undue burden on plants that are burning the cleaner, western coals by still requiring those firms to install the technology that it not as helpful as for the firms still using the higher-sulfur content coal. The decision to require a technology-specific provision was a political one; forcing eastern and western plants alike increased the costs for emitters from both regions, but the scrubbers had a much greater positive effect only for eastern power plants.

After a set of amendments to the Clean Air Act in 1977 that involved a greater focus on specific technological changes, the primary feature of the 1990 Clean Air Act Amendments (CAAA) was an emission allowance trading program. Rather than a “command-and-control” system with direct rule from the government, this permit trading system gives firms in the industry greater choice regarding if and how they will reduce emissions (Stavins 1998). Permits also tend to decrease the operational costs for the EPA, since most of the information is collected by the participants in the programs and then given to EPA. Burtraw and Palmer (2003) describe this permitting system in their discussion paper for Resources for the Future by stating that “the industry is allocated a fixed number of total allowances, and firms are required to surrender one allowance for each ton of sulfur dioxide they emit. Firms may transfer allowances among facilities or to other firms, or to bank them for use in future years" (p.1). The total cap is set based on scientific data obtained from the Environmental Protection Agency, and each year, total emissions decrease. Stavins (1998) describes the goal of emissions trading as cutting sulfur dioxide pollution to half of 1980 levels by 2000. The full text of the initial 1970 Clean Air Act and the 1990 amendments are available to the public at http://www.epa.gov/oar/caa.txt and http://www.epa.gov/oar/caa/caaa.txt.

The 1990 Clean Air Act Amendments also gave the U.S. EPA much greater enforcement power. If the allowable emission levels are exceeded by a firm, the company must forfeit its pollution allowances for the following year and also pay a fine to the U.S. EPA of approximately $2500 per excess ton of sulfur dioxide emitted. In 2005, it was $3042 and in 2006, it is $3152 per excess ton of sulfur dioxide or nitrogen oxide emissions (U.S. EPA, http://www.epa.gov/EPA-AIR/2005/September/Day-27/a19258.htm). The fee is adjusted each year to account for inflation and to "ratchet" down future pollution by annually increasing the cost to pollute. Stavins (1998) details the two phases of the CAAA emissions trading program. Phase I was completed in 1995 and it set limits for "the 263 most SO_2-emissions intensive generating units at 100 electric utility plants operated by 61 electric utilities, and located largely at coal-fired power plants east of the Mississippi River" (p.70). Phase II began in 2000 and brought the remaining plants under regulation. Prior to CAAA, Ellerman (1998) describes the trend in the industry of plant-life extension. Rather than older plants closing after their expected life capacity, firms instead elected to make repairs to the older plants. Since new plants were subject to more stringent regulations, firms preferred to keep their existing plants in operation, rather than investing in expensive new capital and technology.

Overall, there have been many changes in air quality and emission levels of various air pollutants since 1970. The U.S. EPA "National Air Quality and Emissions Trends Report" (2003) indicates that even though the U.S. economy has increased over 150 percent since the inception of the law, the emission levels of pollutants have continued to decrease. Most of this success is attributed to the effectiveness of Clean Air Act regulation. Figure 1-4 shows these trends—while population, energy consumption, transportation distances, and gross domestic product (GDP) all increase, the six criteria air pollutants, on average, have seen a significant decrease.

Figure 1-4: United States Emissions versus Growth



U.S. EPA, "National Air Quality and Emissions Trends Report, 2003"
(http://www.epa.gov/airtrends/2003ozonereport/lookat2003.html)

Sulfur dioxide emissions have been cut nearly in half from the 1970 levels. Table 1-1 shows the change in various emissions, using 1970 as a baseline and comparing emissions from 2003 with the initial levels. Lead has nearly disappeared in emissions, and sulfur dioxide (SO_2), volatile organic compounds (VOCs), particulate matter (PM), and carbon monoxide (CO) have all experienced substantial decreases. Of all the measured pollutants, the Clean Air Act has had the least impact on reducing emissions of nitrogen oxides (NOx).

Table 1-1: Criteria Pollutant Emissions in 1970 and 2003

	Millions of Tons	
	1970	2003
CO	197.3	93.7
NOx	26.9	20.5
PM10	12.2	2.3
SO2	31.2	15.8
VOC	33.7	15.4
Lead	.221	.003

U.S. EPA, "Air Emissions Trends - Continued Progress Through 2003" (http://www.epa.gov/air/airtrends/aqtrnd04/econ-emissions.html)

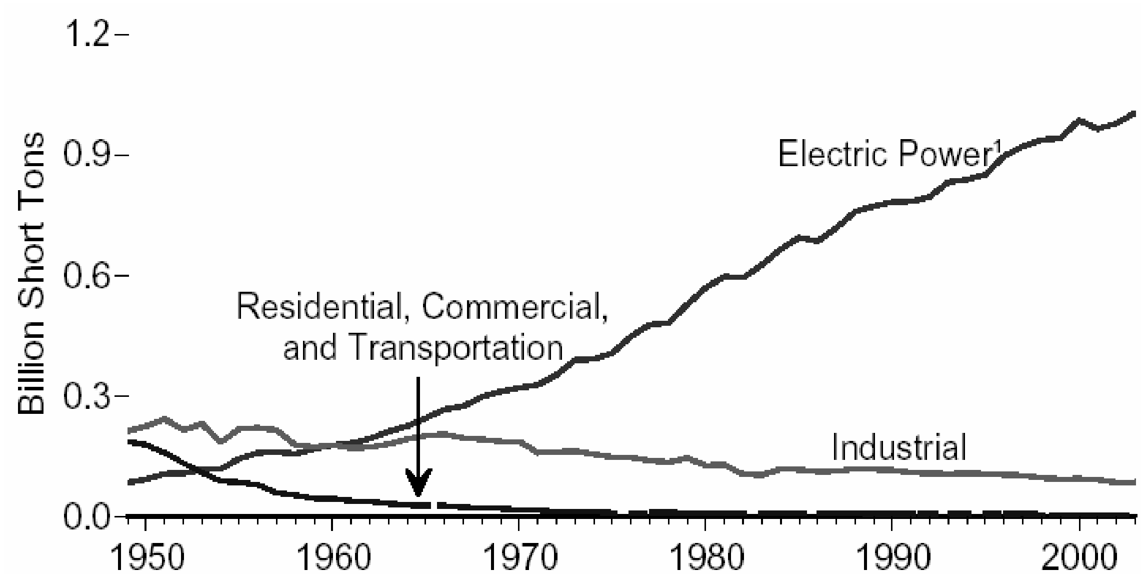
CHAPTER TWO

THE UNITED STATES COAL INDUSTRY

Coal as an Energy Source

Although the emissions from power plants of measured and regulated pollutants have clearly decreased, emissions should not be the only means by which the effectiveness of this legislation is examined. In addition to the direct changes in emissions since the passage of the legislation, indirect impacts should also be evaluated. First, the distribution of power plants, emissions, and changes as a result of the legislation are not consistent across the nation. According to the 2003 annual report published by the United States Department of Energy's Energy Information Administration, in 1949, coal use was well-distributed across a variety of sectors—44 percent of coal use was in the industrial sector, 13 percent was residential, 15 percent was commercial, 15 percent was transportation, and 17 percent was for electricity generation. By 2003, this trend had changed dramatically; only 8 percent of coal use was industrial and 92 percent was for electric power. Figure 2-1 shows that coal use in electric power plants surpasses industrial uses of coal in 1960. It also shows the relative uses of coal by the different sectors. In 1980, electric power accounted for about 80 percent of total coal consumption, and the percentage has continued to rise steadily thereafter. Despite the Clean Air Act, beginning in 1970, electric utilities have continued to increase their dependence on coal as an energy source.

Figure 2-1: Coal Consumption by Sector

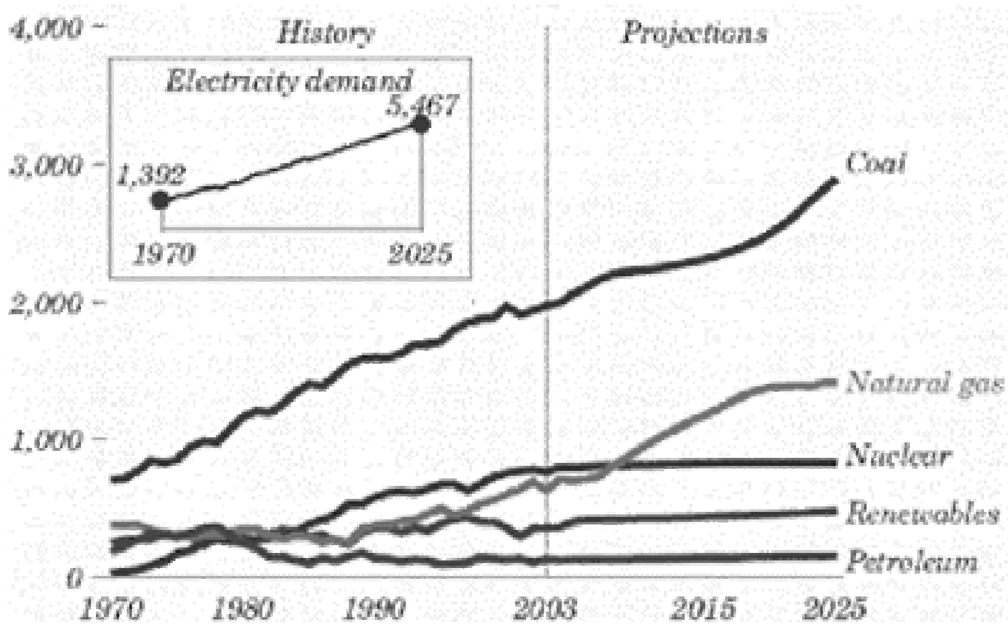


(Energy Information Administration, 2003 Annual Energy Review)

The National Mining Association reports that there are about 1600 coal plants and 1100 manufacturing plants that operate with coal in the United States. Coal reserves comprise approximately 95 percent of the fossil fuel reserves in the country and are responsible for over half of the country's electricity production. Nine tenths of the coal that is used in the U.S. is used to generate electricity (http://www.nma.org).

Figure 2-2 illustrates the increasing dependency on coal as the primary electricity source in the United States. Coal use for electricity has more than doubled from 1970-2003, and it is estimated to continue its steady increase through 2025. Increases in both population and average energy consumption per capita have led to the trend in increased energy demand over time. The degree to which coal is consumed by the electric power sector has also continued to increase. As a result, it is appropriate for the Clean Air Act to primarily target electric power plants; despite the use of other fuels, 90 percent of SO_2 emissions from electricity generation are produced directly from burning coal.

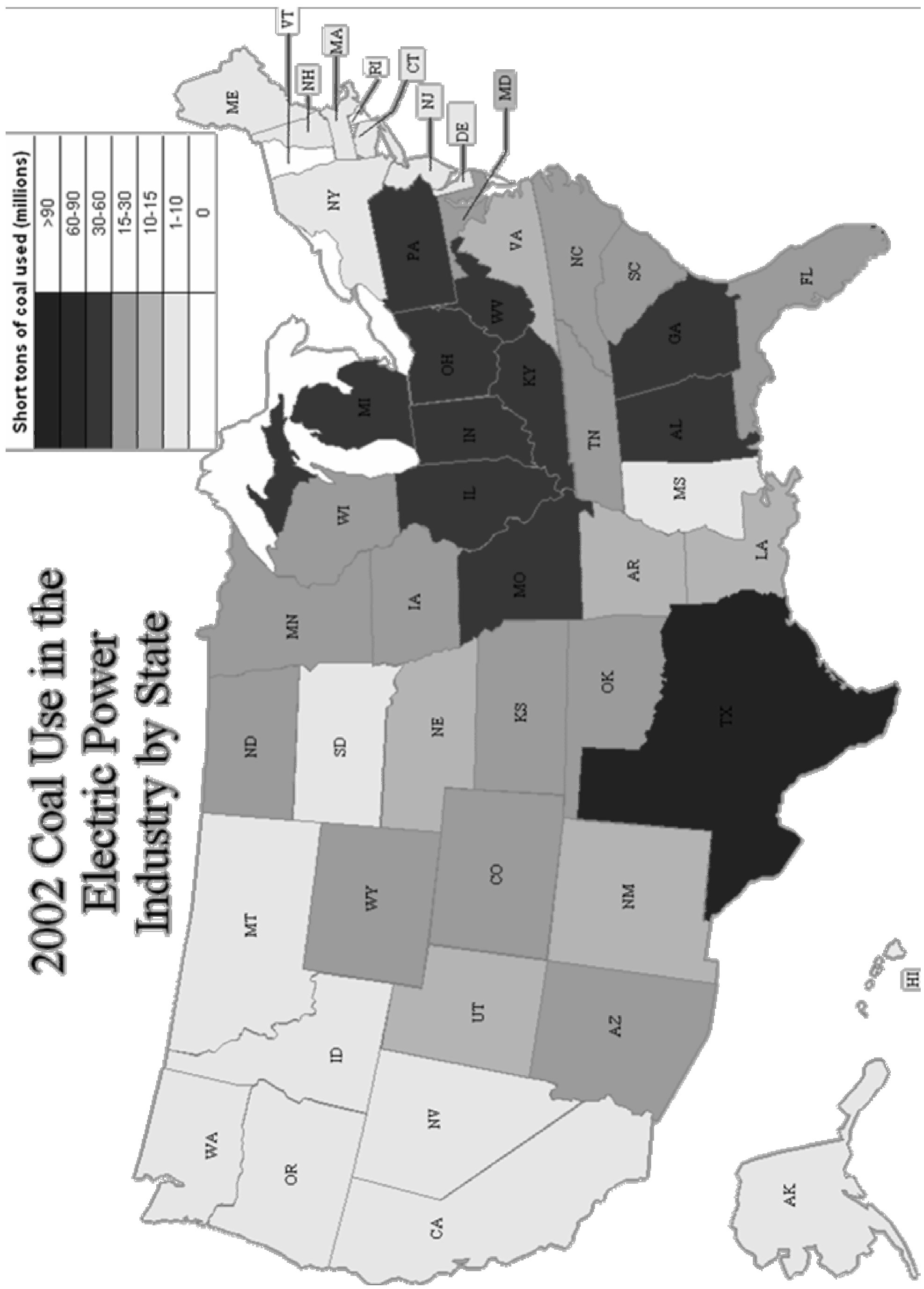
Figure 2-2: Electricity Generation by Fuel Type (measured in billion kilowatt hours)



(Energy Information Administration, Annual Energy Outlook 2005)

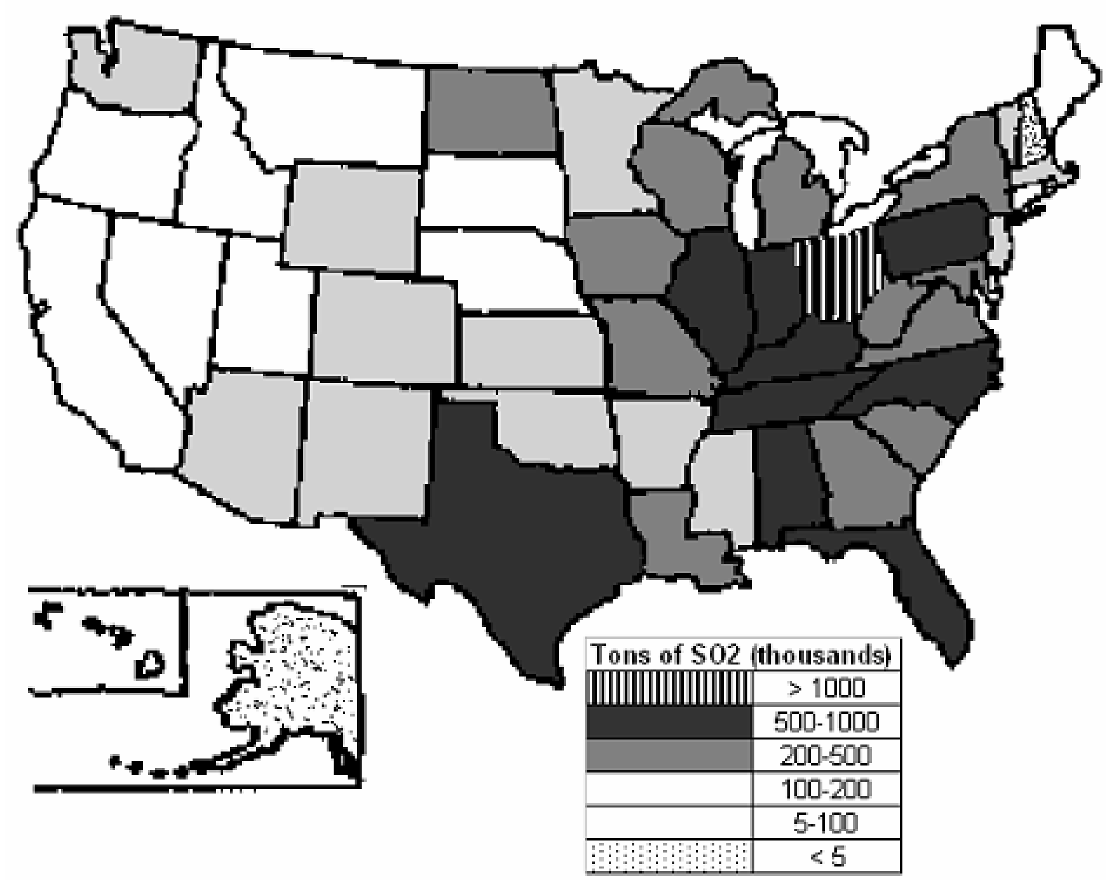
Figures 2-3 and 2-4 show the amount of coal used in each state, as well as sulfur dioxide emissions. Brutraw and Palmer explain that these two measurements are highly correlated and contributed to the Clean Air Act Amendments (2003, p. 1). The regions of the country that are using the greatest amount of coal are the Midwest, East and Central States. Wind patterns in the United States generally move from the West to the East, so any changes in sulfur content or total amount of coal burned in the Interior coal region have repercussions downwind (to the East). Coal use and sulfur emissions are much greater in the East and Midwest than other areas of the country. In 2002, the Midwest, one of the primary areas being targeted by Clean Air Act legislation, had the greatest sulfur dioxide emissions. In 2002, Texas had the greatest coal consumption.

Figure 2-3: Coal Use by State, 2002



Data from U.S. Department of Energy's Energy Information Administration, 2002

Figure 2-4: SO_2 Emissions from the Top 25 Emitters in each State, 2002



Data from Natural Resource Defense Council, 2003

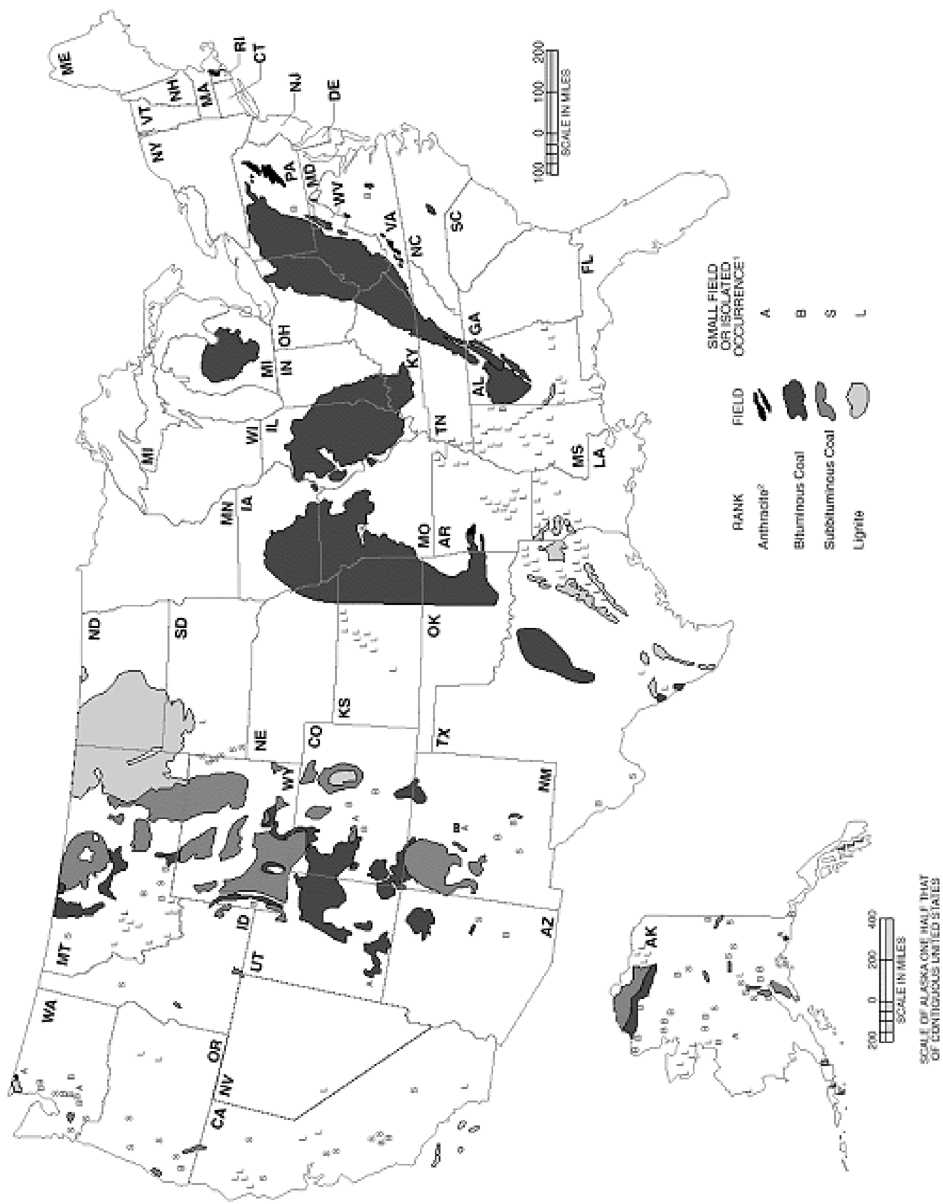
Types and Location of United States Coal

The Kentucky Educational Television (2001) describes the different coal varieties: anthracite, bituminous, subbituminous, and lignite. Anthracite has the highest carbon content, low sulfur content, and the greatest heat capacity (or the ability to provide heat when burned). It is the least common type of coal in the U.S. and is located predominantly in 11 counties in northeastern Pennsylvania; however, most anthracitic coal has already been mined and used. Bituminous has the next-highest heating capacity. It contains large amounts of both carbon and sulfur compounds. The next-most productive coal type is subbituminous. It has a lower heat content but it also has a much lower sulfur content than bituminous coal. Lastly, lignite is a very young coal and has a relatively low heat capacity and a medium sulfur content (http://www.ket.org/trips/coal/agsmm/agsmmtypes.html). About 90 percent of American coal is bituminous and subbituminous.

There are several large coalfields which provide most of the coal for American electric power plants. Figure 2-5 shows the coal deposits in the U.S. by type of coal. Coal is mined in 32 states in three major regions: Appalachia, the Interior, and the West. (Figure 3-3 shows the coal fields and states in each of these designations.) The majority of the East and Interior have bituminous coal and most western coal is subbituminous.

Although U.S. coal reserves are scattered around the country, there is a substantial difference in the amount of coal found in each coal reserve. Table 2-1 shows the amount of coal found in each of the top-ten states and breaks down the total the overall percentage of the United States coal resources. Together, the top ten states contain about ninety percent of the total coal in the country, and over one-quarter of the nation's coal is located in Montana. The Montana state legislature explains in its 2005 report "Understanding Energy in Montana" that "with the exception of the small lignite mine at Sidney, Montana production is entirely low-sulfur subbituminous coal (though there are also smaller lignite and bituminous deposits), with 17-18 million Btu per ton." (http://leg.state.mt.us/content/publications/lepo/2005_deq_energy_report/coal_text.pdf). Although Montana has some bituminous deposits, it does not mine in those locations.

Figure 2-5: United States Coal Deposits by Type



(United States Geological Survey, Coalfields of the United States, 1960-1961; Texas Bureau of Economic Geology, Lignite Resources in Texas, 1980; Louisiana Geological Survey, Near Surface Lignite in Louisiana, 1981; Colorado Geological Survey, Coal Resources and Development Map, 1981; and Mississippi Bureau of Geology, 1983.)

Table 2-1: Demonstrated Coal Reserves (Billion Short Tons)

Rank	State	Total Reserve	% of Total U.S.
1	Montana	120.1	25.4
2	Illinois	78.5	16.5
3	Wyoming	68.7	14.4
4	West Virginia	37.9	8.0
5	Kentucky	30.2	6.3
6	Pennsylvania	29.5	6.1
7	Ohio	18.6	4.0
8	Colorado	17.1	3.6
9	Texas	13.5	2.7
10	Indiana	10.3	2.1
	All Other States	50.1	10.9
	Total U.S.	474.5	100.0

(Wyoming Mining Association)

Meanwhile, Table 2-2 provides the actual production by each coal-producing state in the nation, by state rank. Wyoming produces nearly 400 million short tons of coal, or more than 35 percent of the nation's total. The five largest coal-producing states account for just under 70 percent of the coal production in the United States. The coal production ranking does not correspond exactly with the amount of coal in each state. Montana and Wyoming, the states with the most coal are 6th and 9th respectively in coal production, and the amount produced is far less than the physical amount of coal might indicate.

Table 2-2: Coal Production by State and Rank (in thousand short tons)

	State	2004 Total	% of Total U.S.
1	Wyoming	396,493	35.7%
2	West Virginia	147,993	13.3%
3	Kentucky	114,244	10.3%
4	Pennsylvania	65,996	5.9%
5	Texas	45,863	4.1%
6	Montana	39,989	3.6%
7	Colorado	39,870	3.6%
8	Indiana	35,110	3.2%
9	Illinois	31,853	2.9%
10	Virginia	31,420	2.8%
11	North Dakota	29,943	2.7%
12	New Mexico	27,250	2.5%
13	Ohio	23,222	2.1%
14	Alabama	22,271	2.0%
15	Utah	21,746	2.0%
16	Arizona	12,731	1.1%
17	Washington	5,653	0.5%
18	Maryland	5,225	0.5%
19	Louisiana	3,805	0.3%
20	Mississippi	3,586	0.3%
21	Tennessee	2,887	0.3%
22	Oklahoma	1,792	0.2%
23	Alaska	1,512	0.1%
24	Missouri	578	*
25	Kansas	71	*
26	Arkansas	7	*
	Total U.S.	**1,112,099**	**100.00%**

(Energy Information Administration, "2004 Annual Coal Report," Table 1)

Regional Differences in Coal

Although coal is a very important energy source for the nation, not all regions of the country use the same amount of coal. In addition, the coal that is mined and used varies depending on the depositional environment. Figure 2-6 pictorially shows the type and relative size of energy use by each region. The Pacific Northwest tends towards greater hydroelectric energy generation. The majority of petroleum generation is found in Florida and New York. Natural gas reserves are located in and around Texas, Louisiana, and Oklahoma, and therefore it is used for energy in those areas. California, too, uses natural gas (along with other energy sources), mostly as a result of stringent air pollution policies that prevent the use of coal, which typically emits more pollution than burning natural gas. The Midwest and Appalachian areas use a large amount of coal for energy. Figure 2-6 illustrates the energy type and relative amount used by each energy source throughout the United States.

Figure 2-6: Energy Sources for Electricity Generation by Region

Note: The large icons on this map represent about 10 GW of capacity, not individual plants, in a regional area for each fuel source. Smaller icons represent about 5 GW capacity. Where less than 5 GW of capacity for a fuel type exists for an individual region or State, generating plants are not represented on this map.

(Energy Information Administration, "The Changing Structure of the Electric Power Industry 2000: An Update")

Overall, eastern coal has a higher sulfur content than western coal. Therefore, traditionally the majority of electric power plants east of the Mississippi River used higher-sulfur bituminous coal (Kalyoncu 1998). These areas have higher population densities than many other regions of the country and therefore consume a significant amount of coal and produce a large amount of sulfur dioxide emissions. Before there was a legislative incentive to decrease emissions, areas typically used the closest coal to the plants, as it was least expensive. Lynch (2000) indicates in "Changes in Sulfate

Deposition in Eastern U.S.A." that the decreases in sulfur dioxide emissions were most significant in the Mid-Appalachian and Northeast regions of the country, which is a promising trend. Since these areas have been notorious for higher-sulfur coal use, acid deposition problems have been particularly severe, as have been overall emission levels. The 1990 CAAA helped reduce sulfur dioxide emissions in most eastern states, except, according to Butler et al. (2001) in North Carolina, Florida, and Alabama. Potentially, the relative ease in these states to use alternative sources (such as petroleum, nuclear, and hydroelectric power contributed to emissions increases), but this phenomenon should be studied in greater detail in the future.

The change in distances coal must be moved in order to comply with the Clean Air Act and its amendments is significant. There has been an overall increase in transportation distance of coal, and it therefore seems important that researchers pay more attention to these changes as result of the legislation. In their 2004 report on coal, the Energy Information Administration indicates that, on average, the distance coal is shipped increased from 471 miles in 1977 to 684 miles in 2001 (http://www.eia.doe.gov/cneaf/coal/page/trans/coaltrans.xls#table2.01!A1).

Furthermore, because the Appalachian coal deposits naturally have a higher sulfur content, implementations of any policy that promotes emissions mitigation must recognize this area as a potential problem. Given a variation in sulfur content of coal across the nation, it also becomes important to determine the extent to which the Clean Air Act legislation impacts the type of coal used and the ramifications of those changes. Even if production and use remains consistent, sulfur dioxide emissions can be reduced if lower-sulfur-content coal is used to generate electricity. Geographic proximity to coal, population distribution and density, energy consumption, and coal types in different areas of the country lead to varying capacities for regions to meet Clean Air Act standards. The areas that consume the most coal are clustered around the Appalachian and Interior coal supplies, both of which are, on average, higher-sulfur bituminous coal. It is critical that the movement of coal from lower-sulfur reserves in the West to greater-density populations in the East does not cause new environmental and economic problems in the quest to curtail emissions.

CHAPTER THREE

CLEAN AIR ACT IMPACTS ON THE COAL INDUSTRY

Change in Supply and Demand of Coal by Region

First, it is important to establish the fact that the changes in coal supply and demand cannot be explained by population fluctuations alone. Again, this does not indicate that all of the change can be attributed to the Clean Air Act and its amendments; however, it seems logical that this legislation influenced at least some of the differences over time. Table 3-1 provides population changes between decades (using United States census data that is provided in Appendix B) along with the percent change in coal demanded by each census region in the measured years, 1979, 1987, and 1997. From 1980 to 1990, there was positive growth in each demand region. Similarly, there was an increase in the amount of coal demanded by each region. However, there is a clear difference between the growth of the population and the change in the amount of coal demand for those years. While population continued to grow in all regions between 1990 and 2000 (with more pronounced growth in all regions except the West), the demand for coal decreased in all regions besides the South. Therefore, population increases alone cannot explain the change in demand for coal over time. Since it is intuitive that population influences should be significant, there seems to be some external impetus between 1990 and 2000 that led to decreases in coal consumption. The 1990 Clean Air Act Amendments, therefore, may be at least partly responsible for regions decreasing coal consumption throughout the decade.

Table 3-1: Percent Changes in Regional Population and Coal Demanded

Region	**Population Change** 1980-1990	**Change in Demand** 1979-1987	**Population Change** 1990-2000	**Change in Demand** 1987-1997
Northeast	3.40%	27.21%	5.48%	-2.67%
Midwest	1.36%	45.45%	7.92%	-8.95%
South	13.37%	106.91%	17.31%	3.39%
West	22.27%	84.76%	19.72%	-49.88%
Total U.S.	9.79%	67.37%	13.15%	-9.68%

(U.S. Census Data and Energy Information Administration)

Using U.S. Census divisions shown in Figure 3-1, Table 3-2 lists coal distribution to regions of the country in 1979, 1990, and 2001 as a percentage of the overall total amount of new coal mined and shipped within the country. Looking at the proportions over time is needed to best-reflect the distributional changes of coal distribution on a nationwide level. Rather than use changes in quantity of coal, the percentages over time will help standardize the results. The greatest proportion of coal distribution in 1979 was to the East North Central (30.9%), followed by the South Atlantic (15.6%), East South Central (12.4%), West North Central (11.6%) and Middle Atlantic (11.5%) regions. Since coal-fired power plants supply the country with the majority of the energy used, the large populations in the Northeast and Mid-Atlantic areas help explain the tendency to have a large percentage of the total United States demand for coal.

From 1979 to 2001, the two areas with greatest decreases in proportion of demanded coal were the Middle Atlantic and East North Central regions. These two areas include many of the "dirtier" coal deposits and they are also both northeast, or "upwind" based on typical air streams in the United States, of the Appalachian coal region. With legislation in place that addresses pollution from electric utilities, these places that previously had a cheap energy resource close to home may have started conserving energy as the price increased due to the new policies. The largest increase in demand was in the West South Central region. Between 1990 and 2001, there was little further change in the proportion of coal demanded by any demand region. Despite relatively small changes in the proportion of coal demanded by a given region from 1990 to 2001, it is still possible that the proportion of eastern and western coal can vary while the aggregate remains consistent.

Figure 3-1: Census Regions and Divisions from the Energy Information Administration

Census Regions and Divisions

Census Regions	Census Divisions
Northeast	New England + Middle Atlantic
South	South Atlantic + East South Central + West South Central
Midwest	East North Central + West North Central
West	Mountain + Pacific (Contiguous and Noncontiguous)

Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels.

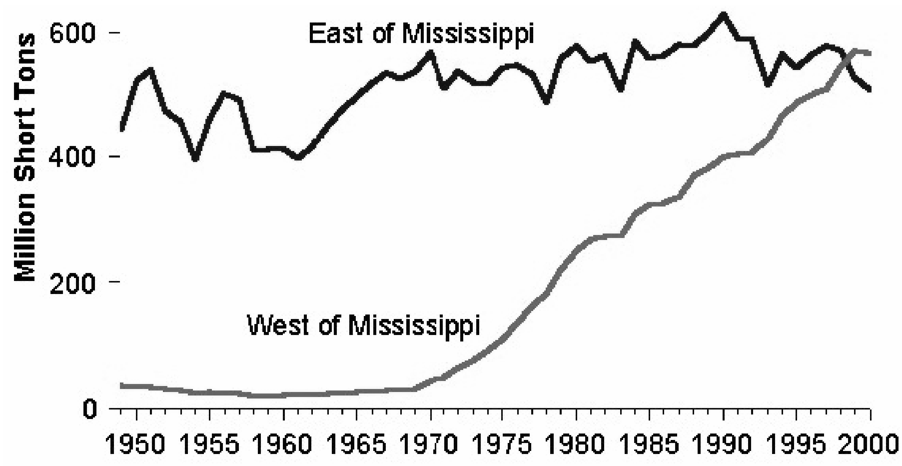
Table 3-2: Domestic Coal Distribution to Census Divisions as a Percentage of Total Coal Shipped, 1979, 1990, 2001

Census Division and Year	1979	1990	2001
New England	0.2%	0.6%	0.3%
Middle Atlantic	11.5%	8.4%	7.2%
East North Central	30.9%	23.3%	22.7%
West North Central	11.6%	12.8%	13.7%
South Atlantic	15.6%	17.1%	17.3%
East South Central	12.4%	10.2%	10.6%
West South Central	7.0%	14.2%	14.5%
Mountain	9.5%	11.7%	11.5%
Pacific	1.2%	1.1%	1.6%
Unknown Destination	0.1%	0.6%	0.6%

(Energy Information Administration Report, "Coal Transportation: Rates and Trends in the United States, 1979-2001")

Although there are numerous coal fields in the United States, they do not all produce the same amount of coal. Figure 3-2 shows the average amount of coal mined east and west of the Mississippi from 1950-2000. Only recently has the total amount of western coal production exceeded that from eastern coal. While coal originating from east of the Mississippi River has fluctuated some, it has remained between about 400 and 600 million short tons per year. On the other hand, coal production from west of the Mississippi was fairly stagnant at just about 25 million short tons before 1970, but by 2000, western production exceeded 500 million short tons per year as eastern production fell. The majority of the increase in western coal production took place in Wyoming, and the changes on this state's coal production before and after the Clean Air Act will be detailed later in the chapter.

Figure 3-2: Coal Production by Location

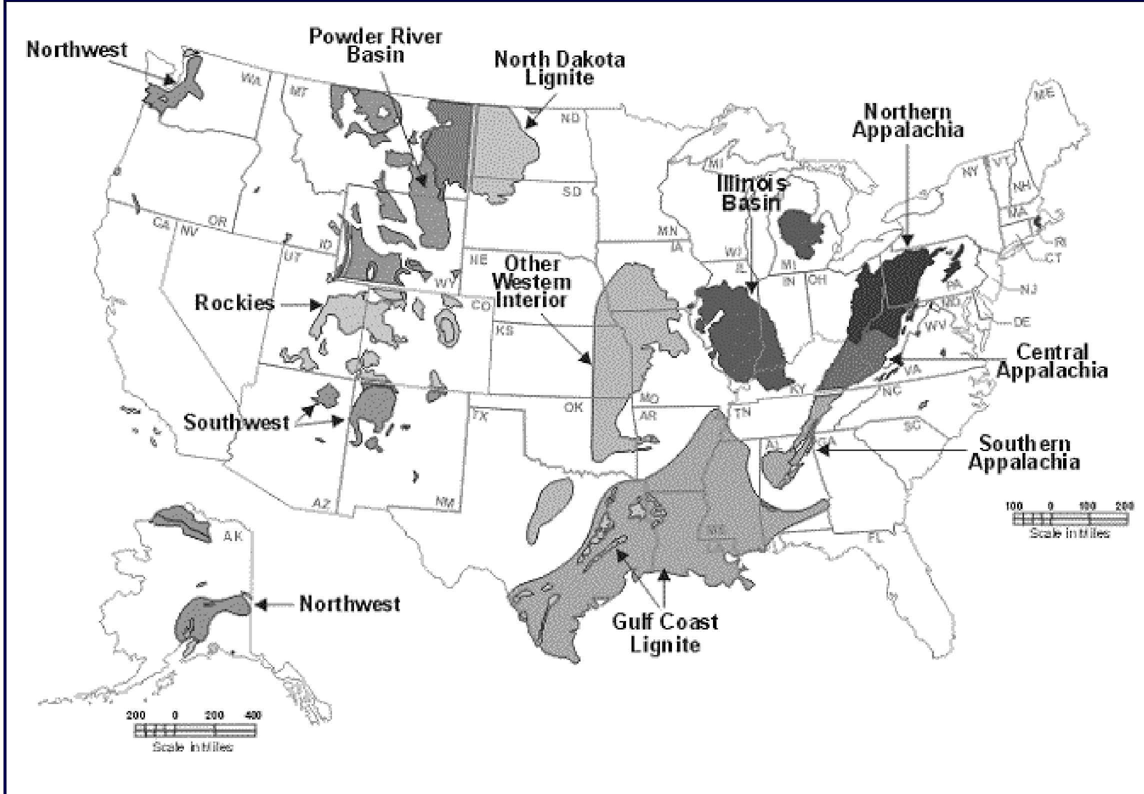


(Energy Information Administration, "2003 Annual Energy Review")

Using the geographic designations that are shown in Figure 3-3, Figure 3-4 gives more specific regional information of coal shipments in 1979, 1990, and 2001. Despite the use of eastern coal far exceeding western coal production for most of the twentieth century, the onset of the Clean Air Act in 1970 led to many changes in coal use and distribution. In 1979, by a large margin, the East North Central region shipped the most coal. Next were the South Atlantic, West North Central, Mountain, and then Middle Atlantic regions. However, by 2001, there were significant changes in the areas from which coal was shipped. Most notable are the drop in coal shipped from the East North Central to less than 40 percent its 1979 level, as well as the large decrease in Middle Atlantic coal shipments. Furthermore, there were large increases in shipments of West South Central, West North Central, and East South Central coal.

Figure 3-3: Geographic Designations by the Energy Information Administration

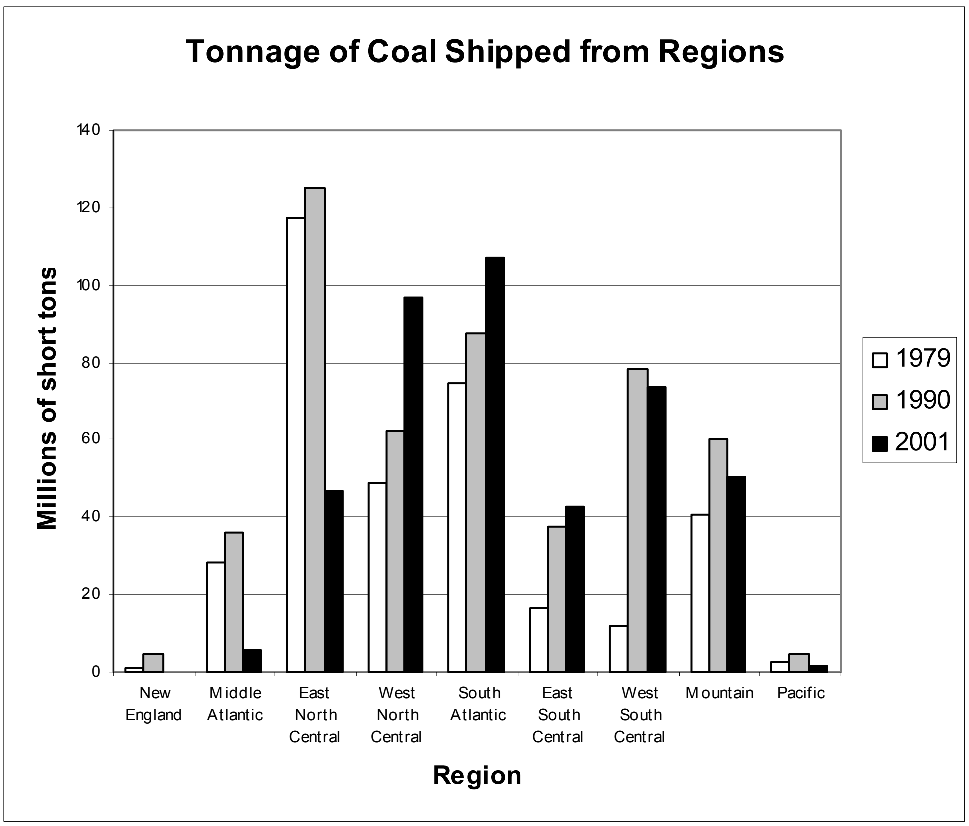
Coal Regions and Coal Fields



Coal Regions	Coal Fields	States
Appalachia	Northern Appalachia	MD, OH, PA, Northern WV
	Central Appalachia	Eastern KY, VA, Southern WV
	Southern Appalachia	AL, TN
Interior	Illinois Basin	Western KY, IL, IN
	Gulf Coast Lignite	TX, LA, MS
	Other Western Interior	AR, IA, KS, MO, OK
West	Powder River Basin	WY, MT
	North Dakota Lignite	ND
	Southwest	AZ, NM
	Rockies	CO, UT
	Northwest	AK, WA

As is evident from Figure 3-4, the majority of coal shipments in 1979 and 1990 are from the eastern part of the United States; however, the large increases in West North Central and West South Central coal supplies resulted in overall western increases. These areas have lower-sulfur coal than Eastern Appalachian and Interior coal; however, the lowest-sulfur coal is even farther west. Seemingly, it pays for firms, on the whole, to switch to a lower-sulfur coal; meanwhile, it can be cost-prohibitive to ship and use the cleanest coals as opposed to an alternative source closer to the energy provider.

Figure 3-4: Tonnage of Coal Shipped from Regions over Time



(Energy Information Administration Report, “Coal Transportation: Rates and Trends in the United States, 1979-2001”)

Table 3-3 combines the supply and demand of coal between the census regions and coal regions (see Figures 3-1 and 3-3 respectively) of the country. Between 1987 and 1995, there is a very substantial production increase in the regions from which the

Midwest and South each receive their coal. Meanwhile, the West and Northeast are unaffected over time in the area from which they receive their coal.

Over time, there has been some fluctuation in the amount of coal demanded by each region. (Table 3-1 and the following discussion helps illustrate that the changes in demand cannot be explained by population influences alone.) Again, proportions of U.S. totals will be used in the comparisons to standardize the results and compare regional changes in distribution over time. While the demand from the Northeast has remained fairly stagnant, the Midwest demanded 48.6 percent of total U.S. coal in 1979, but that lowered to 39.7 percent in 1987, rose slightly to 42.2 percent in 1995, and remained fairly constant at 42.6 percent in 1997. Meanwhile, the South comprised 30.1 percent of the U.S. demand for coal in 1979, increased to 38.8 percent in 1987, was 37.2 percent in 1995, and rose again to 42.6 percent in 1997. There was a decrease in the proportion of coal demanded by the West relative to other regions in the United States from 12.7 percent in 1979 to 7.8 percent in 1997. Despite these changes, due to the proximity of "cleaner" (lower-sulfur) coal to the West, the region has always used coal entirely from within the region. Similarly, because the Northeast is relatively isolated geographically from clean coal, from 1979 to 2001 it received all of its coal from the Appalachian region. Although there is a higher sulfur-content of Appalachian coal relative to Western coal, it appears cost prohibitive for the Northeastern coal-burning power plants to convert to lower-sulfur coal. It is also possible that this region, which seems to have a reduced choice over its coal source due to its location, may not need to shift to a different type of coal, but rather may instead select a different source of energy or technology. This topic will be explored later in the section.

Table 3-3: Utility Contract Coal Tonnage Shipped Between Supply and Demand Regions, 1979, 1987, 1995, and 1997 (Million Short Tons)

Year	Supply Region	Demand Region				U.S. Total
		Northeast	Midwest	South	West	
1979	Appalachia	29.4	45.9	74.5	--	149.7
	Interior	--	60.6	15.9	--	76.5
	Western	--	59.4	12.4	43.3	115.1
	U.S.	**29.4**	**165.9**	**102.8**	**43.3**	**341.3**
1987	Appalachia	30.4	50.2	100.5	--	181.2
	Interior	--	57.6	34.1	--	91.7
	Western	--	59.3	28.8	60.4	148.5
	U.S.	**30.4**	**167.1**	**163.4**	**60.4**	**421.3**
1995	Appalachia	37.4	50.3	116.4	--	204.1
	Interior	--	37.7	24.6	--	62.3
	Western	--	153.3	71.7	80.0	304.9
	U.S.	**37.4**	**241.3**	**212.7**	**80.0**	**571.3**
1997	Appalachia	36.4	40.6	121.4	--	198.4
	Interior	--	30.8	17.0	--	47.8
	Western	--	148.2	81.5	40.1	269.8
	U.S.	**36.4**	**219.7**	**219.9**	**40.1**	**516.0**

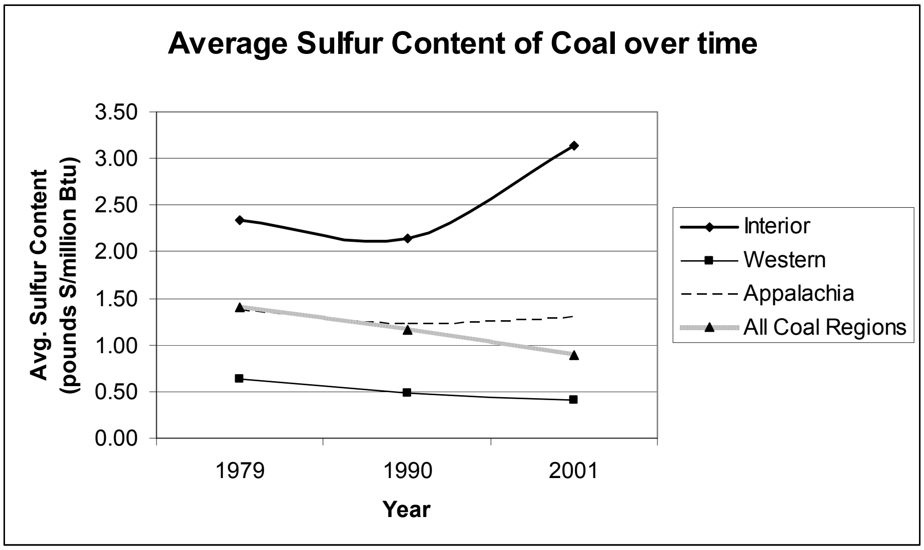
(Energy Information Administration Report, "Coal Transportation: Rates and Trends in the United States, 1979-2001")

The change in area from which coal is demanded is very apparent in the Midwest, and also true to a lesser degree in the South. In 1987, the Midwest demanded almost equal amounts of coal from the Appalachia, Interior, and Western regions (30.0 percent, 34.5 percent, and 35.5 percent respectively), but by 1995, nearly two-thirds of the coal demanded in the Midwest came from the West. Western coal was responsible for 63.5 percent of Midwestern coal demand while the supply from Appalachia dropped to 15.6 percent and the Interior supply fell to just 15.6 percent of Midwestern demand. Considering the fact that the Interior coal region is in the Midwest, a reduction in the demand of Interior coal from 57.6 million short tons to 37.7 million short tons in an eight-year period is noteworthy. Not only is the one-third reduction in actual demand significant, but the fact that there was more than a 30 percent increase in coal demand by the Midwest in the same years (from 167.1 to 241.3 million short tons) means that the relative market share of Interior coal—the coal that is physically located in the Midwest—decreased from 34.5 percent to 15.6 percent of the region's demand.

Meanwhile, the South has decreased its demand over time of Appalachian coal. In 1979, 72.5 percent of its coal came from the Appalachian region, but that number dropped to 61.5 percent in 1987, was 54.7 percent in 1995, and remained fairly constant at 55.2 percent in 1997. Its demand for Interior coal has fluctuated some over time, starting at 15.5 percent of its total coal use in 1979, rising to 20.9 percent in 1987, dropping to 11.6 percent in 1995 and falling further to 7.7 percent in 1997. Notably, the South only demanded 12.1 percent of its coal from the Western region in 1979, but its demand for western coal has increased over time to 17.6 percent in 1987, way up to 33.7 percent in 1995, and up to 37.1 percent in 1997.

Although some increases are evident in Mountain coal use, there appears to be a greater conversion to the middle-sulfur contents rather than a true change to the least polluting coals from the West. Figure 3-5 shows changes over time in sulfur content. Despite a total decrease in sulfur content in all coal regions, there is a nontrivial increase in sulfur content of Interior coal. Conceivably, mining the higher-sulfur coal is least expensive, and firms in the Interior region may decide to pay from cleaner technologies or clean-up after-the-fact, enabling production with the "dirtier" coal.

Figure 3-5: Average Sulfur Content of Coal by Area over Time



("Coal Transportation: Rates and Trends in the United States, 1979-2001" Energy Information Administration Report)

Of the Interior coal, the Energy Information Administration reports that there are decreases in average transportation distances of the higher-sulfur, Midwestern, bituminous coal and slight increases in transportation distances of the (relatively) lower-sulfur lignite coal from the southern end of the region. The increase in average sulfur content in the Interior region also corresponds with a total decrease in the shipment of coal from the region. The coal that is mined remains in the area and has a higher sulfur content but there is also less Interior coal being used in aggregate. Likely, the firms in the Interior region select technological changes over different coal shipments. The total decrease in the amount of Illinois Basin coal mined coupled with an increase in average sulfur content, shows that overall decreases in emissions results from more than just changing the type of coal burned. Using less expensive higher sulfur coal may be the option of the industries, with technological mitigation techniques employed rather than changes in coal type. These choices are the backbone of permitting systems; however, it is also necessary to ensure the ecological sustainability of targeted areas. More research on the choice between the effectiveness of technology improvements versus changing the coal source (and all external benefits and harms of either decision) is needed.

Table 3-4 shows the amount of coal use by electric utilities in each state as well as the proportion coal comprises of total electric utility consumption. None of the states with less than 40 percent of the state's energy consumption coming from coal produce even 1 percent of the nation's total coal. Similarly, each of the states whose electric power consumption comes at least 90 percent from coal are the nation's top coal producers; in fact, 65.2 percent of the country's coal production comes from these six states whose total energy is over 90 percent from coal.

New Jersey and states further north use coal for just 0 to 22 percent of their energy production. Instead of using lower-sulfur coal, the region can afford to use the higher-sulfur, closer coal because the majority of their energy comes from other non-coal sources. Meanwhile, the South (except for Florida, Texas and Louisiana which have petroleum and natural gas reserves—recall Figure 2-6) tends to use coal to provide over half of the states' energy. The West, unless the state uses hydroelectric or natural gas energies, obtains an even larger percentage of its energy from coal, on average, than the South.

Interestingly, the fourth- and fifth-largest coal producers, Pennsylvania and Texas, only use coal for electric power in the state for about 55 and 41 percent respectively, while Illinois, the 9th-largest producer and home to the 2nd-most coal reserves in the country uses coal for only about 45 percent of its energy. Pennsylvania has decreased its coal production while receiving many large government payouts recently to clean abandoned mines in the state. Texas is the state that uses both the most coal and the most energy in the country, so diversification of its energy sources is no surprise. Coal from Illinois, although plentiful, has the highest sulfur content in the nation, so given the option to use coal from a different region or shift to different energy resources seems to have stimulated the state to use other energy types.

Table 3-4: Electric Power Sector Consumption Estimates, 2001

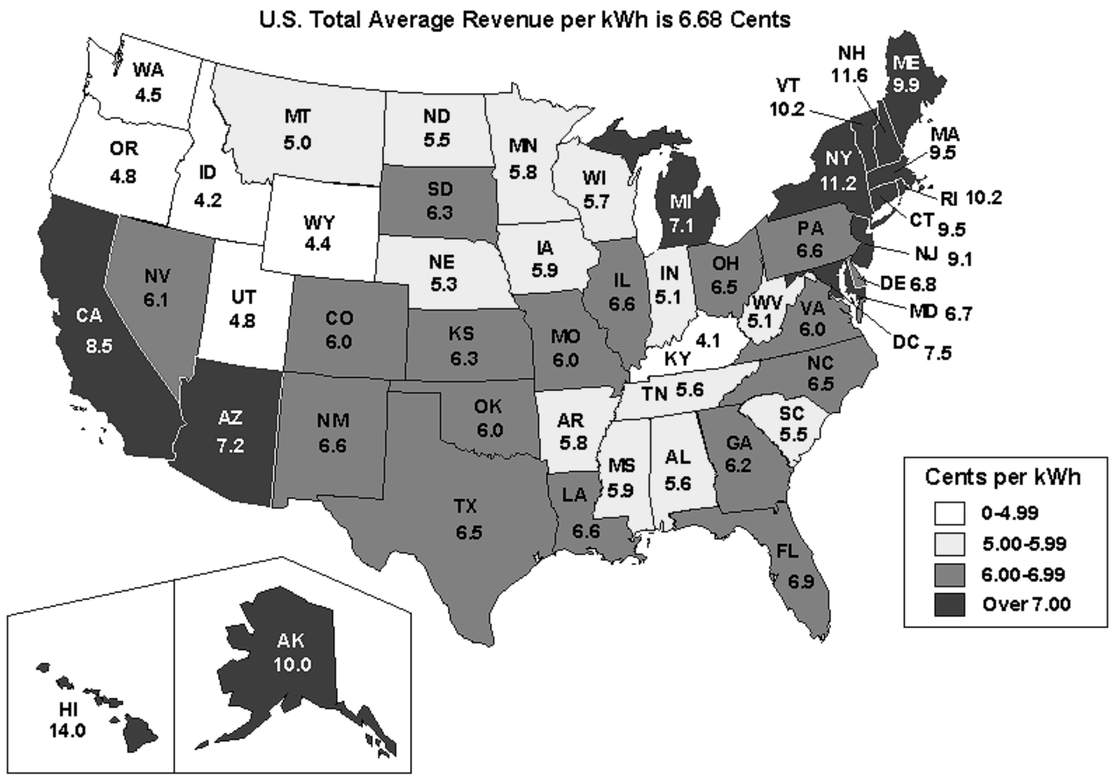
STATE	Coal (trillion BTU)	Total (Trillion BTU)	Coal Use Proportion of Total Energy	STATE	Coal (Trillion BTU)	Total (Trillion BTU)	Coal Use Proportion of Total Energy
ID	0	85	0.0000	AR	263.1	479.4	0.5488
RI	0	63.3	0.0000	PA	1106.5	1986.5	0.5570
VT	0	66.1	0.0000	MD	283.3	503	0.5632
CA	21.1	2026.2	0.0104	MI	690.5	1135.3	0.6082
ME	4.6	166.2	0.0277	NC	707.5	1149.8	0.6153
DE	33.8	646.4	0.0523	TN	591.9	957.8	0.6180
OR	43.4	427.7	0.1015	MN	328.9	522.7	0.6292
WA	96	821.5	0.1169	GA	720.5	1132.4	0.6363
CT	39.9	318.2	0.1254	OK	361.6	565	0.6400
AK	8.5	64.4	0.1320	AL	740	1120.5	0.6604
HI	15.7	109.4	0.1435	NE	216.4	323.9	0.6681
NY	241.1	1494.4	0.1613	MT	181.7	257.8	0.7048
NJ	112	601.1	0.1863	KS	350.8	490.3	0.7155
NH	40	161.9	0.2471	WI	450.6	621.7	0.7248
MA	107.1	383.8	0.2791	CO	386.7	492.4	0.7853
LA	238	719.1	0.3310	MO	688.2	828.2	0.8310
FL	694.4	1879.5	0.3695	NM	295.2	346.4	0.8522
MS	194.5	504.8	0.3853	IA	378.2	440.2	0.8592
SC	361.3	898.5	0.4021	OH	1243.2	1426.4	0.8716
TX	1417.1	3425.5	0.4137	UT	339.1	365.3	0.9283
AZ	409.3	925.3	0.4423	ND	324.4	340.2	0.9536
IL	867.2	1909.4	0.4542	KY	944.1	989.2	0.9544
SD	37.8	77.9	0.4852	WY	464.2	480	0.9671
NV	183.7	359.1	0.5116	IN	1209.6	1239	0.9763
VA	391.4	742.5	0.5271	WV	789.5	800.1	0.9868

(Energy Information Administration, http://www.eia.doe.gov/emeu/states/sep_sum/html/sum_btu_eu.html)

Figure 3-6 provides the cost of energy by state. The Pacific Northwest has some of the least expensive energy through hydroelectric power supply. Wyoming and

Kentucky, two large coal-producing states also have very inexpensive energy costs. Otherwise, New England and parts of the Southwest have higher electricity prices.

Figure 3-6: Estimated Average Revenue per Kilowatthour for All Sectors at Electric Utilities by State, 2000



(Energy Information Administration, http://www.eia.doe.gov/cneaf/electricity/epav1/fig12.html)

In addition to looking at Table 3-3 from the perspective of demand regions, the effects of the Clean Air Act should also be studied by observing specific supply regions over time. The supply of Appalachian coal as a percentage of overall supply has been fairly consistent from 1979 to 1997. However, there was a drop in supply from 43.0 percent of the U.S. supply (181.2 million short tons with a national supply of 421.3 million short tons) in 1987 to 35.7 percent (204.1 million short tons with a national supply of 571.3 million short tons) in 1995. The Interior region experienced a similar consistency in supply between 1979 and 1987, and 1995 and 1997, but experienced a drop in supply from 21.8 percent in 1987 to 10.9 percent in 1995. Both the Appalachian and Interior regions saw a decrease in the relative supply from that region between 1987 and 1995, and the 1990 CAAA are a likely cause for these changes.

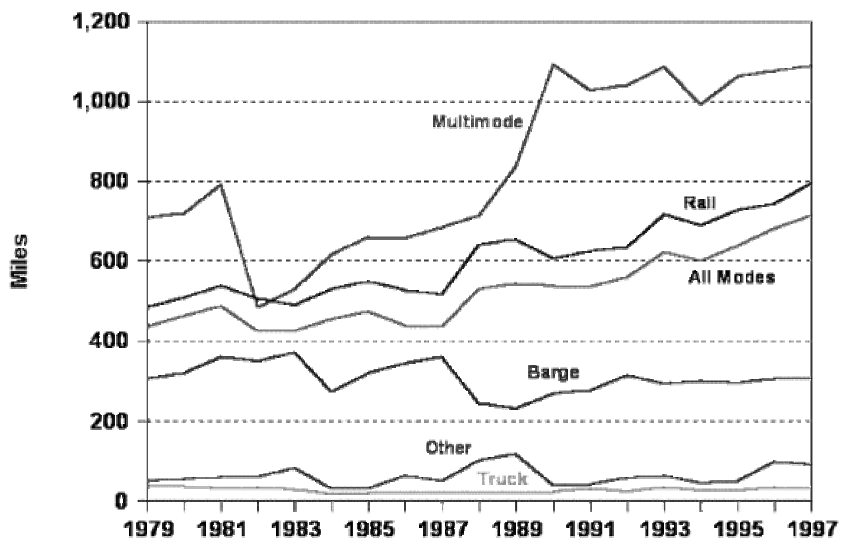
To make up for the decreases in supply of Appalachian and Interior coal, the supply of Western coal increased from 35.2 percent in 1987 to 53.4 percent in 1995. This large increase in supply of Western coal was primarily to the Interior region, as Western coal comprised just under 40 percent of Midwestern coal in 1987 but it increased to just over 50 percent in 1995. The supply of western coal has increased over time in aggregate, but has decreased as a relative proportion of its own supply. Given that all of the coal consumed in the West is supplied by western mines and that the percentage of western coal used in the West has decreased significantly from 1987 to 1995 to 1997 (40.7 percent to 26.2 percent to 14.9 percent), while the total amount of western coal supplied within the U.S. has increased, there must be an impact on transportation of coal over the same time frame—the coal must get from the West to the South and Interior.

The increase over time in supply of western coal relative to eastern coal substantiates these proportional changes over time in demanded coal. It would be counterintuitive for the demand regions to use coal from farther away if there was not a financial incentive to do so. The Clean Air Act has seemed to create the desire and need for firms to switch to western coal when it is not cost prohibitive to do so. Clearly, the aggregate amount of western coal has increased over time, and to accommodate the shift in demand from the West, one must look at potential changes in transportation of the coal over time.

Impact on Transportation Distances

As is shown in Figure 3-7, there is an overall average increase in transportation distance of coal. Most movement of coal requires a variety of transportation methods, but railroads are the most common single source (excluding multimode and all modes) of coal movement. The changes in distance and method of coal transport also vary by coal field. According to the Energy Information Administration's Coal Transportation Rate Database, from 1979 to 1997, there were changes in the average distance of coal shipped for electric utility contracts. Appalachian coal increased in transportation distance from 261 miles to 324 miles; Interior coal decreased from 242 miles to 189 miles; and Western coal increased from 770 miles to 1087 miles (Energy Information Administration).

Figure 3-7: Average Distance Coal Shipped by Transportation Mode

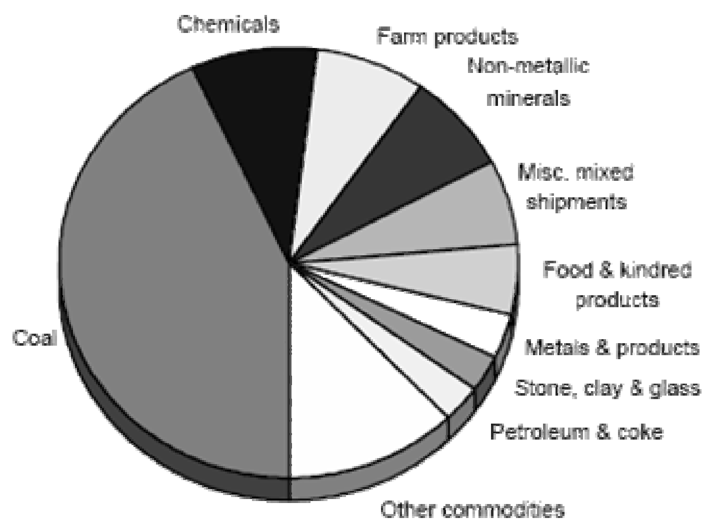


(Energy Information Administration, Coal Transportation Rate Database)

As is illustrated in Figure 3-8, in 2004, 41.2 percent of all railroad commodities in the United States were coal. This resulted in over 8.4 billion dollars of total gross revenue (over 20 percent of the total) for the railroad industry. The current productivity of American railroads is vastly different from before 1970. During the 1970's, nearly all

Northeastern railroad companies declared bankruptcy. Along with the deregulation of railroads in 1980 under the Staggers Railroad Act, the need to transport large amounts of coal long distances appears to have helped save the struggling industry. (http://www.aar.org/GetFile.asp?File_ID=140)

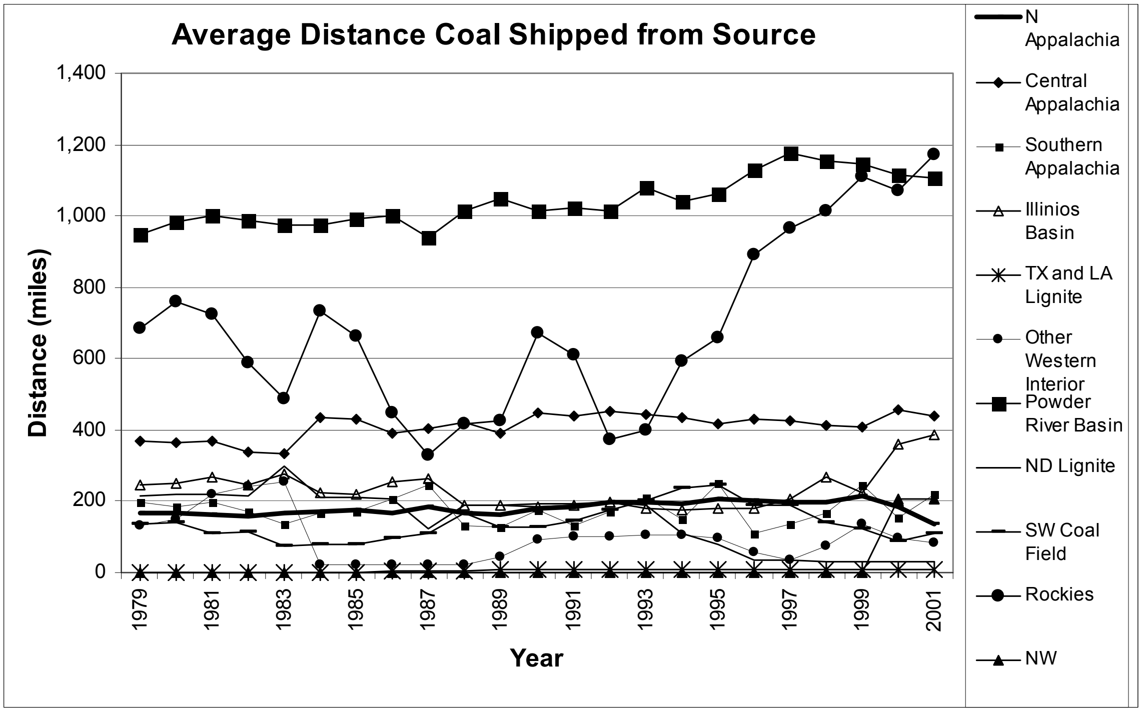
Figure 3-8: 2004 Railroad Tons of Commodities



(Association of American Railroads http://www.aar.org/PubCommon/Documents/AboutTheIndustry/Statistics.pdf)

Figure 3-9 shows that the average distance of Powder River Basin coal (mined in WY and MT) has consistently been high since 1979, and the greatest increase in transportation distance is from Rockies coal (subbituminous, low-sulfur coal from CO and UT). Despite slight decreases in total amount of coal mined, by 2001, about 50 million short tons of Rockies coal were mined (Figure 3-2). Therefore, these large transportation increases over time are significant.

Figure 3-9: Average Distance Coal Shipped



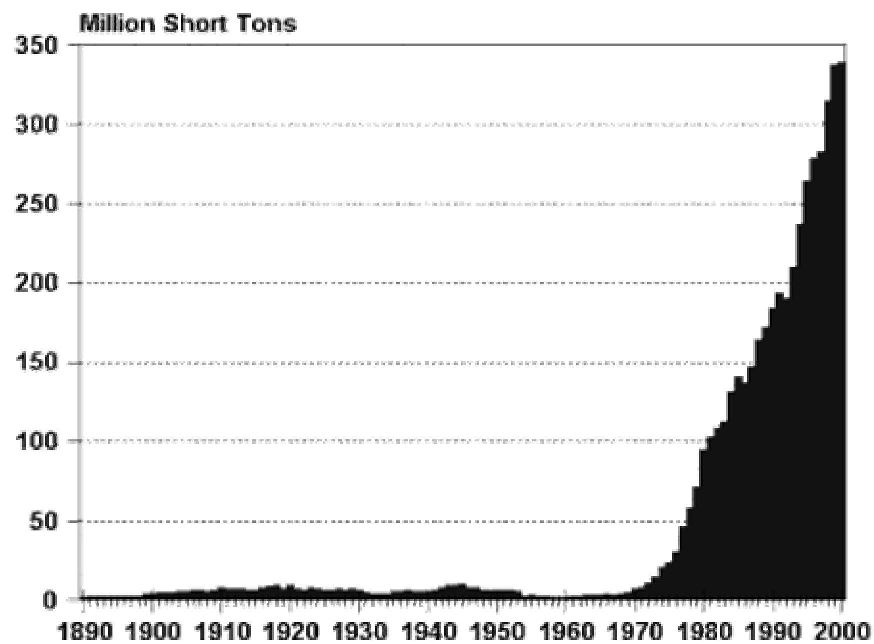
(Energy Information Administration Report, "Coal Transportation: Rates and Trends in the United States, 1979-2001")

Aside from Power River Basin, coal which over time has been shipped long distances, and Rockies coal, which has increased over the past fifteen years in shipping distance, there are few changes in the distance coal is shipped from its source. Therefore, most (non-western) coal traditionally has and still is being used close to its source. By virtue of the fact that the production of western coal has increased substantially since 1970, the long transportation distances—even if they do not continually increase—of western coal could be significant. With more coal over time shipped long distance, the total distance coal is shipped can increase, even if the distance shipped from a specific area does not also rise. Not only does this increased need for large, long-distance coal shipments provide large financial rewards for the railroad industry, but it also means that more energy is required to move coal long distances.

Case Study: Comparative Advantage of Mining Coal in Wyoming

Many western states have profited financially from the Clean Air Act because it has become necessary for most coal-fired electric utilities to use "cleaner" coal. On average, western coal has far less sulfur than eastern coal, so in the attempt to decrease sulfur dioxide emissions, western coal producers have developed a market advantage over eastern producers. Figure 3-10 shows the very drastic change increase in coal production in Wyoming starting at near the initial inception of the Clean Air Act in 1970. While other western states have also increased their production since the legislation, the degree to which Wyoming has created its market niche is astounding.

Figure 3-10: Historical Coal Production in Wyoming



(1890-1978, U.S. Bureau of Mines file data, including State-level statistics not published in Bureau of Mines Mineral Industry Yearbooks. 1979-present, Energy Information Administration, Annual Coal Report (2001) and precedent reports (Coal Industry Annual, 1993-2000; and Coal Production (year), 1979-1992).)

In actuality, 14.4 percent of the total coal found in the United States is located in Wyoming, making it the state with the third-most coal deposits in the nation (Table 2-1).

However, by 2004, "Wyoming produced a record 396.5 million short tons of coal, an increase of 5.4 percent for the year. This production level was only 17.0 million short tons less than the combined total of the next five largest coal-producing States (West Virginia, Kentucky, Pennsylvania, Texas, and Montana)" (EIA 2004 Review, "U.S. Coal Supply and Demand"). In 2004, western coal provided 51.8 percent of the nation's coal and Wyoming produced nearly 70 percent of that total (http://www.eia.doe.gov/cneaf/coal/page/special/feature.html). Therefore, in 2004, Wyoming coal production accounted for over 35 percent of the nation's total supply. Although Montana has 25.4 percent of all the coal deposits in the nation, nearly double the amount located in Wyoming, Montana is responsible for just 3.5 percent of the total coal mined yearly. Practically all of Montana's coal mining occurred after 1970, but the amount it has prospered from coal mining is far less than the benefits reaped by the state of Wyoming.

Table 3-5 details the largest ten mines in the United States, based on total production. (Appendix A lists the top 61 mines by production, which account for 61.9 percent of the total U.S. coal production.) In 2004, Wyoming had the ten largest coal mines, which together accounted for 365,359,185 tons of coal, or 32.85 percent of the total coal mined in the U.S. These ten mines in Wyoming provide nearly one-third of the nation's total coal supply, although the state has less than half that supply in its deposits.

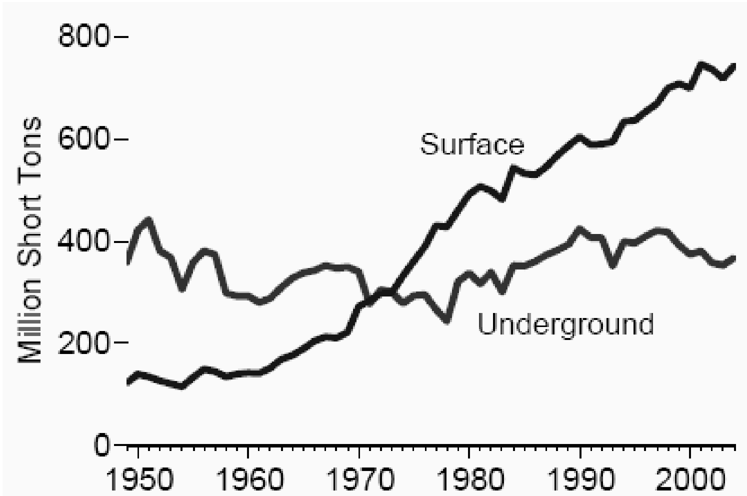
Table 3-5: Largest U.S. Coal Mines by Production, 2004

Rank	Mine Names/Company	Mine Type	State	Production (short tons)
1	North Antelope Rochelle Comple/Powder River Coal Company	Surface	Wyoming	82,471,922
2	Black Thunder/Thunder Basin Coal Company LLC	Surface	Wyoming	72,220,213
3	Cordero Mine/Cordero Mining Co.	Surface	Wyoming	38,743,666
4	Jacobs Ranch Mine/Jacobs Ranch Coal Company	Surface	Wyoming	38,548,799
5	Antelope Coal Mine/Antelope Coal Company	Surface	Wyoming	29,682,854
6	Caballo Mine/Caballo Coal Company	Surface	Wyoming	26,480,950
7	Eagle Butte Mine/Rag Coal West, Inc.	Surface	Wyoming	23,004,687
8	Buckskin Mine/Triton Coal Company	Surface	Wyoming	20,266,859
9	Belle Ayr Mine/Foundation Coal West Incorporation	Surface	Wyoming	18,704,482
10	North Rochelle/Triton Coal Company LLC	Surface	Wyoming	15,234,753
	Top-10 Total **U.S. Total**			**365,359,185** **1,112,098,870**

Energy Information Administration, Annual Coal Report 2004
(http://www.eia.doe.gov/cneaf/coal/page/acr/acr_sum.html)

Figure 3-11 shows the change over time in producing surface versus underground coal—as the amount of coal mined in the West, especially in Wyoming, increased, so did the relative amount of surface mining. In 1963 just 33 percent of American coal came from surface mines; by 1973 that figure reached 60 percent. As coal production shifted to the West with the onset of the Clean Air Act, similarly nationwide production converted from predominantly underground mining to surface mining.

Figure 3-11: U.S. Coal Production by Mining Method



(http://www.eia.doe.gov/emeu/aer/ep/ep_frame.html)

In addition to having its coal industry sparked by the Clean Air Act, Wyoming's coal production in turn has indirectly helped the railroad business tremendously. Wyoming has just four railroads in the state, placing it 46th in the nation (only exceeding the District of Colombia, Nevada, Alaska, Rhode Island, and Hawaii). It is 33rd in terms of total rail miles in the state, 25th in rail employment by state. Despite these paltry rankings, it is first both in origin of rail carloads and origin of rail tons by state. By weight, Wyoming has over 3.5 times the number of tons of freight as the second-highest state, West Virginia. With such great loads (over 420 million tons) coming from Wyoming, it is 34th in the nation in termination of rail tons, at just over 16 million tons of cargo. These heavy, numerous shipments are almost all leaving the state; less than 4 percent of Wyoming's shipments, by weight, remain within its borders.

As it was detailed earlier in the chapter, coal is responsible for over 40 percent of the total railroad shipments in the United States each year. Coal accounts for over 95 percent of Wyoming's total shipments by rail, and the approximately 400 million tons of coal shipped from Wyoming in 2004 comprised 48.9 percent of the nation's total coal shipments, by state of origin. Therefore, in 2004, the coal shipments from Wyoming alone provided over one-fifth of the total railroad business in the United States that year! (National Mining Association and the Association of American Railroads)

Abandoned Mine Lands

The United States Environmental Protection Agency currently defines abandoned mine lands as "those lands, waters, and surrounding watersheds contaminated or scarred by extraction, beneficiation or processing of ores and minerals, including phosphate but not coal. Abandoned mine lands include areas where mining or processing activity is temporarily inactive" (U.S. EPA, http://www.epa.gov/superfund/programs/aml/basicinf.htm).

While the U.S. EPA does not address the environmental problems resulting from abandoned coal mines, the environmental impact of these abandoned mines can be quite severe. Some of the environmental and public health hazards include acid mine drainage, clogged steams and stream lands, dangerous highwalls and vertical openings, dangerous impoundments, hazardous equipment or facilities, industrial and residential waste, surface burning, underground mine fires, and vertical openings. Acid mine drainage concerns water that is discharged from a mine that, as a result of dissolved ions from the mineral or ore being mined, results in acidic water. The sulfur found in coal causes water to become more acidified and if the water enters local waterways, it can lead to a degradation of those natural systems and the biological activity therein. Clogged streams involve the runoff from abandoned mines carrying silt and debris that can block the original flow of the stream. This can result in physical barriers for the biota, as well as flooding surrounding areas, either natural or manmade. When piles of mine waste are left alone, they can also block the previous flow of water in the watershed. If the piles (or holes) are in a common path to the stream, they can lead to the deposition of chemicals that may harm the stream system. Dangerous highwalls are the steep faces after the last cut into the mine. If left alone, an open pit remains and can cause injury or death to a person who may not realize the danger. Vertical openings, if they are not properly sealed, create dangerous, steep shafts that are hazardous to a nearby population. Impoundments hold a large amount of water from a mining operation. They can be dangerous, however, because if they rupture, rapid flooding and toxic runoff can quickly enter vital areas to both humans and the natural biota. Abandoned equipment can pose a physical threat to a local population if not contained and protected properly. Also, there are instances where abandoned mines are used for the disposal of residential or industrial waste or trash burning. Unmonitored disposal of wastes can lead to further toxic runoff and harmful fume emission. Surface burning and underground mine fires include the problems gas emission from a source that may include numerous toxic chemicals. If this combustion is close to a populated area, there can be many negative health ramifications. (National Association of Abandoned Mine Land Programs)

The U.S. EPA is able to explicitly define its role in cleaning mines as excluding coal mines because there is another organization responsible for the remediation of abandoned *coal* mines. Clearly the potential harm from abandoned coal mines can be severe and varied, and since 1977, the Department of the Interior has been responsible for the remediation of coal mines. Interestingly, just four days before the passage of the 1977 Clean Air Act Amendments, the Surface Mining Control and Regulation Act

(SMCRA) was passed on August 3, 1977. The passage of both laws within a single week seems more than coincidental; the very success of the Clean Air Act is dependent, at least in part, on the compliance by all states. This includes those states that are harmed financially by the new regulations that are more likely to handle having to close mines when there is such a large fund from which they can draw. In evaluating the Clean Air Act, it becomes necessary to note that some of the clean-up effort is coming from a different policy in a different governmental agency, so all of the successes cannot be attributed solely to the CAA.

Through the Department of the Interior, SMCRA serves to help regulate and mitigate environmental damages that result from coal mining. With the passage of SMCRA in 1977, two programs were created: one that addresses current coal mining operations, and the other that deals with abandoned mines. The Office of Surface Mining was created within the Department of the Interior to help oversee the state regulatory initiatives along with their reclamation programs. (http://www.osmre.gov/osmreg.htm) The mission statement of the Office of Surface Mining and Enforcement is to:

> Carry out the requirements of the Surface Mining Control and Reclamation Act in cooperation with States and Tribes. Primary objectives are to ensure that coal mines are operated in a manner that protects citizens and the environment during mining and assures that the land is restored to beneficial use following mining, and to mitigate the effects of past mining by aggressively pursuing reclamation of abandoned coal mines. (http://www.doiu.nbc.gov/orientation/osm2.cfm)

The Abandoned Mine Land Reclamation Program was created by Title IV of the Surface Mining Law to provide aid for mines that were closed (abandoned) prior to the passage of the act in 1977. Before President Carter signed it into law in 1977, it had been vetoed twice previously by President Ford, in 1974 and 1975. Ford believed the law would "harm the coal industry, increase inflation, and restrict the energy supply" (http://en.wikipedia.org/wiki/Surface_Mining_Control_and_Reclamation_Act_of_1977). Coal production is such an integral process in providing energy for the nation, and the president feared this piece of legislation would harm an industry that would in turn cause ramifications in other economic markets. Nonetheless, the regulation passed in the next president's term, and it helps achieve some of the remediation needs that resulted from the Clean Air Act.

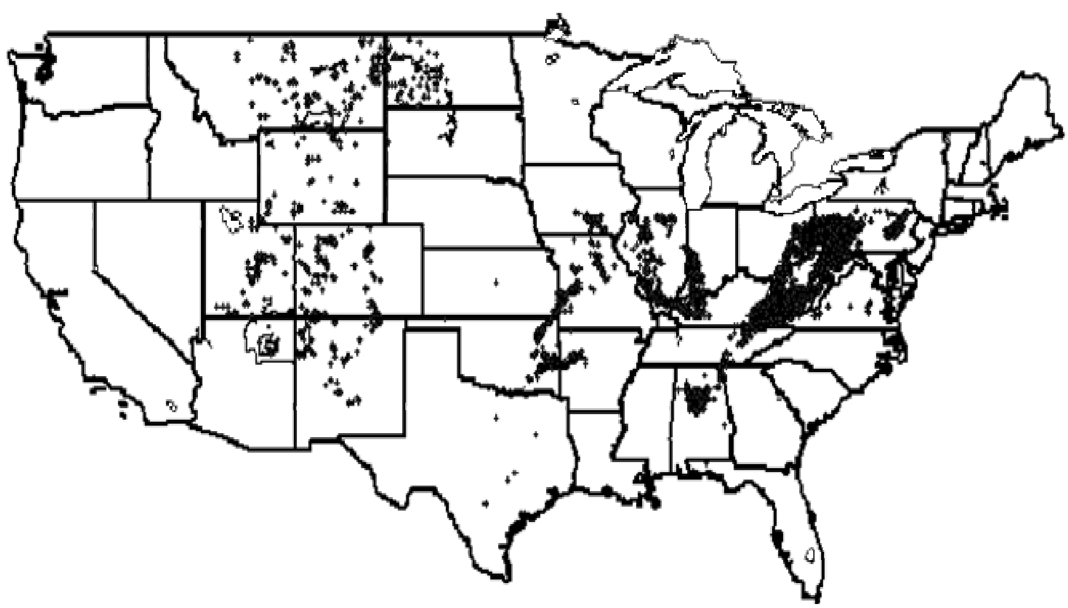
Money is collected into the Abandoned Mine Land (AML) fund through a fee per unit of coal mined. It costs a coal producer 35 cents per ton of surface coal mined, 15 cents per ton of underground coal mined, and 10 cents per ton of lignite coal mined. Half of the fees collected are earmarked for the state in which the producer is located, and the other half is split between the most severe problems. The dangers of the abandoned mines are divided into priority levels, where Priority 1 and Priority 2 sites are those that will receive funds before the monies are allocated to other programs. Priority 1 involves the "the protection of public health, safety, general welfare, and property from extreme danger of adverse effects of mining practices or a condition that could reasonably be expected to cause substantial physical harm to persons or property, and to which persons or improvements on real property are currently exposed" and Priority 2 concerns "the protection of public health, safety and general welfare from adverse effects of mining practices or a condition that is threatening people but is not an extreme danger" (Abandoned Mine Land Program definitions, http://www.osmre.gov).

As of September 30, 2005, nearly $5.8 billion had been allocated by Congress to states and Indian territories, and almost $7.5 billion had been collected into the Abandoned Mine Land fund (http://www.osmre.gov/fundstat.htm). The Surface Mining Control and Regulation Act was intended to target areas where coal mining has significantly harmed the surrounding land or water. In the ranking of the problems, extra weight is given to abandoned mines that have harmful impacts on local waterways. (http://www.osmre.gov/acsiplan.htm)

An additional component of the AML Fund is the "historical production" account. Twenty percent of the total Abandoned Mine Reclamation Fund must be allocated to states in proportion to the historical amount each state or tribe produced coal before 1977. This stipulation exists because the Office of Surface Mining reports that there is a strong correlation between "the severity of abandoned mine land problems in a state and the amount of coal that was removed before the enactment of the Surface Mining Law" (http://www.osmre.gov/annualreports/04aml.pdf). If, however, an area completes all of its reclamation programs, it is no longer eligible for this portion of the Fund. In addition, ten percent of the Fund is earmarked to the Department of Agriculture and its administration of the Rural Abandoned Mine Program. The last twenty percent of the Fund that is not required to remain within the producing state is used for federal programs, including the federal Emergency Program, the federal High-Priority Program, the Clean Streams Program, the Small Operator Assistance Program, and overall program administrative costs (Office of Surface Mining, Abandoned Mine Land Program Overview, 2001).

In 2003, a study conducted by the Office of Surface Mining estimated that, despite the amount of money already invested in remediation projects, there are still approximately 3.5 million Americans that live within one mile of health and safety hazards resulting from abandoned coal mines. Figure 3-12 illustrates the areas of the country that are considered "high priority" coal-related problems. "The unreclaimed high priority problems are quite concentrated in a few states. Eight states (Pennsylvania, West Virginia, Kentucky, Kansas, Virginia, Ohio, Oklahoma, and Illinois) account for 95 percent of these problem costs" (http://www.osmre.gov/aml/remain/zintroun.htm). The problem areas are located in states that had higher historical coal production levels and have lately been out-competed by the cleaner producers in the West, thereby abandoning some of the mines that were historically used in producing coal.

Figure 3-12: Abandoned Mine Land High Priority Areas



(Office of Surface Mining and Enforcement, http://www.osmre.gov/aml/inven/usmap.gif)

In a 2003 white paper, the Office of Surface Mining indicated the number of people in each state that are potentially at risk of the high-priority abandoned coal mines. The values are given for residents living within a ½-mile radius as well as a one-mile radius of a Priority 1 or 2 hazard in Table 3-6. States with a high historical production level (namely the largest eastern producers) have the highest risk rates. The lower rates are in areas with lower population densities as well as less historic coal production.

Table 3-6: People Potentially Harmed by Priority 1 and 2 AML Hazards

State	People Potentially at Risk-1/2 Mile	People Potentially at Risk-1 Mile
Alabama	27,469	100,383
Alaska	148	596
Arkansas	4,490	17,782
Colorado	24,185	32,196
Illinois	49,331	101,348
Indiana	9,410	24,432
Iowa	3,440	11,602
Kansas	15,157	57,023
Kentucky	114,228	402,001
Louisiana	0	0
Maryland	9,161	30,969
Missouri	14,958	36,127
Montana	1,157	4,591
New Mexico	987	3,964
North Dakota	594	2,368
Ohio	56,626	169,198
Oklahoma	18,455	55,611
Pennsylvania	527,120	1,649,959
Tennessee	13,694	42,505
Texas	875	2,867
Utah	324	1,297
Virginia	47,932	140,577
Washington	9,280	16,255
West Virginia	265,758	693,161
Wyoming	2387	9,716
Cheyenne River	3	11
Crow Tribe	5	18
Hopi Tribe	0	0
Navajo Nation	42	166
Windriver	4	19
Total/Average	1,217,220	3,606,742

(Office of Surface Mining and Enforcement, White Paper on "People potentially at risk from Priority 1 and 2 AML hazards")

While the intent of Surface Mining Control and Regulation Act was to work specifically on the high-priority, very dangerous areas, the trend has shifted in recent years. States that can confirm that all of their coal reclamation programs have been completed are eligible to use their state monies for other non-coal remediation programs. Louisiana, Montana, Texas, Wyoming, the Hopi Tribe, and the Navajo Tribe have all finished their emergency reclamation projects. Therefore, additional funds these states and tribes receive from the Abandoned Mine Land Fund can be used to mitigate degradation on non-coal lands.

At the onset of the legislation, the majority of the funding came from the areas that had the greatest abandoned mine land problems. Initially, 75 percent of money was raised from the eastern states, where 94 percent of the AML problems were located, while 25 percent of the funds came from the West, home to just 6 percent of the harmful areas. As coal mining has shifted westward since the enactment of the Clean Air Act, the fees collected have also moved from areas that once had historically high production (and therefore, greater current abandoned mine problems), and into areas with few—or zero—remaining abandoned mine problems. Between 1977 and 1993, about 99 percent of state money was used on abandoned coal mines, of which 95 percent were high-priority areas. Between 1994 and 2002, the use of state grant money was reduced to 71 percent for abandoned coal mines and 64 percent of that total was used for the high-priority abandoned coal mine sites. Seventy-one percent of the current Fund balance is designated to western states, so this trend of a reduced proportion of AML Funds being spent on coal mines and high priority coal mines will likely continue. (Office of Surface Mining AML Annual Report 2004)

Table 3-7 provides the total 2002 grant distribution and indicates the per capita at risk amount of funding by state and tribe. The four states and two tribes that have since claimed to be finished with Priority 1 and 2 remediation problems (Louisiana, Montana, Texas, Wyoming, the Hopi Tribe, and the Navajo Tribe) received amounts in the thousands of dollars per person within ½ mile of the hazard. (Louisiana and the Hopi Tribe already had zero people at risk, so grant money per person is listed as zero, though technically it is infinite.) Other states with very large per-capita funds are Alaska, New Mexico, North Dakota, Utah, and the Crow Tribe. These states and tribes have low population densities and very low historic mining rates. Since the AML Fund includes a guarantee that states will receive back money, and it includes a program specifically for Indian tribes, a disproportionate amount of money is allocated to these groups.

Table 3-7: Grant Funds Spent on People Potentially Impacted by AML Hazards

State	Total FY 2002 State/Tribal Grant Distribution	Grant Funds Per Person-1/2 Mile	Grant Funds Per Person-1 Mile
Alabama	$3,751,100	$137	$37
Alaska	$1,525,000	$10,304	$2,559
Arkansas	$1,515,000	$337	$85
Colorado	$2,537,574	$105	$79
Illinois	$10,093,413	$205	$100
Indiana	$5,744,338	$610	$235
Iowa	$1,673,253	$486	$144
Kansas	$1,965,000	$130	$34
Kentucky	$16,759,599	$147	$42
Louisiana	$99,758	$0	$0
Maryland	$1,663,769	$182	$54
Missouri	$1,722,031	$115	$48
Montana	$3,736,665	$3,230	$814
New Mexico	$1,834,749	$1,859	$463
North Dakota	$1,600,000	$2,694	$676
Ohio	$8,520,317	$150	$50
Oklahoma	$1,713,135	$93	$31
Pennsylvania	$27,176,830	$52	$16
Tennessee	$4,351,000	$318	$102
Texas	$1,584,087	$1,810	$553
Utah	$1,629,570	$5,030	$1,256
Virginia	$5,328,704	$111	$38
Washington	$614,210	$66	$38
West Virginia	$25,356,855	$95	$37
Wyoming	$28,659,989	$12,007	$2,950
Cheyenne River	$0	$0	$0
Crow Tribe	$550,551	$110,110	$30,586
Hopi Tribe	$428,219	$0	$0
Navajo Nation	$241,477	$5,749	$1,455
Windriver	$0	$0	$0
Total/Average	$162,376,193	$133	$45

(Office of Surface Mining and Enforcement, White Paper on "People potentially at risk from Priority 1 and 2 AML hazards")

Wyoming, although it receives the highest per capita funding of any state, has invested the most money into the system. By charging a greater per-unit fee for surface mining than for underground mining, miners in the West will pay the larger fee for a larger percentage of their coal mined than the East, the region that is split more evenly between surface and underground coal mining. In 2004, for example, Wyoming paid over $135 million in fees and received back for state projects about $30 million. From 1978 to 2004, Wyoming had received federal emergency money for 38 reclamation projects, which is less than .1 percent of the total number of federally-funded emergency reclamation needs. With 2501 total federally funded emergency projects through 2004, Pennsylvania accounted for over 52 percent of the total number of emergency programs.

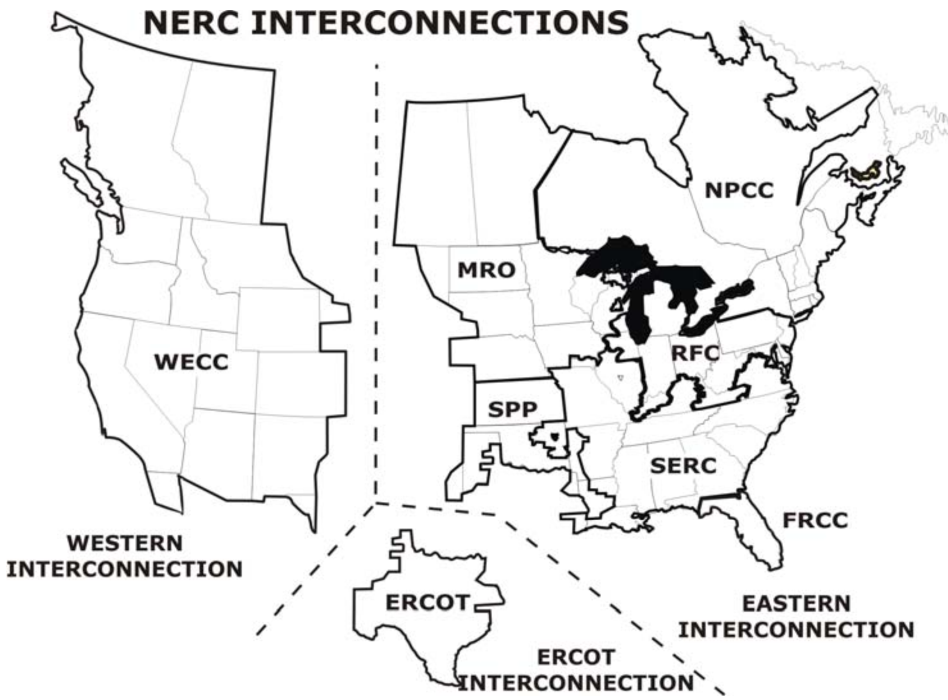
Energy Distribution over Time

Rather than transport coal long distances, it is important to determine whether other alternatives to converting to lower-sulfur coal are possible. In addition to physically moving coal, transmitting electricity is another way to provide adequate energy needs for the population. Is it possible then, instead of shipping large amounts of coal long distances, that the legislation instead promoted more power plants to open in the West that could then ship electricity to the East?

There has been an increase in the quantity of power providers over time, but due to the existing power grid structure, the new plants could not be built in the West to transmit power to the East. "A critical early decision to rely on alternating current (AC) technologies for high-voltage transmission has led to the construction of three major interconnected power systems: the Eastern and Western Interconnections, and the Electric Reliability Council of Texas" (http://www.pi.energy.gov/pdf/library/TransmissionGrid.pdf, p. 2).

Figure 3-13 depicts these three primary divisions within the U.S. electricity system. The West, East, and most of Texas each control the energy within each respective area. While energy transmission within one of these larger regions is fairly easy, the three systems are relatively disconnected, and energy transfers between them are much less common. Physically, the capacity to move large amounts of electricity between the interconnections does not exist.

Figure 3-13: North American Electricity Transmission Systems



(North American Electric Reliability Council, http://www.nerc.com/regional/NERC_Interconnections_BW.jpg)

These interconnections were formed to help regulate the flow of electricity from suppliers to consumers. Since the transmission of high-voltage energy over long distances involves decreases in energy efficiency (due to losses of energy to heat), the three main regions were established to control energy flow while maximizing energy efficiency within each area. Also, any disturbance or problem within an individual interconnection is felt almost simultaneously throughout the whole region. The question still exists, then, as to whether there should be more cooperation today between the interconnections. Furthermore, is there a way to approximate some of the costs incurred in this process?

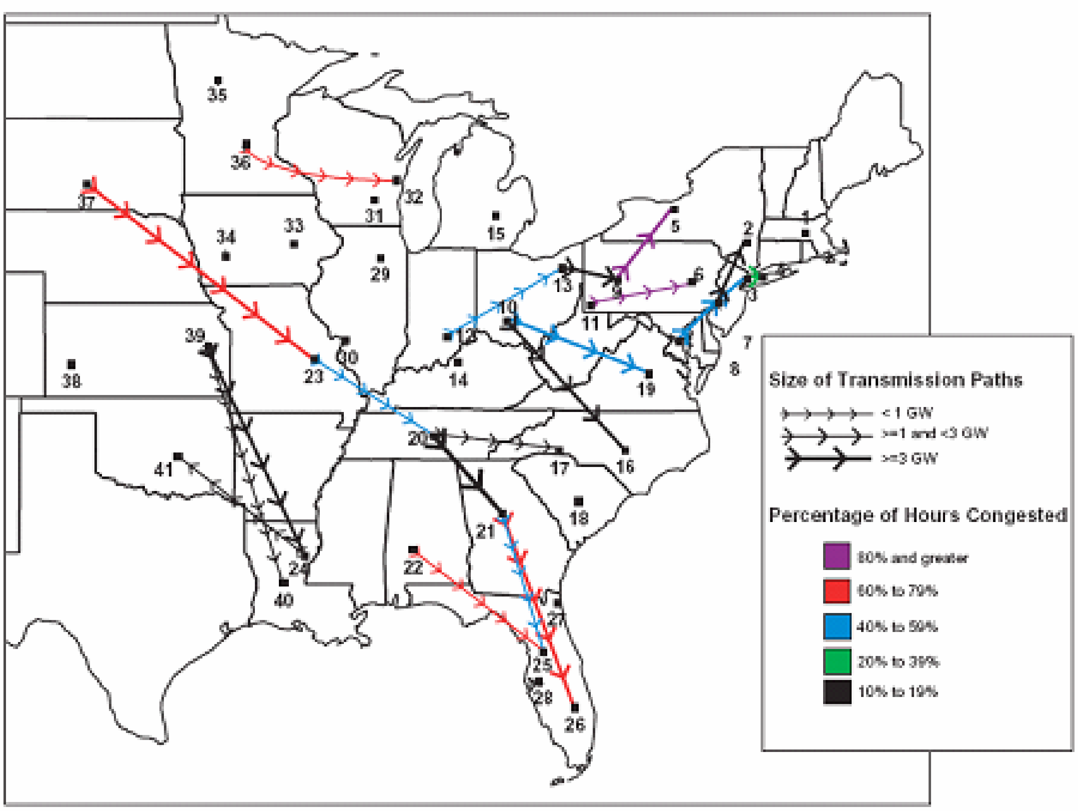
For example, in 1999, the Texas Public Utility Commission did a study to determine the cost of connecting the ERCOT (see Figure 3-13) with the Eastern Interconnection. Aside from issues that would inevitably arise with jurisdiction problems, the preliminary estimates on the costs to physically connect some of the Texas plants with those in the Southwest Power Pool within the Eastern Interconnection would be between about 300 and 350 million 1997 U.S. dollars. This is not to say that increased connectivity is too financially burdensome; rather, it is important to realize the difficulty in converting the current system to one that is more interconnected.

The National Electric Reliability Council (NERC) was formed voluntarily in 1968 by the electric utility industry to better-guard against large scale, regional energy problems. Management of electricity in a region or sub-region was divided so more localized management of energy transmission was possible. The Public Utility Regulatory Policies Act of 1978 (PURPA) was enacted to give smaller electricity providers a better chance of entering the highly regulated electricity industry. It helped set the stage for some of the future deregulation in the following decades. As the amount of competition in the electric industry continues to increase (as it already has due to deregulation of the industry and the movement towards more privately-owned firms), there will be an increased pressure to remove further boundaries.

Smaller, newer firms used to have difficultly being connected to a regional system. In 1996, however, the Federal Energy Regulatory Commission (FERC) created new rules, 888 and 889, that would give more equitable access to buyers and sellers of electricity, regardless of firm size and location. Despite the changes to the industry that have increased its competitive nature, there still seem to be some barriers to nationwide energy transmission. It is important for future researchers to determine if these physical boundaries between interconnections are beneficial to the industry or if they create unnecessary costs. (http://www.eia.doe.gov/cneaf/electricity/page/prim2/toc2.html) Do the decreases in energy loss due to intrinsic efficiency issues with energy transmission and the ability to have more local control of electricity transmission which would otherwise be far more burdensome at a nationwide level outweigh the costs of increased regulation? Intrinsically, it would seem that greater connectivity between the interconnections would be desirable, but we must ensure that the resulting congestion due to new electricity corridors would not cause greater costs than currently exist with the fragmentation of energy distribution in the nation.

With an increased demand for energy by the large populations in the East, a problem called grid congestion has occurred. When the electricity system is overloaded, there are transmission and distribution energy losses. In 1970, distribution losses were approximately 5 percent, and by 2001, they had increased to 9.5 percent. (http://www.energetics.com/gridworks/grid.html) These result both from an increased power demand and from the increase in transmission needs through the power grid system. Figures 3-14 and 3-15 are part of the 2002 Department of Energy's "National Transmission Grid Study" and they show the congestion paths and relative size of grid congestion in the East and West. Eastern congestion tends to be a problem as energy is transmitted further east and western congestion problems are mostly due to energy needs of southern California. "The highest levels of congestion [in the East] are found along transmission corridors from Minnesota to Wisconsin, the Midwest into the Mid-Atlantic, from the Mid-Atlantic to New York, and from the Southeast into Florida" (National Transmission Grid Study, p. 11-12).

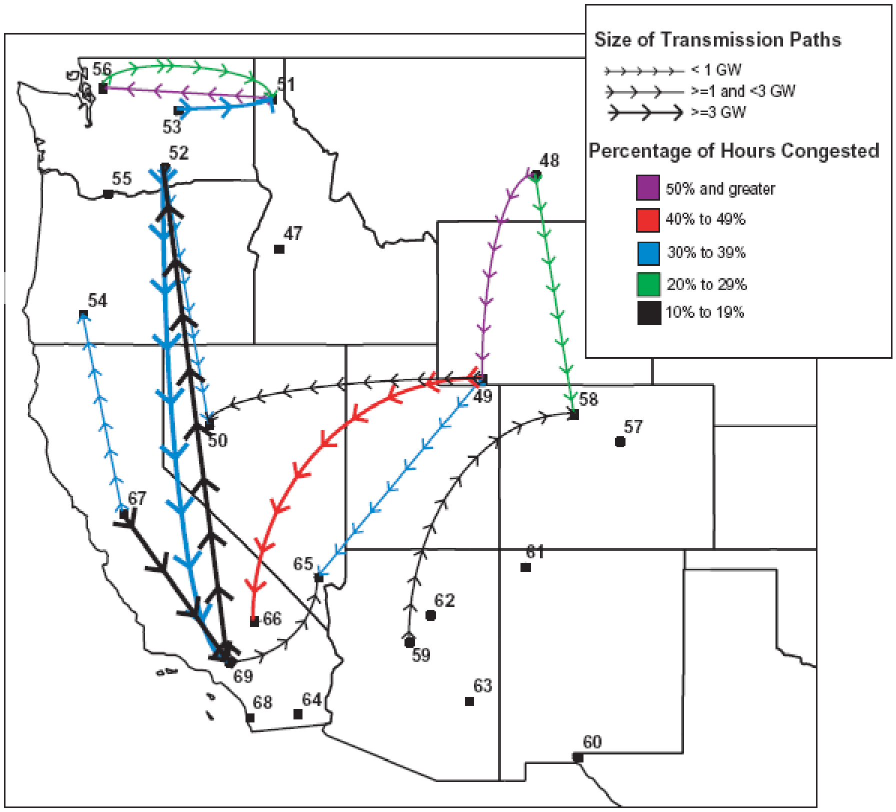
Figure 3-14: 2001 Energy Grid Congestion in the Eastern Interconnection



(http://www.pi.energy.gov/pdf/library/TransmissionGrid.pdf, page 12)

While the western interconnection also experiences some congestion, it was built initially with the intent of shipping energy long distances. Power plants were built in remote locations and power was to be moved. The Pacific Northwest provides most of its energy from hydroelectric power. The energy supply from this area is greatest in spring and summer, after the snow melts. During these seasons, excess energy is transmitted further south, primarily to the densely populated areas in California. The Pacific Northwest demands most of its energy in the colder months, and in the winter, it receives its energy from other areas in the larger region. This seasonal (and constant) movement of energy has always been the goal of the western grid, so congestion tends not to be as bad in the West as it is in the East. (U.S. Department of Energy, "National Transmission Grid Study")

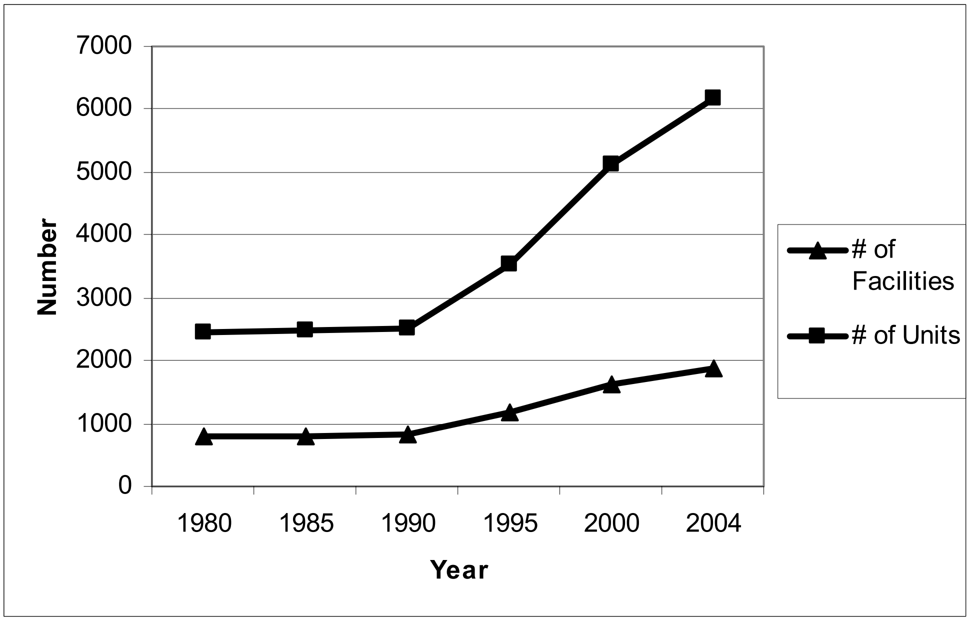
Figure 3-15: 2001 Energy Grid Congestion in the Western Interconnection



(http://www.pi.energy.gov/pdf/library/TransmissionGrid.pdf, page 15)

In looking at the number of electric facilities and units over time, it is clear that, while energy congestion has increased, so have the number of facilities. A facility is the registered energy producer or firm; within the facility, there can be several "units" that actually produce the energy, such as the type of boiler or turbine used to burn coal. Figure 3-16 shows that before 1990, the number of power plants was relatively constant, but there was a large increase around 1990. This corresponds with the 1990 Clean Air Act Amendments. The 1992 Energy Policy Act has also served to increase competition within the electric industry through deregulation, but not all states have decided to take part in the restructuring of the electricity industry.

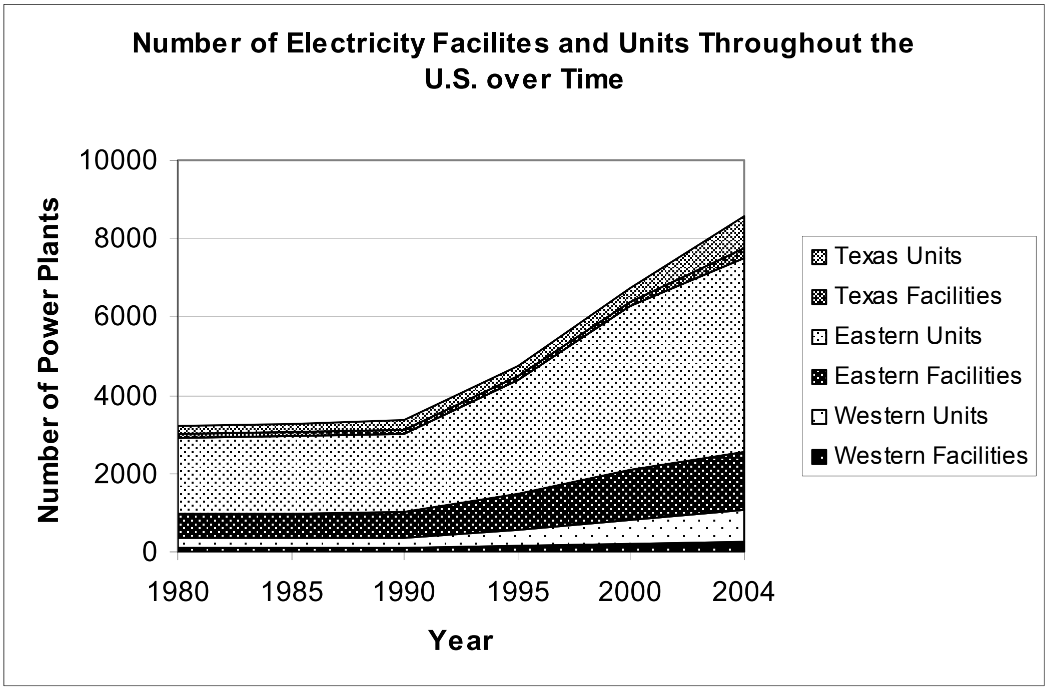
Figure 3-16: The Number of U.S. Electric Facilities and Units from 1980-2004



(data from U.S. EPA Clean Air Markets Division, Data Trends and Maps)

While the aggregate number of facilities and units has increased in recent years, the relative increases have varied throughout the nation. The share of eastern facilities in the total market has always far exceeded that of the West or Texas. Furthermore, starting in 1990, the number of facilities in each grid region increased, but the degree to which the increase occurred in the East was much larger than the other two regions. To provide energy for the large population in the East, facilities had to be built in the East as opposed to a different region of the country that could ship the energy to the larger populations. Figure 3-17 shows the number of electric facilities and units in the United States from 1980-2004 divided into the three primary grid regions. Although the increase in facilities in the East was much larger than the other areas, the relative increase in facilities within each eastern region was relatively constant. The market share of the eight eastern sub-regions did not change much, though the total number of facilities and units has been greatest in the east central (ECAR) and southeastern (SERC) areas.

Figure 3-17: Number of United States Electricity Facilities and Units by Interconnection, 1980-2004



(data from U.S. EPA Clean Air Markets Division, Data Trends and Maps)

Evidently, the number of facilities has increased over time, as the population and demand for energy have continued to grow. However, the United States is limited in its capacity to move electricity between the three distinct interconnected electricity grid systems. Conceivably, if these systems were more interconnected between each other (not just within themselves), the need to ship coal long distances would not have been as substantial. Both the Clean Air Act Amendments and energy deregulation policies in the early 1990's seem to have influenced a large increase in power plant construction and capacity. Since many new facilities and units were built, the large investment in physical capital does not seem too steep to warrant the investment. The barrier of shipping electricity does seem to prevent more firms from opening where the cleaner coal deposits are located. (It is also important to recognize that many of the building materials and human capital are also likely more concentrated in the East, so materials and labor would need to be moved to build plants closer to the energy resources.)

Summaries

It is clear that there are many distributional changes of coal production and use since the inception of the Clean Air Act. The targeted regions, those that had the greatest base levels of pollution, seem to have changed their coal consumption behavior by shifting in part to western coal. Specific states, particularly Wyoming for production increases and Pennsylvania for production decreases, have altered coal mining substantially.

To accommodate changes in production, there are many other factors that have been influenced. Transportation distance has increased, and the Wyoming coal shipments are over 40 percent of total railroad shipments and 20 percent of total railroad revenues in 2004. The Clean Air Act, then, has not just served to decrease emissions; it has also stimulated the railroad industry.

A decrease in eastern coal production in the East necessitates closing mines that historically produced coal. In response to closing mines, the Abandoned Mine Land Fund was created in 1977. The Department of the Interior is now responsible for cleaning areas that have degraded the environment and pose severe public health and safety problems. The fund has now received approximately $5 billion over time to combat current and historic coal mine degradation.

Although moving electricity as opposed to raw materials (coal) seems a feasible option, this has not actually occurred. The segmentation of the electricity grid system in the Untied States has prevented the movement of energy from the areas close to the cleanest and largest coal deposits in the West (Montana and Wyoming especially), and more units and facilities have instead been built closer to the areas that demand the electricity.

All of these influences are consequences at least to some degree of the Clean Air Act and its amendments, though with varying degrees of harms and benefits. It would be interesting to determine the degree to which the CAA caused these market and environmental changes, as well as speculate in greater detail how to overcome some of the challenges faced when designing an environmental policy that has so many additional influences in other natural sectors and markets.

CHAPTER FOUR

CONCLUSIONS

Overall, the Clean Air Act Amendments have been successful at achieving the intended goal: emission reduction in the United States. For the most part, sulfur dioxide emission levels in the targeted areas have decreased as well. However, there are a few areas of concern. Despite overall emission reductions, many of the regions that are responsible for large proportions of energy use are still using high-sulfur coal. Also, the increase in relative sulfur content of Interior coal over time is disconcerting. Focusing future efforts specifically on coal use, since it is directly related to emissions, in addition to energy use is a likely avenue for furthering emission reductions. Now that there have been significant reductions in emissions, the opportunity cost of further reductions is greater.

Although sulfur dioxide emissions have decreased (and very substantially), if the negative consequences of these industry changes are not being measured by those doing the policy assessments, then the relative benefits of the Clean Air Act may be over-quantified. Changes in transportation are indicative of the trends that result from the passage of this legislation. Although many of the impacts are still speculative, the recognition of the potential influences can help guide further research on permitting effects, both on the affected industry and on the ecological systems being targeted.

In addition to potential harms of increased transportation, the affect of the decreased production and sale of higher-sulfur coals should also be studied. Are unfair advantages given to the firms that produce lower-sulfur coal? Is the legislation effectively subsidizing the companies that have moved to the West, while shifting the old problem to other spheres? The trade-off between sulfur dioxide decreases and other environmental problems that result from the movement of industries, changes in job opportunities, and impacts on transportation, need much more research by experts and comprehensive studies.

Also, when determining the overall success of the Clean Air Act, it is important to take into account the costs that have resulted from its implementation. In this instance, the Abandoned Mine Land Fund was created in 1977 and is quite connected with the CAA. That this fund was needed as a direct consequence of the Clean Air Act—it is very unlikely that eastern firms would have shifted to western coal without the need to do so from legislation. Although promoted as cost-saving, analysts must recognize that these AML costs should be included as financial costs of the Clean Air Act, despite the fact that the closing of dirty mines may be the desired outcome.

The suspicion that the CAA may have stimulated the movement of power plants to the West, in addition to or in exchange for shipping western coal to the East does not seem to have occurred. The current electricity grid system does not permit the movement of electricity between the East and the West. It would be valuable to explore the relative costs and benefits, economically and environmentally, of building power plants in the East and West if the current natural restrictions on moving energy did not exist. Would more raw building materials and labor need to be moved than currently is shipped in the form of coal?

Although the trading system on the whole has been viewed as successful, the extent to which sulfur mitigation may contribute to carbon increases should also be considered. This is especially true since the lowest-sulfur coals have greater carbon contents. With potential future carbon sequestration programs riding on the success of the Clean Air Act, recognizing the impacts of one pollutant on the mitigation of another is critical. Other synergies should also be studied, including pollutant-pollutant, pollutant-ecosystem, and pollutant-industry effects.

Not all pollutants have been reduced as successfully as sulfur dioxide. Relative to SO_2 successes, nitrogen oxide programs have not fared as well. Whereas more than the majority of sulfur dioxide pollution can be attributed directly to coal-fired power plants, addressing nitrogen oxides is not nearly as simple. Since about 80 percent of the Earth's atmosphere is comprised of nitrogen, the burning of fuels for energy does not only have the capacity to emit nitrogen oxides; the burning also breaks air molecules to form even more nitrogen oxides. It is not impossible to still attempt to use permitting systems; however, a better understanding of the fundamental differences between the sources, results, and other differences between these two pollutants is needed. Only then can effective mitigation programs be designed with the full knowledge of the targeted areas and potential impacts of the designed policies.

In addition, more about the relatedness of environmental systems and economic markets should be studied. These relationships will help provide more information when designing new policies and amending old ones. Sample topics include the interconnectedness of air and water systems, the impact of one pollutant on the attempted mitigation of another, and clear industry shifts that may result from the inception of a new law. An example of this includes the links between sulfur dioxide pollution and either mercury or carbon dioxide emissions.

Ensuring that all externalities are measured in the sulfur dioxide mitigation program, as well as using specific regional impacts to dictate future policies can lead to further pollution mitigations. Using this sulfur dioxide program first, successes can be used to model changes to NO_x, mercury, and ultimately carbon dioxide programs. In order to do this, policy designers must keep in mind intrinsic differences about the different pollutants as well as their primary sources. While it is easiest to design permitting systems for point sources, such as electric utilities when mitigating sulfur dioxide, innovative methods to control pollution from disparate sources is also possible. The future for economic solutions to environmental problems is promising; we just need to ensure that the assessments are realistic and valid.

REFERENCES

Burtraw, Dallas, and Palmer, Karen, "The Paparazzi Take a Look at a Living Legend: The SO_2 Cap-and-Trade Program for Power Plants in the United States." *Resources for the Future*. April 2003. Discussion Paper 03-15. 1-7.

Butler, T. J., G. E. Likens & B.J.B. Stunder, 2001. Regional-scale Impacts of Phase I of the Clean Air Act Amendments in the USA: the Relation between Emissions and Concentrations, both Wet and Dry. *Atmospheric Environment*. 2001. *35*. 1015-1028.

Ellerman, Denny, "Note on the Seemingly Indefinite Extension of Power Plant Lives, a Panel Contribution." *Energy Journal*. March 1, 1998. *19*. 129-133.

Kalyoncu, Rustu, "Coal Combustion Products." *United States Geological Survey Mineral Yearbook*. 1998.

Kim, Janice J, "Ambient Air Pollution: Respiratory Hazards to Children." *Pediatrics*. December 2004. *114*. 1699-1707.

Koren, Hillel S, "Associations between Criteria Air Pollutants and Asthma." *Environmental Health Perspectives Supplements*. September 1995. *103*. 235-242.

Lynch, James A., Bowersox, Van C., and Grimm, Jeffrey W, "Acid Rain Reduced in Eastern United States." *Environmental Science Technology*. 2000. *34*. 940-949.

________________, "Changes in Sulfate Deposition in Eastern USA following Implementation of Phase I of Title IV of the Clean Air Act Amendments of 1990." *Atmospheric Environment*. 2000. *34*. 1665-1680.

Samet, Jonathan M., et al, "Fine Particulate Air Pollution and Mortality in 20 U.S. Cities," *New England Journal of Medicine*, 14 December 2000, *343*, 1742-1749.

Schmalensee, Richard, et al., "An Interim Evaluation of Sulfur Dioxide Emissions Trading." *Journal of Economic Perspectives*. Summer 1998. *12*. 53-68.

Stavins, Robert N, "What Can We Learn from the Grand Policy Experiment? Lessons from SO_2 Allowance Trading." *Journal of Economic Perspectives*. August 1, 1998. *12*. 69-88.

American Council for an Energy Efficient Economy, "Improve the Efficiency and Reduce the Emissions of the Existing Power Plant Fleet," http://www.aceee.org/energy/powerkey.htm.

American Lung Association, Air Quality Division, "Electric Utilities." April 2000, http://www.lungusa.org/site/pp.asp?c=dvLUK9O0E&b=23353.

Association of American Railroads, “Class I Railroad Statistics.” January 2006. http://www.aar.org/PubCommon/Documents/AboutTheIndustry/Statistics.pdf.

Britannica Student Encyclopedia, "Clean Air Act of 1990," 2004 Encyclopedia Britannica Premium Service, 21 November 2004, <http://www.britannica.com/ebi/article?tocId=9310724>.

Clean Air Act, full text, http://www.epa.gov/oar/caa/caa.txt.

"Clean Air Act," Microsoft® Encarta® Online Encyclopedia 2004 http://encarta.msn.com © 1997-2004 Microsoft Corporation. All Rights Reserved.

Clean Air Act Amendments, full text, http://www.epa.gov/oar/caa/caaa.txt.

Clean Air Council, “Clear the Air: National Campaign against Dirty Power,” 2003, http://www.cleanair.org/Air/clearTheAir.html.

Kentucky Educational Television, “COAL: Ancient Gift Serving Modern Man,” 2005, *American Coal Foundation,* Types of Coal. http://www.enviroliteracy.org/article.php/18.html.

Montana State Legislature, “Understanding Energy in Montana: A Guide to Electricity, Natural Gas, Coal, and Petroleum Produced and Consumed in Montana.” http://leg.state.mt.us/textonly/publications/lepo/2005_deq_energy_report/2005deqenergytoc.asp.

National Atmospheric Deposition Program, 2004 Annual Summary, http://nadp.sws.uiuc.edu/lib/data/2004as.pdf.

National Mining Association. http://www.nma.org.

North American Electric Reliability Council, “NERC Interconnections.” http://www.nerc.com/regional/NERC_Interconnections_BW.jpg.

"Surface Mining Control and Reclamation Act of 1977." *Wikipedia, The Free Encyclopedia*. 26 Jan 2006, 18:33 UTC. 17 Apr 2006, 17:37 <http://en.wikipedia.org/w/index.php?title=Surface_Mining_Control_and_Reclamation_Act_of_1977&oldid=36821296>.

United States Census Bureau, http://www.census.gov.

United States Department of Energy, “Annual Energy Review, 2003,” Energy Information Administration Report, 2003.

United States Department of Energy, "Coal Transportation: Rates and Trends in the United States, 1979-2001," Energy Information Administration Report, 2002.

United States Department of Energy, "National Transmission Grid Study," http://www.pi.energy.gov/pdf/library/TransmissionGrid.pdf. May 2002.

United States Department of Energy, "Electric Power Industry Overview." http://www.eia.doe.gov/cneaf/electricity/page/prim2/toc2.html

United States Department of Energy, Office of Electricity Delivery and Energy Reliability, "Overview of the Electric Grid." http://www.energetics.com/gridworks/grid.html

Unites States Environmental Protection Agency, Office of Air and Radiation, http://www.epa.gov/air/data/reports.html.

United States Environmental Protection Agency, Office of Surface Mining, http://www.osmre.gov/osmreg.htm.

United States Environmental Protection Agency, "Janet Reno's November 3, 1999 Speech on the Coal-Fired Power Plant Enforcement Initiative" http://www.epa.gov/compliance/civil/programs/caa/coal/reno.html.

APPENDIX A: Major U.S. Coal Mines in 2004 by Production

Rank	Mine Names/Company	Mine Type	State	Production (short tons)
1	North Antelope Rochelle Comple/Powder River Coal Company	Surface	Wyoming	82,471,922
2	Black Thunder/Thunder Basin Coal Company LLC	Surface	Wyoming	72,220,213
3	Cordero Mine/Cordero Mining Co.	Surface	Wyoming	38,743,666
4	Jacobs Ranch Mine/Jacobs Ranch Coal Company	Surface	Wyoming	38,548,799
5	Antelope Coal Mine/Antelope Coal Company	Surface	Wyoming	29,682,854
6	Caballo Mine/Caballo Coal Company	Surface	Wyoming	26,480,950
7	Eagle Butte Mine/Rag Coal West, Inc.	Surface	Wyoming	23,004,687
8	Buckskin Mine/Triton Coal Company	Surface	Wyoming	20,266,859
9	Belle Ayr Mine/Foundation Coal West Incorporation	Surface	Wyoming	18,704,482
10	North Rochelle/Triton Coal Company LLC	Surface	Wyoming	15,234,753
11	Freedom Mine/The Coteau Properties Company	Surface	North Dakota	15,208,281
12	Rosebud #6 Mine & Crusher & Conv/Western Energy Company	Surface	Montana	12,664,823
13	Spring Creek Coal Company/Spring Creek Coal Company	Surface	Montana	12,068,328
14	Enlow Fork Mine/Consol Pennsylvania Coal Company	Underground	Pennsylvania	10,218,960
15	Bailey Mine/Consol Pennsylvania Coal Company	Underground	Pennsylvania	10,133,685
16	Foidel Creek Mine/Twentymile Coal Company	Underground	Colorado	8,557,741
17	McElroy Mine/McElroy Coal Company	Underground	West Virginia	8,357,061
18	Decker Mine/Decker Coal Co.	Surface	Montana	8,241,467
19	Kayenta/Peabody Western Coal Company	Surface	Arizona	8,180,942
20	Navajo Mine/BHP Navajo Coal Company	Surface	New Mexico	7,990,021
21	San Juan South/San Juan Coal Company	Underground	New Mexico	7,685,041
22	Falkirk Mine/The Falkirk Mining Company	Surface	North Dakota	7,578,153
23	Sufco/Canyon Fuel Company	Underground	Utah	7,568,276

	LLC			
24	Rawhide Mine/Caballo Coal Company	Surface	Wyoming	6,869,989
25	Elk Creek Mine/Oxbow Mining, LLC	Underground	Colorado	6,551,034
26	Galatia Mine/The American Coal Company	Underground	Illinois	6,517,541
27	West Elk Mine/Mountain Coal Company LLC	Underground	Colorado	6,493,363
28	Absaloka Mine/Washington Group International	Surface	Montana	6,474,339
29	Jewett Mine/Texas Westmoreland Coal Co.	Surface	Texas	6,456,625
30	Robinson Run No 95/Consolidation Coal Company	Underground	West Virginia	6,245,830
31	Sandow Mine/Alcoa Incorporated	Surface	Texas	6,105,182
32	Oak Hill Strip/TXU Mining Company LP	Surface	Texas	5,975,453
33	Century Mine/American Energy Corporation	Underground	Ohio	5,820,654
34	Mckinley/Pittsburg & Midway Coal Mining	Surface	New Mexico	5,799,112
35	Lee Ranch Coal Co/Lee Ranch Coal Company	Surface	New Mexico	5,775,777
36	Emerald Mine No. 1/Emerald Coal Resources, LP	Underground	Pennsylvania	5,768,397
37	Blacksville No 2/Consolidation Coal Company	Underground	Pennsylvania	5,718,668
38	Centralia Coal Mine/Trans Alta Centralia Mining LLC	Surface	Washington	5,653,221
39	Jim Bridger Mine/Bridger Coal Company	Surface	Wyoming	5,597,531
40	Beckville Strip/TXU Mining Company LP	Surface	Texas	5,560,732
41	Colowyo Mine/Colowyo Coal Company L P	Surface	Colorado	5,435,256
42	Cumberland Mine/Cumberland Coal Resources, LP	Underground	Pennsylvania	5,194,971
43	Loveridge No 22/Consolidation Coal Company	Underground	West Virginia	4,970,733
44	Federal No 2/Eastern Associated Coal Corp	Underground	West Virginia	4,889,905
45	Samples Mine/Catenary Coal Company	Surface	West Virginia	4,790,415
46	Dotiki Mine/Webster County Coal LLC	Underground	Kentucky	4,780,111
47	Wyodak/Wyodak Resources Development Co	Surface	Wyoming	4,780,101

48	Black Mesa Mine/Peabody Western Coal Company	Surface	Arizona	4,549,887
49	Powhatan No. 6 Mine/The Ohio Valley Coal Company	Underground	Ohio	4,536,510
50	Dry Fork Mine/Dry Fork Coal Company	Surface	Wyoming	4,533,621
51	Kemmerer Mine/The Pittsburg & Midway Coal Mining	Surface	Wyoming	4,490,573
52	Hobet 21 Surface Mine/Hobet Mining, Inc.	Surface	West Virginia	4,417,418
53	Buchanan Mine #1/Consolidation Coal Company	Underground	Virginia	4,376,918
54	Big Brown Strip/TXU Mining Company LP	Surface	Texas	4,339,582
55	No 1 Surface/Alex Energy, Inc.	Surface	West Virginia	4,277,629
56	South Hallsville No 1 Mine/Sabine Mining Company	Surface	Texas	4,275,227
57	Farmersburg Mine/Black Beauty Coal Company	Surface	Indiana	4,267,613
58	Twilight MTR Surface Mine/Progress Coal	Surface	West Virginia	4,122,751
59	Center Mine/BNI Coal, Ltd.	Surface	North Dakota	4,103,859
60	Bowie Mine #2/Bowie Resources, LLC	Underground	Colorado	4,096,085
61	American Eagle Mine/Speed Mining Inc	Underground	West Virginia	4,095,165
	Subtotal			688,519,742
	All Other Mines			423,579,128
	U.S. Total			**1,112,098,870**

Note: · Major mines are mines that produced more than 4 million short tons in 2004. The company is the firm operating the mine.
Source: · Energy Information Administration Form EIA-7A, "Coal Production Report," and/or U.S. Department of Labor, Mine Safety and Health Administration, Form 7000-2, "Quarterly Mine Employment and Coal Production Report."

APPENDIX B: U.S. Population and Coal Demand by Region

U.S. Population

Region	1980	1990	2000	%change '80-'90	%change '90-'00
Northeast	49,136,816	50,809,229	53,594,378	0.0340	0.0548
Midwest	58,866,998	59,668,632	64,392,776	0.0136	0.0792
South	75,367,068	85,445,930	100,236,820	0.1337	0.1731
West	43,171,317	52,786,082	63,197,932	0.2227	0.1972
Total U.S.	226,542,199	248,709,873	281,421,906	0.0979	0.1315

Coal Demanded by Region (million short tons)

Region	1979	1987	1997	%change '79-'87	%change '87-'97
Northeast	29.4	37.4	36.4	0.2721	-0.0267
Midwest	165.9	241.3	219.7	0.4545	-0.0895
South	102.8	212.7	219.9	1.0691	0.0339
West	43.3	80	40.1	0.8476	-0.4988
Total U.S.	341.4	571.4	516.1	0.6737	-0.0968

(Data from U.S. Historic Census Data and the Energy Information Administration)