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MASTER

EFFECTS OF A FLEXIBLE DEFINITION OF NEW SOURCE
PERFORMANCE STANDARDS FOR UTILITY BOILERS
FIRING ANTHRACITE COAL

P-2973

September 1978

Prepared for

ANTHRACITE OFFICE
DEPARTMENT OF ENERGY
Washington, DC

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Master

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Prepared for

Dr. Jerry Pell
Anthracite Office
Department of Energy
Washington, DC

Prepared by

Barbara Buckley
Richard DeFieux
Robert Holzheimer
Sharon Lowenthal
Brian Murphy
Joel Watson

ENVIRONMENTAL RESEARCH & TECHNOLOGY, INC.
696 Virginia Road, Concord, Massachusetts 01742

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LIST OF ABBREVIATIONS

ATF	Anthracite Task Force
BACT	Best Available Control Technology
Conrail	Consolidated Rail Corporation
ICC	Interstate Commerce Commission
kw	kilowatt
kwh	kilowatt hours
Mw	megawatt
NSPS	New Source Performance Standards
PP&L	Pennsylvania Power and Light
PSNH	Public Service Company of New Hampshire
S	sulfur
SAMRP	State Abandoned Mine Reclamation Program
SO ₂	sulfur dioxide
tpy	tons per year

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1. INTRODUCTION

This study is intended to answer the following three questions.

- 1) Would a flexible interpretation of the proposed New Source Performance Standards/Best Available Control Technology (NSPS/BACT) requirements for new steam-electric generating plants make anthracite competitive as a boiler fuel in those plants?
- 2) If increased power plant demand for anthracite resulted in the opening of a large open-pit anthracite mine, would significant environmental benefits occur through the reclamation of previously mined lands?
- 3) What would be the socioeconomic benefits to eastern Pennsylvania due to increased use of anthracite?

The term "flexible interpretation" is used throughout this report to mean that an anthracite-fueled power plant built at a given location would be required to have sulfur dioxide (SO_2) emissions as low or lower than a bituminous-fueled power plant built at the same site. Because of the lower sulfur content of anthracite, a flexible interpretation would generally require less pollution control equipment for an anthracite plant than for a bituminous plant. For anthracite coal to be competitive, the economic advantage provided by the reduced requirement for pollution control equipment must overcome certain higher costs for mining and use of anthracite.

Section 2 discusses the present status of the anthracite industry in eastern Pennsylvania. Anthracite's place in the national energy plan and the geographic advantage of anthracite as an energy source for the northeastern United States is discussed in Section 3. Section 4 consists of an economic analysis of NSPS/BACT requirements on the anthracite industry. The potential for local environmental and socioeconomic benefits is discussed in Section 5. Conclusions are presented in Section 6.

2. DESCRIPTION OF PRESENT ANTHRACITE INDUSTRY AND MARKETS

Anthracite is a hard, black coal characterized by a high fixed-carbon content, low volatile-matter content, and low sulfur content. Anthracite has been mined in the United States for over 200 years and occurs in abundance in eastern Pennsylvania.

At present, anthracite accounts for only 1% of all coal mined in the United States (Manula et al. 1978). Anthracite production in Pennsylvania reached its peak in 1917, when over 100 million tons were mined. In the same year, 171,074,411 tons of bituminous coal were mined in Pennsylvania (Commonwealth of Pennsylvania Department of Environmental Resources 1977). In 1976, a total of 5,291,776 tons of anthracite coal were mined in Pennsylvania, compared to 85,747,874 tons of bituminous coal (Commonwealth of Pennsylvania Department of Environmental Resources 1977). Figure 2-1 shows production rates for Pennsylvania anthracite from 1870 through 1976; Figure 2-2 shows the anthracite consumption rate in the United States between 1955 and 1976. Both of these figures show a steady decline in the importance of anthracite.

Anthracite usage has dropped more than 90% in the past 40 years (Manula et al. 1978) for several reasons. Anthracite coal is generally more expensive to mine than bituminous coal because of difficult geologic conditions; environmental constraints have also limited production of anthracite. Between 1930 and 1940, management problems also contributed to anthracite's decline (Manula et al. 1978).

This section deals with the current status of the anthracite industry in Pennsylvania and discusses the availability of anthracite, mining methods currently in use, and markets using anthracite.

2.1 Location of Anthracite Reserves

It is estimated that 96% of the anthracite in the United States is located in Pennsylvania (Bureau of Mines 1975). In 1970, the Bureau of Topographic and Geologic Survey of the Commonwealth of Pennsylvania estimated that the state's remaining, in-place reserves of anthracite totaled 16 billion tons. These reserves are located in the eastern

Source: Commonwealth of Pennsylvania Department of Environmental Resources 1977.

Figure 2-1 Anthracite Production in Pennsylvania

Figure 2-2 United States Anthracite Consumption 1955 to 1976

Source: Anthracite Task Force 1977.

part of the state. Figure 2-3 shows the location of major anthracite and bituminous coal fields.

Pennsylvania's anthracite reserves are divided into four regional fields located in ten counties (Carbon, Columbia, Dauphin, Lackawanna, Lebanon, Luzerne, Northumberland, Schuylkill, Susquehanna, and Wayne). Information on each regional field is presented in Table 2-1. The anthracite reserves in these four fields are within 150 miles of one-eighth of the population of the United States.

In the Northern, Eastern Middle, and Western Middle Fields, nearly all of the remaining reserves are situated within 3,000 feet of the surface; in the Southern Field (where a proposed open-pit mine would be located), 75% of the remaining reserves are within 3,000 feet of the surface (Manula et al. 1978). Presently, most strip mining does not extend deeper than a few hundred feet (Bureau of Mines 1975). A proposed new open-pit mining method (described in Section 3) would reach a depth of nearly 1,000 feet below the surface (Manula et al. 1978).

The most extensive anthracite reserves are located in the Southern Field, where the anthracite beds are steeply inclined and are fractured by numerous faults. Often two or more beds merge, forming a single bed of great thickness. An example of this is the Mammoth Seam, which attains a maximum thickness of 30 to 50 feet in some places. This seam divides into other areas in separate "splits," each averaging in thickness from 8 to 10 feet (Manula et al. 1978).

Based on the estimates of available reserves, Pennsylvania's anthracite industry could produce enough coal at the 1917 (peak) rate of 100 million tons per year (tpy) for the next 35 years. At the current rate of 6 million tpy, these reserves would last for more than 500 years (Manula et al. 1978).

2.2 Characteristics of Pennsylvania Anthracite

One major advantage of anthracite as a fuel is its low sulfur content. The average sulfur content of Pennsylvania anthracite is 0.7% (Manula et al. 1978). Of Pennsylvania's known anthracite reserves, 88% have a sulfur content less than or equal to 1.0% by weight (Bureau of Mines 1975). Figures 2-4 and 2-5 illustrate the range of sulfur content

Figure 2-3 Location of Anthracite Reserves
in Pennsylvania

Source: Commonwealth of Pennsylvania Department of Environmental Resources 1977.

TABLE 2-1
AREA, SEAM THICKNESS, AND PRODUCTION OF
PENNSYLVANIA'S ANTHRACITE FIELDS

Regional Field	Area (square miles)*	Range of Average Seam Thickness** (feet)	Production** (tpy) [†]
Northern	176	3 to 13	1 million
Eastern Middle	33	3 to 21	3/4 million
Western Middle	94	3 to 14	1-1/4 million
Southern	181	4 to 36	2-3/4 million

*Manula et al. 1978.

**Mining Information Services 1977.

[†]Average production for recent years.

Figure 2-4 Anthracite Coal Reserves in Pennsylvania

Figure 2-5 Bituminous Coal Reserves in Pennsylvania

of Pennsylvania anthracite and bituminous coals. Note, however, that recent borings in selected sites in the proposed anthracite open-pit mine area indicate a range of sulfur content from 0.3% to 2.9% (Coal Age 1978). This variability as a potential impediment to anthracite use is discussed further in Section 6.

Anthracite has a high fixed-carbon content, averaging 81.9% compared to 67% for Pennsylvania bituminous. Volatile matter content for anthracite coal averages 4.4%, while for low-volatile Pennsylvania bituminous coal it averages 19.7%. The ash content of anthracite, an average 11%, exceeds that of low-volatile bituminous at 9.2% (Manula et al. 1978).

The Btu per pound heat content for anthracite (12,600) is slightly higher than that of bituminous (12,000). The ignition temperature of anthracite is 925°F, considerably higher than that of bituminous coal (766°F) (Manula et al. 1978).

2.3 Production of Anthracite

In 1976, a total of 5,291,776 tons of anthracite was produced in Pennsylvania (Commonwealth of Pennsylvania Department of Environmental Resources 1977). Eighty-six percent of this coal was provided by operators who produced over 25,000 tons in 1976; 70% was provided by operators who produced over 100,000 tons in 1976 (Commonwealth of Pennsylvania Department of Environmental Resources 1977). Figure 2-6 shows a distribution of operators producing over 25,000 tons by the amount produced in 1976. Table 2-2 lists the operators who produced over 25,000 tons of anthracite in 1976. The remaining 14% of anthracite (732,243 tons) mined in 1976 was accounted for by 194 operators whose output ranged from 32 tons to 25,000 tons (Commonwealth of Pennsylvania Department of Environmental Resources 1977). It should be noted that one operator (Jeddo-Highland Coal Company) produced 797,774 tons, more than all the under-25,000-ton operators combined.

Each operator may run several mines; generally, the larger operators have more mines. Jeddo-Highland Coal Company has 11 mining areas that produced anthracite in 1976, Reading Anthracite had 12, and Bethlehem

Figure 2-6 Operators Producing Over 25,000 Tons of Anthracite in 1976

Source: Commonwealth of Pennsylvania Department of Environmental Resources 1977

TABLE 2-2
PENNSYLVANIA ANTHRACITE OPERATORS PRODUCING
25,000 TONS OR MORE IN 1976

Operator	Production (tons)
Jeddo-Highland Coal Company	797,774
Reading Anthracite Company	545,983
Bethlehem Mines Corporation	468,817
Beltrami Enterprises, Inc.	388,013
Manbeck Dredging Company, Inc.	277,320
Leon E. Kocher Coal Company	267,129
Heckla Machinery & Equipment Company	262,969
Ken Pollock, Inc.	132,667
Swatara Coal Company	132,046
Gilberton Coal Company	131,057
Clarence Marsden	123,926
B-D Mining Company	119,110
C-L-S Coal Company	115,319
Brook Contracting Corporation	95,586
Kerris & Helfrick, Inc.	92,598
Rosini Coal Company	78,270
Carrier Coal Company, Inc.	73,954
John Percival	57,353
Split Vein Coal Company, Inc.	51,555
Bush Coal Company	51,921
Phoenix Contracting Company	44,966
William Schickram	40,775
Gowen Coal Company, Inc.	36,969
Gale Coal Company	36,672
C. & T. Coal Company, Inc.	35,273
Heavy Media, Inc.	33,531
Hatter Coal Company	33,331
N. & L. Coal Company	30,036
Schuylkill Contracting Company	28,809
Sebastopol Coal Company, Inc.	25,804

Source: Commonwealth of Pennsylvania Department of Environmental Resources 1977.

Mines Corporation had 6. Most of the under-25,000-ton operators had only one or two producing mines running in 1976 (Commonwealth of Pennsylvania Department of Environmental Resources 1977).

In 1976, a total of 85,747,874 tons of bituminous coal were produced in Pennsylvania. There were 34 operators who produced over 200,000 tons of deep-mined bituminous coal, and 44 operators produced over 200,000 tons of surface bituminous coal (Commonwealth of Pennsylvania Department of Environmental Resources 1977).

2.4 Description of Current Anthracite Mining Methods

There are three main methods of extracting anthracite from the ground: strip or surface mining, underground or deep mining, and culm bank/dredging mining. The most prevalent method since the early 1960s is surface mining, which involves exposing the anthracite by removing the overburden. This is done with massive earth-moving equipment. The coal can then be removed and the land reclaimed for recreational or other uses. Open-pit mining is a form of surface mining that combines the resource recovery efficiency of strip mining with the deep recovery of underground mining. Coal is extracted after removing the overburden in a large, terraced pit.

Underground mining, once the primary method used in the anthracite industry, has been on the decline. This method involves carving tunnels and chambers underground, leaving some material intact as support. The coal is removed and hauled above ground. The advent of large underground mining equipment has made this method of mining more economical, but it has not offset many of the hazards inherent in underground work (see Section 2.5).

Culm banks are refuse piles left behind from mining operations in the days of peak production. These banks are an easily accessible source of anthracite. Similar refuse piles exist in rivers near the banks; these can be mined by dredging.

2.5 Trends in Mining Methods

Figure 2-7 illustrates the trends in methods of anthracite mining in Pennsylvania from 1950 to 1976. Over this period of time, underground mining declined significantly. In 1950, underground mining

Figure 2-7 Trends in Anthracite Mining In Pennsylvania 1950 to 1976

Source: Manula et al, 1978.

accounted for 67% of all anthracite mined in Pennsylvania, while in 1976, only 10% of the anthracite was mined underground. In contrast, surface mining and culm bank/dredging mining have increased substantially. In 1950, strip mining accounted for only 27% of the total anthracite output of Pennsylvania; this figure rose to 56% in 1976. Culm bank and dredging methods increased from 6% in 1950 to 34% in 1976.

There are several reasons for the decline in underground mining. First, the cost per ton is approximately twice that of surface-mined anthracite (Coal Outlook 1978). Secondly, there are many safety hazards associated with underground mining. These include the risk of roof collapse, flooding, mine fires, and long-term respiratory problems. Third, the level of training required for underground mine employees is more involved than for surface mine workers. There are also problems attracting workers to this hazardous form of employment. Another reason for the decline in underground anthracite mining is that the rate of resource recovery per ton of material moved is lower than that for surface mining.

Surface mining has increased in prominence since 1932 when records were first kept for this method (Commonwealth of Pennsylvania Department of Environmental Resources 1977). Surface mining is generally safer and less costly than underground mining. One disadvantage associated with surface mining is that it is not economically feasible in cases where overburden is excessively thick.

Culm bank and dredging mining has nearly doubled in the 11 years from 1965 to 1976. This increase is due to two factors: (1) development of new markets and (2) it is a relatively inexpensive and safe method.

2.6 Current Markets for Pennsylvania Anthracite

Pennsylvania anthracite has three major markets - space heating, electric power generation, and iron and steel industry applications. These three markets account for over 75% of the consumption of Pennsylvania anthracite. This section examines these three markets, as well as exports and minor applications.

The largest market for Pennsylvania anthracite is residential and commercial space heating; this market accounted for 34% of the Pennsylvania anthracite consumption in 1975 (Mining Information Services 1977). Smaller sizes of anthracite are often less expensive as a fuel than oil or natural gas (Manula et al. 1978). There are efficient systems on the market that provide automatic combustion of anthracite for home or commercial heating. The drawbacks of anthracite as a heating fuel include storage and ash-removal problems, plus the additional cost of the burner, which is somewhat more expensive than a comparable oil or natural gas burner. Due, in part, to these drawbacks, anthracite has declined as a heating fuel in existing markets and has failed to capture much of the new construction market (Manula et al. 1978). Figure 2-8 illustrates the decline in this market between 1971 and 1975.

Public utilities are the second largest users of Pennsylvania anthracite; in 1975 public utilities in the United States accounted for 24% of the consumption of Pennsylvania anthracite (Mining Information Services 1977). Figures 2-9 and 2-10 illustrate the role of all forms of coal as fuel for steam electric plants. Figure 2-11 shows the rate of consumption of Pennsylvania anthracite by public utilities between 1971 and 1975.

While most coal-fired power plants in the United States burn bituminous coal, there is an increased interest in the use of anthracite, due to its low sulfur content. The Federal Energy Supply and Environmental Coordination Act of 1974 gave the Federal Energy Administration the authority to order power plants to convert, where possible, from oil and natural gas to coal. The Clean Air Act Amendments of 1977 have led to the reexamination of anthracite as a clean-burning fuel.

Currently, Pennsylvania Power and Light Company (PP&L) has two electric generating plants that use Pennsylvania anthracite as part of their fuel supply. The Sunbury Steam Electric in Shamokin burns both oil and coal; part of the coal is Pennsylvania anthracite (Mining Information Services 1977). The anthracite boilers at this plant are the largest in operation in the United States and are capable of producing approximately 50,000 kilowatts (kw) (the largest bituminous boilers presently have a capacity of 800,000 kw to 900,000 kw) (Manula

Source: Mining Information Services 1977.

Figure 2-8
Consumption of Pennsylvania Anthracite in Residential
and Commercial Heating 1971 to 1975

Source: Mining Information Services 1977.

Figure 2-9

Coal (all forms) as a Percent of Fuel Used in Steam Electric
Plants in Pennsylvania

Source: Mining Information Services 1977.

Figure 2-10

Coal (all forms) as a Percent of Fuel Used in Steam
Electric Plants in the United States

Source: Mining Information Services 1977.

Figure 2-11
Consumption of Pennsylvania Anthracite by Public Utilities
1971 to 1975

et al. 1978) and plans exist for 1,300,000 kw and more. The Holtwood Steam Electric Station in Holtwood burns oil and coal; part of its coal supply is Pennsylvania anthracite (Mining Information Services 1977).

Pennsylvania anthracite is also used for electric power generation and space heating on United States military bases in Europe; in 1973, a total of 695,788 tons of anthracite was exported to military bases (Manula et al. 1978). It is estimated that one half of the anthracite used by United States military bases is exported from Pennsylvania.

The growth of anthracite as a fuel for electric power generation has been hindered by several factors. One is the capital expense associated with boiler construction; anthracite has a higher ignition temperature and longer burning time than bituminous coal, requiring more costly burners (Manula et al. 1978). Another factor is increased expense of particulate removal. Conventional electrostatic precipitators do not adequately remove particulates generated by anthracite combustion; therefore, bag filtration systems must be used. This added expense, however, is offset by savings in flue gas desulfurization (Manula et al. 1978). Section 4 explains these issues in more detail and in particular describes how the recent requirements of NSPS/BACT may considerably alter the competitiveness of anthracite as a utility boiler fuel. Another consideration is the reliability of long-term supply. Since bituminous-fired plants are more numerous and well-established, their supplies of fuel are well-established. Development of anthracite-fired plants will require similar long-term commitments from anthracite suppliers.

The third largest market for Pennsylvania anthracite is the iron and steel industry; this market accounted for approximately 20% of the consumption of Pennsylvania anthracite in 1975 (Mining Information Services 1977). The largest application for Pennsylvania anthracite in this industry is coke-making. Figure 2-12 shows the recent trend in consumption of Pennsylvania anthracite for coke making. To meet requirements for use as a coking fuel, a coal must have low ash and sulfur content, low coking pressure, and high coke strength (Mining Information Services 1977). Since it is unlikely that any single coal could meet all four of these requirements, blends of various coals are often used.

Source: Mining Information Services 1977.

Figure 2-12
Consumption of Pennsylvania Anthracite in Iron
and Steel Industry Coke Making
1971 to 1975

Pennsylvania anthracite is sometimes used as one component of such a blend. Sintering and pelletizing applications, used in the beneficiation of iron ore, accounted for 5% of the consumption of Pennsylvania anthracite in 1975 (Mining Information Services 1977). Figure 2-13 shows fluctuations in consumption of Pennsylvania anthracite for these applications between 1971 and 1975. Pennsylvania anthracite is also used for lining pots and molds, as an industrial carbon, and as a foundry coke substitute (Manula et al. 1978).

Much of Pennsylvania's anthracite is exported to countries around the world. Figure 2-14 shows destinations of United States anthracite, excluding shipments to United States military bases. Figure 2-15 shows Pennsylvania anthracite exports between 1971 and 1975.

The remainder of Pennsylvania's anthracite is used for a number of other applications. Egg, stove, and chestnut sizes (see Table 2-3) are used by the chemical industry in the manufacture of soda ash (Pennsylvania State University 1978). Egg coal is used as a substitute for foundry coke, which is in short supply (Manula et al. 1978). Pea, buckwheat, and rice sizes are used in the carbon industry; the coal is calcined and made into paste for cathode blocks, which are needed in the aluminum industry (Manula et al. 1978). This calcined coal is also used to manufacture coal electrodes for electric furnaces used in the steel industry (Manula et al. 1978). Small amounts of all sizes of Pennsylvania anthracite are used for water filtration (Manula et al. 1978). Finally, a very small amount of the anthracite is used at the mine itself to generate heat and power (Mining Information Services 1977).

Source: Mining Information Services 1977.

Figure 2-13

Consumption of Pennsylvania Anthracite Iron and Steel Industry
Sintening and Pelletizing
1971 to 1975

Source: Mining Information Services 1977.

Figure 2-14

Destination of United States Anthracite Exports 1976

Excludes shipments to U. S. military bases.

Source: Mining Information Services 1977.

Figure 2-15

Pennsylvania Anthracite Exports 1971 to 1975

Excludes shipments to U. S. military bases.

TABLE 2-3

STANDARD ANTHRACITE SPECIFICATIONS APPROVED AND ADOPTED BY THE PENNSYLVANIA ANTHRACITE COMMITTEE,
EFFECTIVE JULY 28, 1947

Size	Round Test Mesh, inches	Percent					
		Oversize Maximum	Undersize		Maximum Impurities ^a		
			Maximum	Minimum	Slate	Bone	Ash ^b
Broken	Through 4-3/8	--	--	--	1-1/2	2	11
	Over 3-1/4 to 3	--	15	7-1/2	--	--	--
Egg	Through 3-1/4 to 5	5	--	--	1-1/2	2	11
	Over 2-7/16	--	15	7-1/2	--	--	--
Stove	Through 2-7/16	7-1/2	--	--	2	3	11
	Over 1-5/8	--	15	7-1/2	--	--	--
Chestnut	Through 1-5/8	7-1/2	--	--	3	4	11
	Over 13/16	--	15	7-1/2	--	--	--
Pea	Through 13/16	10	--	--	4	5	12
	Over 9/16	--	15	7-1/2	--	--	--
Buckwheat No. 1	Through 9/16	10	--	--	--	--	13
	Over 5/16	--	15	7-1/2	--	--	--
Buckwheat No. 2 (Rice)	Through 5/16	10	--	--	--	--	13
	Over 3/16	--	17	7-1/2	--	--	--
Buckwheat No. 3 (Barley)	Through 3/16	10	--	--	--	--	15
	Over 3/32	--	20	10	--	--	--
Buckwheat No. 4	Through 3/32	20	--	--	--	--	15
	Over 3/64	--	30	10	--	--	--
Buckwheat No. 5	Through 3/64	30	(c)	(c)	--	--	16

^aSlate is defined as any material that has less than 40 percent fixed carbon. Bone is defined as any material that has 40 percent or more, but less than 75 percent, fixed carbon. When slate content in the sizes from Broken to Chestnut, inclusive, is less than above standards, bone content may be increased by 1-1/2 times the decrease in the slate content under the allowable limits, but slate content specified shall not be exceeded in any event.

A tolerance of 1 percent is allowed on the maximum percentage of undersize and the maximum percentage of ash content.

The maximum percentage of undersize is applicable only to anthracite as it is produced at the preparation plant.

^bAsh determinations are on a dry basis.

^cNo limit.

Source: Bureau of Mines 1975.

3. ANTHRACITE PRODUCTION PROJECTIONS AND TRANSPORTATION ANALYSIS

3.1 Projections for Production and Use

Projecting anthracite production beyond the next several years is difficult due to the constantly changing nature of the energy market. In the past (see Section 2), the primary use of anthracite was for residential and commercial heating. The major competitors were oil and natural gas. However, the current expansion market for anthracite lies in the electrical utilities and power generation areas, where the major competitor will be other forms of coal. The extent of anthracite expansion into other areas of the energy market is, therefore, difficult to assess given current market and technological uncertainties concerning new electric power plants. A principal uncertainty described further below and in Section 4 is whether or not a flexible interpretation of NSPS will be permitted.

Table 3-1 shows a series of projections developed using different scenarios for anthracite production from 1985 to 2000. The Bureau of Mine's projection (Bureau of Mines 1975) assumes that technology will be able to substantially reduce the production costs of anthracite compared with those of competing fuels and bases its forecast on an assessment of the positive and negative effects of technological developments, competitive price relationships with alternative energy sources, and the influence of environmental controls. The Berger report (Berger Associates and A. B. Riedel Associates 1975), on the other hand, assumes that all major production and consumption constraints will be overcome and that a substantial growth in anthracite consumption will be possible as a result of their elimination.

A progress report by the ATF and DOE (1975) also estimated potential markets for 1990 and 2000. Their estimates were made by analyzing all potential markets for coal in the regional area. The President's National Energy Plan was also used by ATF to predict that coal use will increase at an annual rate of 8.5% through 1985. It was further assumed that anthracite consumption will increase at a rate of 0.5% through 1985.

TABLE 3-1

ESTIMATED ANNUAL ANTHRACITE CONSUMPTION
(thousands of tons)

	1985	1985 Range	1990	1990 Range	2000	2000 Range
Bureau of Mines (1975)	5,000	3,000 7,000	(NA)	(NA)	5,000	7,000 7,000
Berger Report (Berger Associates and A. B. Riedel Associates 1975)	8,144 (av.)	5,886 10,403	19,790 (av.)	13,606 25,973	49,886	37,910 6,186
ATF Utilization Task Force (1975)	5,334	(NA)	7,366	(NA)	15,015	(NA)

The anthracite industry will continue to be faced with major production and consumption constraints. The ATF projections considered the future availability of energy fuels, the environmental implication of energy use, and the relative economic attractiveness of alternative energy sources. These constraints will have to be overcome if anthracite is to become a major alternative energy fuel. Yet, given a substantial growth in anthracite consumption, the incentive to solve these problems will most likely be generated. Figure 3-1, the projected uses of anthracite from 1974 to 1990, was based on the ATF projections and estimates of potential use. By 1990, an estimated 15 million tons of anthracite coal could be used annually. This tonnage is approximately three times greater than current production. This estimate is considered to be relatively conservative, recognizing the massive production constraints on anthracite and the nation's increasing dependence on domestic fuels and the permanent higher cost of all fuels. The largest growth in anthracite use is anticipated to be in the electric utilities area. If flexible NSPS are adopted (see Chapter 4), ATF suggests that by 1990 approximately 70% of projected anthracite production will be used by the power generation markets compared to the 20% to 30% currently used.

Predictions for growth have not been carried beyond 2000. This limit is because the growth of nuclear power as well as other sources of energy for the generation of electricity could well restrict any further growth in the use of anthracite beyond that date.

The estimated reserves of anthracite in the United States are more than sufficient to meet the potential consumption. Space heating is presently the most significant use of anthracite. However, most of the commercial and residential users operate older equipment that has, in the past, been replaced with units designed to burn other fuels.

"The retail market should continue to experience further decline, but in the immediate anthracite area, where retail use of anthracite coal is greatest and a cost advantage is obtained over oil and gas, the home heating and commercial market should stabilize." (Berger Associates and A. B. Riedel Associates 1975)

Figure 3-1 Projected Use of Anthracite 1974 to 1990

Therefore, anthracite will continue to have some local significance for space heating.

Electric utilities, as the second largest user of anthracite, currently are predicted to provide the major market for future expanded anthracite production (see Figure 3-2). About 66% of total estimated consumption for 2000 is anticipated to be accounted for by the utilities. Existing utility companies in the vicinity of the anthracite fields are the most likely potential users. Pennsylvania Power and Light, New York State Electric and Gas, Metropolitan Edison, Pennsylvania Electric, and Philadelphia Electric have the greatest potential. Two other utilities with locational advantages, United Gas Improvement Corporation and Pottsville Gas Company, would also consider anthracite as an energy source if the gasification process proves feasible (Berger Associates and A. B. Riedel Associates 1975). Another potential market for anthracite would be new power plants located near the mines, since this would minimize transportation costs and make anthracite more cost competitive.

In general, the significance of the utility industry as a market for expanded anthracite production will be a function of comparative costs of other fuels, interpretation of environmental legislation (particularly the recent federal Clean Air Act Amendments of 1977), and advances in end-use technology. The utility companies, however, would have to be ensured of the long-term availability of anthracite at an attractive price prior to building an anthracite-fired boiler. In the past, utility companies have been discouraged from using anthracite coal because of doubts concerning the coal's long-term availability. Since power plants are designed for a specific energy fuel, conversion is both costly and impractical. If the flexible NSPS are adopted, expanded use of anthracite by utilities may be possible.

One possible incentive for new utility consumption of anthracite is the federal Energy Supply and Environmental Coordination Act of 1974, which gave the Federal Energy Administration the authority to order power plants capable of burning coal to convert from oil or natural gas. Furthermore, new power plants may be required by the Federal Energy Regulatory Commission to burn coal. The National Energy Plan, which

Source: Berger Associates and A. B. Riedel Associates 1975.

Figure 3-2 Distribution of Anthracite Coal 1972 and 1990

calls for an increase in domestic coal production by two-thirds by 1985 (over 1 billion tons), also proposes requirements for new major stationary sources to burn coal (and certain categories of existing sources to convert to coal), rather than fuel oil or natural gas, all while preserving environmental quality.

A feasibility study was conducted by Pennsylvania State University in January 1978 to determine whether anthracite "holds promise for future use by electric utility companies" (Manula et al. 1978, p. 13). The study deals with the application of open-pit mining methods, developed by the metal mining industry, to a specific site in the southern portion of the anthracite region. The open-pit method was designed to ensure complete removal of the coal to safe working elevations, and excavation techniques were planned to provide for compacted pit backfilling with the large volumes of generated overburden. Complete revegetation of mined out areas concurrent with the advancement of the active pit was also included in the simulation. The aim of the open-pit mine design was to maximize resource recovery rather than minimize mining costs. The Manula report further indicates the scope of mining required to meet market demands, while simultaneously including the costs of reclaiming existing mined-out land and cleaning up acid mine drainage. The conclusions of this report within the framework of constraints placed on the operation by environmental and socioeconomic factors are discussed in Chapter 5.

Industrial uses account for the next largest demand, and the iron, steel, and coke industries may also provide an expanded market for anthracite. While other resources are available for use in these industries, recent trends indicate some potential for increased anthracite demand as a "new" source of carbon for their processes. Industrial users are optimistic about the potential of anthracite coal in steel making.

"The competition for low sulphur bituminous coal among the utilities, foreign users and steel manufacturers has caused a shortage in metallurgical coal. As a result, steel firms have increased their use of anthracite in the coking process.

"The steel companies' effort to maintain a high carbon injection in the blast furnace has also expanded the use of anthracite. It appears that the units of carbon in coke have been declining, and therefore the industry is mixing greater proportions of high carbon anthracite coal with the coking coal.

"Again, the high fixed carbon quality of anthracite coal, specifically the fines, makes it an attractive fuel for the sintering of ores in the steel industry." (Berger Associates and A. B. Riedel Associates 1975).

The significance of anthracite in the iron, steel, and coke industries could increase geographically beyond the anthracite region. For example, although the steel plants close to the anthracite region have the greatest potential as markets for anthracite coal, there are also iron and steel markets further removed from the region that could be of significant potential despite additional transportation costs.

"An increase in demand in these markets would occur... if there is an acceleration of the present trend in the use of anthracite for the production of coke and the manufacture of castings for motor vehicle components, railroad and electrical equipment and heavy machinery." (Bureau of Mines 1975)

Forecasts to the year 2000 suggest that anthracite demand in the iron, steel, and coke industries could surpass that in the space heating market (Bureau of Mines 1975). However, it does not appear that industrial uses alone will "revitalize" the anthracite industry, even though anthracite has the potential for capturing a significantly large share of the 80 million tpy coke market (Bureau of Mines 1975).

The carbon market for chemical industries may also serve as another source of demand for future expansion of anthracite production. The chemical industry is a stable and essentially a guaranteed market.

"The high fixed carbon quality of anthracite is generally preferred over coking coal in the soda ash process and in the manufacture of electrodes. Anthracite is also used by chemical firms as a blend in the manufacture of foundry coke." (Berger Associates and A. B. Riedel Associates 1975)

In 1973, consumption of anthracite by the chemical industry represented only 5.7% of total demand. While this market may experience expansion, it will likely remain relatively insignificant when compared to other uses.

Moreover, the chemical industry faces the same situation as the iron, steel, and coke industries. Although these industries would like to consume a greater quantity of anthracite coal, current high prices for anthracite and the scarcity of it have caused them to consider alternatives. For example, nonferrous metal production and nonmetallic products industries are not potentially significant markets for anthracite due to the availability of other resources as substitutes.

Anthracite will continue to face competition from bituminous coal and other energy sources throughout the foreseeable future, unless problems relating to the reliability of supply and end use technology can be overcome to an extent that makes anthracite coal effectively competitive in most major markets. Long-term available supplies of anthracite could be distributed through contracts with utilities and other consumers. The establishment of long-term contracts would reduce the impact, on both producers and consumers, of rapidly changing prices and seasonal and cyclical fluctuations. Through the maintenance of reasonable prices, market stability could be established, allowing the anthracite industry to expand. Action on the part of the government could greatly assist the anthracite industry by stabilizing the allocation of alternative energy fuels and reducing domestic dependence on energy imports. Moreover, if domestic stability is established, there is a good probability that the export market for anthracite could expand substantially (see Figure 3-2).

3.2 Transportation Analysis

3.2.1 Introduction

The primary purpose of this section is (1) to provide a brief overview of how Pennsylvania's anthracite coal is presently transported from where it is mined to consumers and (2) also to determine if significant transportation cost advantages presently exist for major shipments of anthracite to northeastern states.* Section 3.2.2 describes the existing mode of anthracite transportation and other general background information related to coal transportation. A comparison of

*Massachusetts, Connecticut, Rhode Island, Vermont, New Hampshire, Maine, Pennsylvania, New York, New Jersey, and Delaware.

relative rail transportation costs for anthracite and bituminous coals is presented in Section 3.3.3. A summary of conclusions reached as a result of this work is presented in Section 3.3.4.

3.2.2 Existing Transportation Conditions

Coal Field Locations

This section and the following section focuses on anthracite coal transportation considerations. Information presented on bituminous coal is presented for comparative purposes. Figure 2-3 illustrates the location of Pennsylvania's bituminous and anthracite coal resources in context with both New England and selected northeastern states.

Mode of Transport

Any long distance movements of large amounts of coal into New England would likely be by rail (Coal Transportation Task Force 1978). Nationally speaking, rail has been the principle means of transporting domestic coal to the market place. For example, rail shipments accounted for approximately two-thirds of the national coal production in 1975. Trucks, on the other hand, transported only about one-tenth of the 1975 production, while other less important modes of transportation moved the remainder of the total production.

Table 3-2 provides a summary of rail and truck shipment of anthracite coal for selected years between 1950 and 1960. The table also indicates how much of the rail and truck shipments were within the relatively nearby Pennsylvania, New Jersey, and New York region for these same years. Rail has generally been the principle mode of transportation in the past. Truck transport has gained as a means of transporting Pennsylvania coal in more recent decades. This change in the proportion of rail and truck shipments of anthracite within the closer Pennsylvania, New York, and New Jersey region is illustrated by Figure 3-3. Figure 3-4 illustrates that most of the anthracite production shipped by truck in 1975 was within the three state Pennsylvania,

TABLE 3-2

PENNSYLVANIA RAIL AND TRUCK SHIPMENTS OF ANTHRACITE
Selected Years 1950 to 1976

Year	Shipments (tons)	Rail		Shipment (tons)	Truck	
		Percent of Rail Shipments Destined to PA, NJ, and NY	Rail Proportion of Total Shipments		Percent of Truck Shipments Destined to PA, NJ, and NY	Truck Proportion of Total Shipments
1950	31,350,908	70%	82%	6,880,685	99%	18%
1955	18,357,270	69%	70%	8,050,298	99%	30%
1960	8,369,680	68%	49%	8,668,416	98%	51%
1965	6,421,919	54%	49%	6,811,607	98%	51%
1970	3,522,000	41%	44%	4,527,000	98%	56%
1975	3,601,000	99%	65%	1,977,000	38%	35%
1976	3,626,000	--%	65%	1,923,000	--%	35%

Source: Minerals Yearbook, U.S. Bureau of Mines, Selected Years.

"Pennsylvania Anthracite Weekly," Mineral Industry Surveys, U.S. Bureau of Mines.

Revitalization of Pennsylvania Anthracite, Berger Associates, 1975.

U.S. Mineral Industry Surveys, various years.

Percentage of Total Shipments with Pennsylvania, New York, and New Jersey Destinations

Figure 3-3 Change in Proportion of Rail and Truck Shipments of Anthracite to Pennsylvania, New York, and New Jersey Destinations

Figure 3-4 1975 Truck Shipments of Pennsylvania Anthracite
by Destination

New York, and New Jersey region. Similarly, Figure 3-5 illustrates the 1975 distribution of anthracite coal production to various destinations. This figure (3-5) when compared to Figure 3-3 indicates that rail shipments accounted for a much larger percentage of the anthracite moved outside of the New York, New Jersey, and Pennsylvania region. The cost of transporting coal is typically from the mine to a breaker, where it is prepared, and then onto the user. The cost of transport from mine to breaker is normally included in the per ton cost of the coal, while the cost associated with transporting coal from the breaker to where it is used is typically considered an added cost accepted by the user. Thus, costs considered here deal with these latter transport costs not typically included in the per ton price of coal.

Truck and rail are presently the principal modes of shipment of anthracite for both the mine to breaker and breaker to consumer movements. Export to foreign markets is presently relatively small in relation to total anthracite production, an estimated 10% to 12%. About 72% of the 1977 total exported anthracite was shipped to Canada by rail. The remaining 0.28% of the exported anthracite likely involved some transshipment by freighters after its delivery to east coast ports by truck and/or rail. Figure 3-6 illustrates the destination points of exported anthracite for 1977.

In summary, annual anthracite coal production within Pennsylvania is 5 million tpy to 6 million tpy. About 2 million of the 1976 production was shipped by rail (that is, about 30% to 40%). Thus, the majority of anthracite produced is presently shipped by truck and also used within the Pennsylvania, New York, and New Jersey region. It is estimated that 77% of the 1975 production was used in this region, 82% of which was shipped by truck and about 14% by rail. Mine to breaker shipments in the anthracite region are now all done by truck. This emphasis on the use of trucks has resulted from changes in mining techniques in more recent years from the deep-mine type operations to stripping operations. The general decline in total anthracite production is well documented. This decrease in total production has been accompanied also by a more general decline in shipments of anthracite by

Figure 3-5 1975 Rail Shipments of Anthracite by Destination

Figure 3-6 1976 Total Anthracite Exports by Destination

Source: Mining Information Services 1977.

rail. For example, anthracite tonnage moved by rail has declined by about 94% over the past 25 years. During this same period, total truck volumes have also decreased, but by a lesser percentage (50%). An estimated 12% of the 1975 anthracite production was exported to Canada and overseas, with only about 11% of the total production being transported to more distant domestic (United States) destinations. Essentially all of this export and more distant domestic marketed anthracite moved by rail (a total of 23% of production). This anthracite plus that moved by rail within Pennsylvania, New York, and New Jersey, therefore, accounted for a total of 37% of the 1975 anthracite production. Thus, 63% of the 1975 production was shipped by other modes of transportation, principally truck.

Probable Mode of Transport for Future Major Coal Consumers

Rail transport is expected to continue to be the principal mode of transporting coal to new coal-fired electrical generating stations coming online during the 1976 to 1985 time period since the most energy efficient manner of hauling large volumes long distances is by rail. Generally speaking, for distances greater than approximately 250 miles, rail transportation will be less costly than truck, trucks being more efficient for short hauls such as the mine to breaker shipments. It has been estimated that on the average, railroads move over three times as many ton miles per gallon of fuel as do trucks. The following is a summary of how projected future (1980 and 1985) coal demand nationally might be transported.

<u>Mode of Transport</u>	<u>Percent of Total Demand</u>	
	<u>1980</u>	<u>1985</u>
Rail	65.6	61.7
Truck	22.4	21.7
Barge	9.1	6.3
Other	2.9	10.3

Condition of Rail System in Anthracite Region

The anthracite region's rail system has declined as the anthracite coal industries' share of the total market has decreased during the last 25 to 30 years. This means that some costs of rail improvement to more efficiently ship coal out of the production region (for example, directly from an open-pit mine) could result from major increases in production. Such increased costs are difficult to estimate other than for specific cases. However, in general, the conditions of the existing rail lines within the anthracite region are considered adequate for current demand.

Unit Coal Trains

It is reasonable to assume that export of Pennsylvania coal in quantities required for a power plant as discussed in this report would be by "unit trains." A western unit train usually is made up of approximately 100 rail cars, with a total capacity of about 10,000 tons of coal (for example, 100 rail cars x 100 tons per car). This typical western unit train is pulled by five locomotives and includes one caboose. A unit train operates differently than typical freight trains. A unit train operates continuously between the mine and the point where the coal is consumed and, as such, the switching of rail cars or other movements within railroad terminals rarely occurs.

Unit Coal Train Tariffs

The unit train tariffs or cost of shipping the coal charged by railroads are filed with the Interstate Commerce Commission (ICC). Unit train tariffs are clearly established rates but subject to some negotiation based on a variety of factors. For example, the major factors influencing transportation costs and considered in negotiating a specific unit train tariff include:

- a rate charged per ton;
- the amount of time required to both load and unload the coal;
- penalty charge for time delays in either loading or unloading;

- the routing of the unit train with respect to its origin, the mine, and its destination at an electrical generating station;
- the minimum annual tonnage of coal that must be transported by unit train;
- the supply and maintenance of the rail cars and locomotives that make up the unit train; and
- provision of the train's crew.

Status of Unit Train Movements in New England/Northeast

Unit train activity is not as common to the northeast as to the western states. Most unit train movements are associated with movements of western bituminous coal related to more recent resource development. However, it should be noted that PP&L has used the unit train concept for a number of years and has gained substantial experience in this area. The company's unit train experience dates back to 1964 when it bought its first train of 74 rail cars. Now PP&L has nine unit trains. Most of the maintenance work is done in railroad shops (for example, Conrail), with minor adjustments and routine servicing provided for at PP&L's facilities.

The July 1977 issue of Power Engineering provides a detailed cost estimate of rail car maintenance over PP&L's 13 years of unit train experience. Table 3-3 provides a summary of PP&L's experience related to the average per car cost of maintenance. A major factor in the total cost figure of a \$4.2 million maintenance expense is the increasing cost associated with mandatory Federal Railway Administration inspections and repairs. According to PP&L, the average maintenance cost per car will not get below \$1,000. The nearly \$2 million maintenance costs of PP&L in 1976 might be put into better perspective by noting that the company's 7,550,000 tons of coal, which was about 1.9% of the coal moved by all railroads last year. During the 13 years of PP&L's experience with unit trains, about 43.25 million tons of coal have been hauled.

Only one unit train shipment presently occurs in New England. It involves an 880-mile route from a point in West Virginia to an electric generating station in New Hampshire [Public Service Company of New Hampshire's (PSNH) power plant located in Bow, New Hampshire]. The

TABLE 3-3

PP&L AVERAGE PER CAR MAINTENANCE FOR UNIT TRAINS

Year	Maintenance Amount Incl. Employee Expense	Number of Cars	Maintenance Cost Per Car Average	
1964	\$ 48	74		0
1965	8,638	(a) 210	74	116
1966	22,760	(b) 315		307
1967	39,197	315	210	186
1968	58,816	(c) 420	315	186
1969	89,236	420	315	283
1970	65,650	420	420	156
1971	112,725	(d) 551	420	268
1972	62,321	(e) 682	420	148
1973	283,902	682	551	515
1974	337,559	(f) 787	682	494
1975	1,346,986	(g) 892	787	1,711
1976	1,770,565	892	892	1,984
13-year total	(h) 4,198,409	892	892	(i) 6,361

*Does not include employee expense.

(a) 136 cars added 9/65 - not averaged until 1967

(b) 105 cars added 8/66 - not averaged until 1968

(c) 105 cars added 7/68 - not averaged until 1970

(d) 131 cars added 6/71 - not averaged until 1973

(e) 131 cars added 11/72 - not averaged until 1974

(f) 105 cars added 11/74 - included in 1975 fig.

(g) 105 cars added 7/75 - not averaged

(h) Average cost per year \$322,954

(i) Average cost per car per year \$489 (13 years)

1976 figure includes \$613,372 for FRA inspection and repair on 420 cars
\$ 460 per car in 1975 these figures were \$134,916 for 336 cars for a
\$401 average.

Source: Power Engineering 1977.

current (1978) transportation cost for coal in this unit train is equal to \$8.22 per ton. PSNH owns and maintains the rail cars that make up this unit train. Consolidated Rail Corporation (Conrail) provides the locomotives, the maintenance for these engines, and the required crew. As a result, the cost of transporting coal in this particular instance is about \$0.00934 per ton mile. It is estimated that if PSNH did not supply the rail cars that the rate charged per ton would increase by approximately \$3.00 (for example, $\$8.22 + \$3.00 = \$11.22$). This per ton rate would translate into a per ton mile transport cost of approximately \$0.01275. The capital cost of the equipment and the associated maintenance costs are incurred by the utility.

Rail equipment is a major capital investment. For example, it is presently estimated that one 100 ton rail car used for coal costs \$30,000+ and that each locomotive would be \$500,000. An example of the cost of equipment for a 100 car unit train follows.

• 100 rail cars @ \$30,000	=	\$3,000,000
• 5 locomotives @ 500,000	=	2,500,000
• 1 caboose @ 100,000	=	<u>100,000</u>
TOTAL		\$5,600,000

Annual equipment maintenance is estimated as follows.

• 100 rail cars @ \$1,000	100,000
• 5 locomotives @ 50,000	250,000
• 1 caboose @ 2,000	<u>2,000</u>
TOTAL	\$352,000

Thus, a western unit train could cost in the order of \$5 million to \$6 million to purchase the equipment and also would have substantial annual average maintenance costs associated with it.

Comparison of Rail Car and Truck Volumes

The following indicates why unit trains can handle large volumes more efficiently than trucks. Rail cars, as noted above, have a 100-ton capacity. Dump trailer trucks that are 30 feet in length, on the other hand, have a capacity of approximately 39 to 43 cubic yard capacities. Coal has a density of about 55 pounds per cubic foot. A 30-foot trailer, therefore, can handle about 29.7 tons. However, the tonnage amount carried by each truck is limited by Commonwealth of Pennsylvania regulations to approximately 24 tons. Thus, four plus such trucks would have to be used to haul comparable amount of coal hauled by a single 100 ton rail car. Likewise, it would mean that 417 truckloads are necessary to equal the total tonnage of a western unit train with 100 rail cars.

Published Tariffs and Negotiated Unit Train Rates

Unit train rates are negotiated as noted above in Section 2.6, and costs are dependent on a number of factors. Costs per ton based on a single carload tariffs are published. Thus, tariff rates that are available for review are presented on a per car load basis compared to a unit train rate basis, which would be associated with any major movement of anthracite to New England generating stations or locations beyond which truck or conveyor transport might be considered more cost effective. The per ton transportation costs for unit trains that exist have been negotiated for specific instances are substantially less than the per ton carload tariff rates that are published. Per mile rate data is not presently available to accurately compare the transportation cost differentials between moving comparable Btu's of Pennsylvania anthracite and bituminous coals to common locations. What tariff data is available to roughly compare costs of anthracite and bituminous coal transport costs is used here.

3.2.3 Comparison of Anthracite and Bituminous Coal Transportation Costs

Approach

Since unit train rates do not exist and no comparable example of a unit train shipping anthracite and bituminous coals to a common New England location exists, the following comparative exercise of available published tariffs was undertaken. The purpose of this was to determine if major cost advantages of shipping Pennsylvania anthracite coal compared to bituminous coal to selected New England locations likely exists given available tariff per carload tariff data. Obviously, unit train rates per ton of coal would be expected to be less than the published rates after accounting for comparable cost factors. It is important to note that the following analysis (1) relies on existing per carload tariffs, (2) does not account for negotiated unit train factors, (3) does not consider differences in Btu values of Pennsylvania anthracite and bituminous coals, and (4) does not include a detailed analysis of rail lines.

The primary sources of data used for the following comparison include:

- "Anthracite and Anthracite Briquettes. -C-250," (Commodity Group Number 1). Effective January 7, 1978.
- "Eastbound Bituminous -C-193-A," (Group 1, Clearfield) Effective May 6, 1978.
- Northbound Bituminous -C-181 (Rate Group 1, From Driftwood, Penn.) - Effective April 1, 1978.

The approach taken involved first establishing selected radii from assumed centroids of Pennsylvania's anthracite and bituminous coal resources. The radii established were for approximately 25 mile increments. Station names and numbers were established at a large number of locations for each of the selected radii and no attempts were made to account for actual routing patterns that might be followed by a unit train in the future. As noted above, efforts were focused on identifying relative differences in per ton published tariffs. Next, the rate

basis was identified for selected locations at the various radii, and the current corresponding per ton rates were determined. The centroid of the anthracite region selected was the location of the proposed anthracite open-pit mine. The centroid of the bituminous resources used for the comparison was what is referred to as the "Clearfield Bituminous District." The Clearfield District was chosen because it is the closest of Pennsylvania's Bituminous Districts to New England locations. It was assumed, therefore, that bituminous unit train movements in the future would originate from this closest source of bituminous coal should Pennsylvania coal be used. Table 3-4 presents rate data for selected stations at or near various radii from the Pennsylvania's anthracite region. Table 3-5 presents similar information for the Clearfield Bituminous District to the same New England stations indicated in Table 3-4 from the anthracite region. Figures were generated to graphically display the per ton dollar transport costs as reflected in the per carload tariffs. Cost data were grouped to spatially plot cost contours. Figures 3-7 and 3-8 illustrate estimated cost contours of rail transportation rates for anthracite and bituminous coal, respectively, on a per carload basis in dollars per ton.

Comparison of Anthracite and Bituminous Rates

Table 3-6 presents the anthracite and bituminous rates and indicates the net differences in rates from the selected anthracite and bituminous origins to comparable destinations. Overlaying Figures 3-7 and 3-8 result in Figure 3-9, which illustrates estimated transportation cost differences between anthracite and bituminous coals tariffs. Separate tariffs exist for anthracite and bituminous coals. For example, the cost of transporting a carload of anthracite and carload of bituminous comparable distances is not the same. Figure 3-9 also indicates spatially where estimated average cost contours may exist, a general area within which anthracite and bituminous transport is relatively similar, and also an area where anthracite may have some relative transportation cost advantage over bituminous.

TABLE 3-4
ANTHRACITE RATES

Distance (miles)	Location	Station No.	Rate Basis	Rate (\$)
75	Sunbury, PA	8592	377 ^H	4.12
			486 ^H	5.30
	Williamsport, PA	5563/58529	584 ^H	6.37
	Norristown, PA	1631	585 ^H	6.38
	Sayre, PA	60376	718 ^H	7.84
	Lewiston, PA	5392	697 ^H	7.61
	Lockhaven, PA	5597/11008	690	6.99
100	Elizabeth/Newark, NJ	204/46142	733 ^H	8.00
	Elmira, NY	46061/50265	754 ^H	8.23
	Binghamton, NY	8832/52160/60473	517	5.65
125	Newburgh, NY	1215/51115	796 ^H	8.70
	Poughkeepsie, NY	9145/44985	991 ^H	10.83
	Cortland, NY	60495	865 ^H	9.45
	Hornell, NY	52340	947	10.34
	Camden, NJ	9883	1059	11.56
	Wellsville, NY	5289	1036	11.31
	Driftwood, PA	5694	991	10.83
150	Norwalk, CT	40270	1059	11.56
	Syracuse, NY	51965/9318/12365	947	10.34
	Geneva, NY	60414/9506	947	10.34
	Olean, NY	6072/52925	1036 ^H	11.31
	Dover, DE	7738	891 ^H	9.73
	Falls Creek, PA	10410/6951	1059	11.56
175	New Haven, CT	40820	1064	11.62
	Albany, NY	72	947	10.34
	Schenectady, NY	9233/62	947	10.34
	Utica, NY	52095/9280	947	10.34
200	Hartford, CT	41130	1138	12.41
	Pittsfield, MA	13081	1099	12.00
	Springfield, MA	13056	1138	12.43
	Saratoga Springs, NY	90	991	10.83
	Pulaski, NY	9842	1059	11.56
	Batavia, NY	9402/52670	1015	11.09
	Corry, PA	5945/53405	1059	11.56
	Red Bank, PA	6762	1059	11.56
225	New London, CT	41475/50	1099	12.00
	Northhampton, MA	511	1138	12.43
	Fort Edward, NY	103	1015	11.09
	Watertown, NY	9917	1059	11.56

TABLE 3-4 (Continued)

Distance (miles)	Location	Station No.	Rate Basis	Rate (\$)
225 (Con't)	Niagara Falls, NY	12535	1059	11.56
	Dunkirk, NY	53060	1059	11.56
250	Worcester, MA	13026	1180	12.88
	Westerly, RI	41670	1105	12.06
	Brattleboro, VT	542	1208	13.19
	Ticonderoga, NY	133	1085	11.84
275	Providence, RI	41860	1105	12.06
	Fitchburg, MA	43405	1180	12.88
	Port Henry, NY	137	1085	12.94
	Middlebury, VT	35	1195	13.05
300	Boston, MA	13001	1122 ^{F2}	12.25
	Lawrence, MA	105	1180	12.88
	Manchester, NH	288	1249	13.64
	Concord, NH	301	1274	13.91
	Franklin, NH	321	1302	14.22
	Norwood, NY	10177	1166	12.74
325	Exeter, NH	126	1249	13.64
	Montpelier, VY	5	1302	14.22
	Burlington, VT	540/5	1195	13.05
350	Biddeford-Sacco, ME	138	1217	12.20
	St. Johnsbury, VT	3860/440	1355	14.79
	Rouses Point, NY	179	1166	12.94
375				
400	Portland, ME	143	1180	12.88
	Berlin, NH	26250	1355	14.79
425				
450	Augusta, ME	285	1355	14.79

TABLE 3-5
BITUMINOUS RATES

	Bituminous	Station No.	Rate Basis	Rate
50	60 Lock Haven, PA	NA	-0-	-0-
75	3 Lewistown, PA	NA	-0-	-0-
	61 Williamsport, PA	5565, 58529	8.57	9.36
	62 Sunbury, PA	58489	8.57	9.36
	*59 Red Bank, PA	6762	-0-	-0-
	*13 Wellsville, NY	2890	5.91	9.64
	*17 Olean, NY	2925, 6072	5.91	9.64
100	2 Sayre, PA	60376	9.57	10.45
	6 Elmira, NY	8832, 52160, 60473	9.34	10.20
	11 Hornell, NY	52340	9.34	10.20
	58 Corry, PA	NA	-0-	-0-
125	*28 Batavia, NY	9402, 457, 2670	5.35	8.75
	*34 Dunkirk, NY	14870	4.52	7.39
150	10 Cortland, NY	51925	9.83	10.73
	7 Binghamton, NY	52100, 31	9.83	10.73
	16 Geneva, NY	9506, 60414	9.83	10.73
	*33 Niagara Falls, NY	12535, 9460, 463, 2835	5.91	9.65
175	15 Syracuse, NY	9318, 12315, 51965	9.83	10.73
	1 Norristown, PA	1631, 1629, 58253, 58253	9.57	10.45
200	12 Camden, NJ	758, 57020, 57030, 57040, 57050	9.80	10.70
225	22 Utica, NY	9280, 52095	10.25	11.19
	27 Pulaski, NY	9842	10.08	11.00
	18 Dover, DE	7738	9.90	10.82
	9 Elizabeth, NJ	204, 46142	10.25	11.19
250	4 Newark, NJ	46061, 50265, 60030, 174, 172, 60029, 176, 173, 60028	10.25	11.19
	9 Poughkeepsie, NY	9145, 44985	10.52	11.49
	8 Newbury, NY	12151, 51040	10.52	11.49
	32 Watertown, NY	9917	10.53	11.50
275	14 Norwalk, CT	NA	-0-	-0-
	20 Albany, NY	9193, 12250, 13109, 72	10.52	11.49
	21 Schenectady, NY	9233, 62	10.52	11.49
300	19 New Haven, CT	40820	11.22	12.25
	24 Pittsfield, MA	13081, 40625	11.75	12.83
	26 Sarasota Springs, NY	90	11.05	12.06
	31 Fort Edward, NY	103	11.05	12.06

*North _____

TABLE 3-5 (Continued)

	Bituminous	Station No.	Rate Basis	Rate
375	39 Providence, RI	41860, 130	12.17	13.29
	40 Fitchburg, MA	43405	12.22	13.35
	48 Bethel, VT	NA	-0-	-0-
	51 Montpelier, VT	5	13.55	14.79
	52 Burlington, VT	5	12.37	13.50
	55 Rouses Point, NY	179	12.37	13.50
	65 Worcester, MA	15, 168, 13026	11.95	13.05
400	14 Boston, MA	1, 13001, 42500, 42510	12.22	13.35
	45 Lawrence, MA	105	12.22	13.35
	46 Manchester, NH	288	12.27	13.40
	47 Concord, NH	301	12.27	13.40
425	50 Exeter, NH	NA	-0-	-0-
	54 St. Johnsbury, VT	3870, 4400	13.55	14.79
450	53 Biddeford, ME	NA	-0-	-0-
	57 Berlin, NH	NA	-0-	-0-
475	56 Portland, ME	143	13.27	14.49
500+	Waterville, ME	302	15.18	16.58
	Augusta, ME	285	14.21	15.52
	Bangor, ME	1185	15.85	17.30

TABLE 3-6

COMPARISON OF ANTHRACITE AND BITUMINOUS TARIFFS - NET DIFFERENCES

Distance (Miles)	Location	Anthracite Rate	Bituminous Rate	Anthracite - Bituminous =
75	Sunbury, PA	4.12	NA	NA
		5.30	9.36	4.06
	Williamsport, PA	6.37	9.36	2.99
	Norristown, PA	6.38	10.45	4.07
	Sayre, PA	7.84	10.45	2.61
	Lewiston, PA	7.61	NA	NA
100	Lockhaven, PA	6.99	NA	NA
	Elizabeth/Newark, NJ	8.00	11.19	3.19
	Elmira, NY	8.23	10.20	1.97
	Binghamton, NY	5.65	10.73	5.08
125	Newburgh, NY	8.70	11.49	2.79
	Poughkeepsie, NY	10.83	11.49	0.66
	Cortland, NY	9.45	10.73	1.28
	Hornell, NY	10.34	10.20	(0.14)
	Camden, NJ	11.56	10.70	(0.86)
	Wellsville, NY	11.31	9.64	1.67
150	Driftwood, PA	10.83	-0-	-0-
	Norwalk, CT	11.56	NA	NA
	Syracuse, NY	10.34	10.73	0.39
	Geneva, NY	10.34	10.73	0.39
	Olean, NY	11.31	9.64	(1.67)
	Dover, DE	9.73	10.82	(1.07)
175	Falls Creek, PA	11.56	NA	NA
	New Haven, CT	11.62	12.25	0.63
	Albany, NY	10.34	11.49	1.15
	Schenectady, NY	10.34	11.49	1.15
	Utica, NY	10.34	11.19	1.15
200	Hartford, CT	12.41	12.38	(0.03)
	Pittsfield, MA	12.00	12.83	(0.83)
	Springfield, MA	12.43	12.83	(0.40)
	Saratoga Springs, NY	10.83	12.06	1.23
	Pulaski, NY	11.56	11.00	(0.56)
	Batavia, NY	11.09	NA	NA
	Corry, PA	11.56	8.75	(2.81)
	Red Bank, PA	11.56	NA	NA
225	New London, CT	12.00	12.38	0.38
	Northampton, MA	12.43	12.83	0.40
	Fort Edward, NY	11.09	12.06	1.03
	Watertown, NY	11.56	11.50	0.06
	Niagara Falls, NY	11.56	9.65	(1.91)
	Dunkirk, NY	11.56	7.39	(4.17)

TABLE 3-6 (Continued)

Distance (Miles)	Location	Anthracite Rate	Bituminous Rate	Anthracite - Bituminous =
250	Worcester, MA	12.88	13.05	0.17
	Westerly, RI	12.06	NA	NA
	Brattleboro, VT	13.19	13.86	0.67
	Ticonderoga, NY	11.84	NA	NA
275	Providence, RI	12.06	13.29	1.23
	Fitchburg, MA	12.88	13.35	0.47
	Port Henry, NY	12.94	NA	NA
	Middlebury, VT	13.05	NA	NA
300	Boston, MA	12.25	13.35	1.10
	Lawrence, MA	12.88	13.35	0.47
	Manchester, NH	13.64	13.40	(0.24)
	Concord, NH	13.91	13.40	(0.51)
	Franklin, NH	14.22	NA	NA
	Norwood, NY	12.74	11.66	(1.08)
325	Exeter, NH	13.64	NA	NA
	Montpelier, VT	14.22	14.79	0.57
	Burlington, VT	13.05	13.50	0.45
350	Bidderford-Sacco, ME	12.20	NA	NA
	St. Johnsbury, VT	14.79	14.79	-0-
	Rouses Point, NY	12.94	13.50	0.56
400	Portland, ME	12.88	14.49	1.67
	Berlin, NH	14.79	NA	NA
425	NA	NA	NA	NA
450	Augusta, ME	14.79	15.52	0.73

• Figure 3-7 Estimated Cost Contours of Rail Transportation Rates for Anthracite - Per Carload Basis (dollars per ton)

Figure 3-8 Estimated Cost Contours of Rail Transportation Rates
for Bituminous Coal - Per Carload Basis
(dollars per ton)

Figure 3-9 Estimated Transportation Cost Differences Between Anthracite and Bituminous Coals

3.3 Summary and Conclusions

The following five points summarize the comparative tariff rate differences noted as part of this exercise.

- Radii from Coal Resources - A review of carload tariffs for "as the crow flies" distance from both the anthracite region and from the "Clearfield Bituminous District" to common New England stations indicate that per ton average carload rates for anthracite appears higher than the average rates for bituminous at selected radii:

Average of Selected Station Rates

Radii (miles)	Bituminous		Anthracite		Approximate Percent Difference in Average Tariffs
	Average Tariff	Per Ton Mile	Average Tariff	Per Ton Mile	
200	\$10.70	0.0535	\$11.68	0.0584	9%
300	\$12.30	0.0410	\$13.27	0.0442	8%
450	\$13.38	0.0297			

- Apparent Difference Between Short and Long Haul Costs - Transportation cost of anthracite is thus believed to be greater than the cost of comparable distance hauls of bituminous. The relative differences in cost between anthracite and bituminous is considered less extreme as distance increases. This can be illustrated by data from a somewhat dated schedule of rates to move single carloads of anthracite and bituminous 10 miles and 1,350 to 1,400 miles as follows.

Distance (miles)	Coal Type	Per Ton Tariff/ Per Ton Mile	Percent Difference
10	Anthracite	\$ 6.40/0.6400	
	Bituminous	\$ 5.57/0.5570	~15%
1,350 to 1,400	Anthracite	\$20.20/0.0144	
	Bituminous	\$19.65/0.0140	~3%

Thus, although anthracite would be approximately 15% more expensive to ship per ton than bituminous a distance of 10 miles, this difference would decrease to about 3% at 1,350 to 1,400 miles.

- Cost Contours Anthracite and Bituminous - Figures 3-7 and 3-8 illustrate estimated cost contours for anthracite and bituminous tariffs, respectively. These cost contours represent only a "crude attempt" to graphically depict relative transportation costs based on currently published per ton carload tariff data. Contours do not represent per ton unit train rates that would, of course, be less. It is estimated that unit train rates (depending on distances, routes, and other previously noted factors related to ownership and maintenance of equipment) could be on the order of \$0.65 to \$3.00 per ton less than the published carload rates.
- Synthesis - Figure 3-9 combines the estimated \$0-\$10, \$12, and \$14 contours. It indicates the area of overlapping anthracite and bituminous \$0-\$10 cost contour and an area within the \$0-\$10 contour in which anthracite most probably has some relative advantage over bituminous. The cost contours at the \$12 and \$14 rates and their averages are also noted on Figure 3-9 and indicate that relative cost differences beyond the \$10 contour may be small. Cost differences at greater distances between anthracite and bituminous in this case may not be significant, particularly since unit train rates can be expected to be applied to any major shipments of coal.
- Degree of Cost Advantage - Figure 3-10 is an attempt to illustrate the relative degree to which anthracite may have a cost advantage over bituminous for rail transportation costs. These cost contours reflect general estimates based on computing net cost differences (that is, by subtracting from selected bituminous tariffs the anthracite tariffs to similar destinations). It again illustrates that as shipments are moved further distances from the anthracite region, the less of a distinct, if any, transportation cost advantage exists for bituminous coal.

Figure 3-10 Relative Transportation Cost Advantage of Anthracite Coal Over Bituminous Coal

4. EFFECTS OF NSPS ON THE ANTHRACITE INDUSTRY

The economic analysis presented in this section is solely intended to determine whether a flexible interpretation of NSPS/BACT could make anthracite coal competitive with bituminous coal as a fuel for steam-electric generating plants. The economic factors involved in this analysis are summarized in Table 4-1. Each of these factors is evaluated in subsequent sections. Each factor evaluation is aimed at determining the relative impact in cost of electricity in mills per kilowatt hour (kwh). The relative positions of anthracite and bituminous coal are determined by quantitatively combining the factors.

The analysis is carried out for BACT requirements for bituminous coal of 90% SO₂ reduction, 85% SO₂ reduction, and 80% SO₂ reduction. This range of reduction requirements is used because NSPS/BACT requirements for steam-electric generating plants are currently being debated within EPA. The draft NSPS document contained a 90% removal requirement, but recent agency communications indicate that a lower requirement is being considered.

A 600 megawatt (Mw) power plant is used throughout this analysis. This is the largest size anthracite boiler that utilities and boiler manufacturers contacted during the course of this study felt confident could be successfully built and operated. Plant location is assumed to be at the anthracite mine, approximately 150 miles from the bituminous coal fields.

A rate of return on capital investment of 12.5% is used in determining annualized plant costs. This figure is based on a survey of the rate of return on equity from 80 power companies in 1976 (FPC 1977) and was confirmed as reasonable for the purpose by power company analysts (Calarco 1977).

4.1 Coal Descriptions and Costs

Figures 2-4 and 2-5 are bar graphs showing relative amounts of anthracite and bituminous coal with various sulfur contents. Based on

TABLE 4-1
ECONOMIC FACTORS

Economic Advantage for Anthracite	Economic Disadvantage for Anthracite
1. Less pollution control equipment required	1. Higher cost of mined coal
2. Geographically closer to the northeast market region	2. Higher cost of boiler and other plant equipment

these data, the following coal characteristics are used in this analysis:

<u>Coal Type</u>	<u>Sulfur Content</u>	<u>Btu Per Pound</u>
Anthracite	0.7%	12,600
Bituminous	2.0%	12,000

These values are representative of coals that might be used in a power plant in eastern Pennsylvania. Prices for these coals are given in Table 4-2 for 1976, 1985, 1990, 1995, and 2000. The anthracite prices are based on a 3 million tpy open-pit mine (Manula et al. 1978). Anthracite prices were estimated in 1976 dollars and escalated at 7% per year for later years. Bituminous coal prices are based on a recent study that predicts a demand market situation for bituminous coal after 1985 (Coal Week 1978). Bituminous prices are predicted to follow oil prices, with demand for coal increasing as limiting factors affect oil and natural gas availability.

4.2 Transportation

A detailed discussion of relative transportation costs for anthracite and bituminous coals is provided in Section 3. Basically, anthracite has transportation in the eastern part of Pennsylvania, New Jersey, and the southeastern quarter of New York. The largest transportation cost advantage is for a mine-mouth anthracite plant. In this case, a bituminous plant in the same location would have a transportation cost of approximately \$6 per ton. This maximum transportation cost advantage for anthracite has been used in the analysis.

4.3 Plant Costs

An anthracite-fired power plant costs more to build than a bituminous-fired plant. The cost difference is due to anthracite's hardness and inherently low volatile content. The basic differences between anthracite and bituminous plants are given in Table 4-3. The result of these differences is that an anthracite plant costs 10% to 15% more than a comparable bituminous plant (Calarco 1977).

TABLE 4-2
COSTS OF COALS

Year	Anthracite		Bituminous	
	Per Ton	Per Million Btu	Per ton	Per Million Btu
1976	\$ 34.00	\$1.34	16.75	0.70
1985	62.51	2.48	46.00	1.92
1990	87.67	3.48	68.00	2.83
1995	122.96	4.88	98.50	4.10
2000	172.46	6.84	144.50	6.02

Sources: Manula et al. 1978; Coal Week 1978.

TABLE 4-3

DIFFERENCES IN EQUIPMENT DESIGN AND OPERATION - ANTHRACITE VERSUS BITUMINOUS COAL

Boiler and Auxiliaries

Furnace

(Anthracite's inherently low volatile content makes it difficult to ignite, requiring long resident time and hotter combustion zones to complete combustion.)

- "Downout" or "Arm Firing" and a refractory lined lower furnace are employed for anthracite firing, whereas bituminous firing employs horizontal firing in either "front and back" or "tangential" firing arrangements. The refractory lining and large furnace values below the arch makes the anthracite boiler more expensive than the bituminous boiler.
- In general, the anthracite boiler efficiency is about 2% less than a comparable bituminous boiler's efficiency. In some instances, an anthracite boiler may be more efficient than a boiler firing "poor" bituminous, sub-bituminous, or lignite.
- The typical anthracite boiler size, utilizing present "proven" technology, is 600-650 MW compared to a 1300 MW bituminous boiler.
- An anthracite boiler will be more difficult to cycle than a bituminous boiler. More oil consumption is required. Approximate min. load without oil: bituminous - 30 to 40% load; anthracite - 50% load.

Firing System (Including Mills)

- Anthracite is typically "harder" than most bituminous coals. This requires larger mills and more power input for coal grinding. Typically, ball and tube mills are employed instead of "bowl" mills. The ball and tube mills require more floor area and are more expensive than bowl mills of comparable output.
- Coal pipe maintenance is greater with anthracite than bituminous due to harder coal. The coal pipes are installed with wear backs and are designed for low coal transport velocities.

Flue Gas Dust Removal

- Anthracite's low sulfur content makes its fly ash more difficult to collect in electrostatic precipitator than bituminous'. Therefore, the industry trend is to utilize bag filters in low sulfur coal ash applications. Bag filters have about the same capital cost as precipitators for high sulfur coals but have substantially higher operating costs. The higher operating costs are due to high flue gas differential pressure (3-5") than a precipitator's (1/2-1").

Estimated costs for a 600 Mw bituminous-fueled power plant without flue gas desulfurization is \$674 per kw in 1976 dollars (EPRI 1977). By escalating this estimated price by 7% per year, the following future cost estimates were produced.

<u>Plant Completion</u>	<u>Cost (\$/kw)</u>
1975	674
1985	1,083
1980	1,510
1995	2,118

Calculation of the cost of electricity due to plant costs were made on the basis of a 70% capacity factor. The results of these calculations are shown below.

<u>Plant Completion</u>	<u>Cost (\$/kw)</u>
1978	14.1
1985	22.7
1990	31.6
1995	44.3

4.4 Scrubbing Costs

The base case considered for scrubbing of SO₂ from flue gas is the NSPS/BACT requirement for 90% removal on anthracite and bituminous-fueled plants. Assuming four 150-Mw scrubber modules plus one redundant module on each plant, the approximate sludge cost differential is 2.7 mills per kwh or \$6 per ton. A breakdown of these costs for the bituminous plant and anthracite plant is presented in Table 4-4. Most of the cost differential is due to reduced capital expenditures for materials handling, the reduced need for limestone, and reduced sludge handling costs for the anthracite plant.

Consideration of other flue gas scrubbing scenarios is based on Figure 4-1, which shows SO₂ emission rates for anthracite and both 2% and 2.5% sulfur bituminous for various flue gas desulfurization removal rates. A flexible interpretation of a NSPS/BACT requirement for 90%

TABLE 4-4
SLUDGE COSTS

	Dollars per Dry Ton	Anthracite	Mills per kwh 2% S Bituminous	3.5% S Bituminous
Base Case (Pond-clay lining)	18.73	0.28	0.81	1.43
Synthetic Lining	6.03	0.09	0.26	0.46
Proprietary Fixation	2.44	0.04	0.11	0.19
Trucking 5 Miles	16.67	0.25	0.72	1.27
Trucking 10 Miles	33.33	0.51	1.45	2.54
Trucking 15 Miles	50.00	0.76	2.17	3.82

Note: Costs are additive to the "base case" costs.

Sludge Production: Anthracite - 30 pounds per Mw hour
 Bituminous (2% S) - 84 pounds per Mw hour
 Bituminous (3.5% S) - 130 pounds per Mw hour

Source: FPC 1977.

Figure 4-1 Emission Rates

removal on 2% sulfur (S) bituminous would produce a requirement for 70% removal on 0.7% S anthracite to maintain the same emission rate. Correspondingly, 85% removal on 2% S bituminous equals 54% removal on anthracite and 80% removal on 2% bituminous equals 39% removal on anthracite. As the percent removal required on anthracite decreases, a reduction in capital costs is realized as the number of scrubber modules is reduced. However, the reduction in capital costs is not nearly as great as the reduction in removal, because much of the capital cost of an FGD system is for equipment that is not substantially reduced when a scrubber module is removed from the system. Figure 4-2 shows graphically the breakdown of costs for an FGD system. The absorber trains only account for 39% of capital expenditures. Reducing the number of absorber trains by 50% would reduce the total costs by only 20%. Consequently, the benefits of partial scrubbing are not as great as might be anticipated. Reduced scrubbing does have cost advantage in operation and sludge disposal. The total cost advantage to anthracite from the flexible interpretation of BACT scenarios of 90%, 85% and 80% removal are 3.5, 3.6 and 3.8 mills per kwh, respectively.

One of the most variable aspects of scrubbing costs is sludge disposal costs. Table 4-4 gives a listing of optional sludge disposal scenarios with associated costs for anthracite and bituminous coal. As noted above, the base case that was used in the cost estimates given above is a disposal pond with a clay lining that costs 0.28 mills per kwh for anthracite and 0.81 mills per kwh for bituminous. Costs for other disposal methods are additive to the base case. For instance, if a plant were to use a proprietary fixation agent and track the sludge 15 miles to a landfill disposal site, the cost would be 1.08 mills per kwh for anthracite and 3.09 mills per kwh for bituminous. Thus, in this case, anthracite has a cost advantage of almost 2 mills per kwh over bituminous rather than the 0.5 mills per kwh advantage provided by the base case.

4.5 Cost of Electricity

The relative costs of electricity produced by anthracite and bituminous fuels are shown in Figure 4-3. Electricity from the bituminous plant costs about 34.6 mills per kwh, assuming 90% SO₂ removal. For

Figure 4-2 Capital Cost Breakdown of a Typical Flue Gas Desulfurization System

Note: Plant located at anthracite mine

Figure 4-3 Electric Power Cost Comparison

this same scenario without a flexible interpretation of NSPS, electricity from the anthracite plant is about 1 mill per kwh more expensive than electricity from the bituminous plant. A flexible interpretation with the 90%, 85%, and 80% removal requirement in each case leaves the cost of electricity from the anthracite plant essentially equal (within .5 mills per kwh) to the cost of electricity from the bituminous plant. Figure 4-4 shows the reduction in electricity costs as the scrubbing requirement on anthracite decreases.

4-13

Figure 4-4 Reduction in Electricity Costs

5. SOCIOECONOMIC AND ENVIRONMENTAL BENEFITS OF INCREASED ANTHRACITE PRODUCTION

5.1 Socioeconomic Benefits

5.1.1 Historical Conditions

Starting with the very first coal production operation, the population and economy of the anthracite region of Pennsylvania have fluctuated with the fortunes of that industry. Figure 5-1 demonstrates the profound influence the coal industry has had on the economy and population of the region. The only significant deviation from the pattern occurs during the World War I (WWI) period, when peak production was not met with a coincident peak in employment. The war influenced a subsequent decline in the employment figures, while driving demand and production upward. The post-war period shows a decline in production, while employment numbers rose. This is due to an increased availability of labor while the nation began to switch to forms of energy other than coal.

The relationship of coal production to coal employment is an important one. During periods when the peak production of coal was the dominant economic activity in the anthracite region, the industry was also the major employer. The peak employment in 1924 for Schuylkill County was in excess of 25,000 and 162,500 for the region as a whole. As the demand for coal fell, employment decreased, and today the industry employs less than 4,000 people. Two major counties of the anthracite region, Luzerne and Lackawanna, have diversified their industrial bases and have reacted less violently to the depression and decline of their dominant economic activity. Schuylkill County has not been able to diversify as successfully.

Between 1960 and 1970, the anthracite work force dropped approximately 70% from 20,269 to 6,286 as the result of declining demand and the increased trend toward surface mining with its lower manpower needs. The differences between the major counties of the anthracite region are clearly demonstrated by their population changes during this period (Figure 5-2). Although both Luzerne and Lackawanna Counties have experienced major population declines since 1930, the period from 1960

Source: Larkin, Peters, and Spicer 1972.

Figure 5-1 Production and Employment Figures for the Anthracite Region

Source: EDCMP 1973.

Figure 5-2 Population Change in the Anthracite Counties of Northeastern Pennsylvania 1930 to 1970

to 1970 showed a stabilization trend. During the same period, Schuylkill County continued to show a population decline. The development of a diversified industrial base in Luzerne and Lackawanna Counties during this time period appears to be the main cause of stabilization. Schuylkill County's downward population trend was the result of a failure to develop a significant number of viable new industries. Without the development of industrial possibilities in Schuylkill County, even the present population cannot be maintained, and additional people will not be attracted to the area.

Many areas of present and former anthracite production are characterized by widespread land disruption and small communities with limited prospects for economic growth. Population in these areas has usually steadily declined, and outmigration of young adults has skewed the population toward an older age composition. Considerable investment in land and water reclamation is necessary in many areas.

In Schuylkill County, any new industry developed since the decline of coal has been in the small manufacturing sector. This new sector has not employed those who would otherwise be working in the mines, but has usually provided jobs for middle-aged women. Many of these women, who may not have been employed before, have been forced to take low paying manufacturing jobs to compensate for mining jobs lost within the family, as miners are generally unemployable elsewhere. In Schuylkill County, much of this new industry has been in the garment or textile manufacturing. These firms are usually small (10 to 50 employees) and economically unstable.

Thus, with the decline of anthracite coal production and the failure of industry in the region to diversify significantly, the economic picture and population situation have been one of decline. The mid-1970s, recession hit the Schuylkill County area extremely hard. The population situation reflects this with high out-migration maintained by exceptionally high death rates and an aged character of the area (Pennsylvania State University 1976).

5.1.2 Potential Socioeconomic Benefits

Planners in the Schuylkill County area have stated that the decline in the county's population should "bottom out" within the next decade, as it already has in neighboring counties (Manula et al. 1978, p. 96). They have urged strongly for diversified manufacturing to increase the presently low median income of county families. The development of industrial parks rather than scattered manufacturing concerns has been the pattern of the past ten years and these have had success in attracting new industry to the county. Concern has also been expressed that the negative image of the anthracite industry will prevent some manufacturing industries from entering the region. Such new industries are needed to help stop the out-migration of young workers, and recently numerous economic groups have worked actively to improve the county's image and attract new employers.

A revitalized anthracite industry would have to merge into this pattern as an integral part, rather than a dominating factor. The social and economic effects of the proposed operations would doubtless be widespread and many not readily quantifiable. The most obvious will be the creation of jobs in an area with chronic unemployment problems and insufficient jobs for male workers. A maximum work force of 973 is expected to be employed by a new large open pit [average work force of 700 (Manula et al. 1978, p. 304)]. Of these, it can be anticipated that a large proportion of the higher salaried positions would be filled by personnel from outside the area, while local residents would make up the remaining positions. Commuters already make up a considerable proportion of the regional labor pool, and there is no reason to expect that this pattern would be changed. An area from Hazleton to Portsville lies within relatively easy commuting distance of the mine site, so little in-migration could be expected that would make undue demands on housing or services.

To assess the possible mine impacts on the local population, a demographic simulation program (Knight and Feuss 1976) was applied to three population levels: community, township, and county. Results suggest that the proposed mine would be effective in curbing the population declines that have characterized the area for many decades. The

population declines anticipated for the "no mine" alternative are due to both the high out-migration rates for young people and the high proportion of older people in the area. The "with mine" alternative, however, indicates that many young people would be encouraged to remain in the area, thus reducing the out-migration rates.

The proposed mine operation would have a maximum payroll of about \$17.5 million (\$12 million for an average work force) per year that can be expected to have a positive effect on the local economy. Other major taxes of benefit to the region would be as follows:

Local taxes per year	\$ 110,197
Royalties per year	.3,000,000
Union welfare per year	3,600,000

The estimated annual operating and maintenance costs of the project are \$32,485,936. The relocation of approximately 26 families from the mine site will also have a socioeconomic impact on the area. However, although relocation is a costly and traumatic procedure, it is an unavoidable impact of the proposed operation.

5.2 Environmental Benefits

5.2.1 Impacts of Anthracite Versus Bituminous Mining

The primary differences between the environmental effects associated with anthracite mining and those associated with bituminous mining are largely due to the differences in geological conditions associated with each. Bituminous coal deposits are generally flat lying to moderately tilted tabular beds with great lateral extent occurring in areas of low to moderate topographic relief. However, anthracite generally occurs in moderately to very steeply dipping beds in areas of complex geologic structure and moderate to high relief. Anthracite beds may thicken or thin greatly over a short distance or may be terminated or displaced at faults. In addition, anthracite beds are generally thicker than bituminous beds and can be mined economically to greater depths.

Due to the geological conditions described above, anthracite mining generally proceeds to greater depths than does bituminous mining and generally involves less surface area disturbance per unit of coal

production. The greater depths and generally smaller areal extent associated with anthracite surface mining dictate somewhat different environmental effects than those associated with bituminous mining, particularly with regard to surface area disturbance, waste material storage, and groundwater conditions. Since anthracite mining commonly involves less surface area disturbance than bituminous mining, attendant impacts to vegetation and soil due to clearing, grubbing, and materials storage are also less extensive. Additionally, anthracite mining commonly generates less waste material to be stored or disposed of per unit of coal produced than bituminous mining. However, deeper excavations in anthracite mining carries an increased potential for interference with the local groundwater regime in comparison to bituminous mine excavations. The necessity of lowering the water table prior to deep open-pit mining can lead to dewatering of aquifers and potential adverse impacts on water supplies. The large quantities of water generated by dewatering of deep surface mines may create water treatment and disposal problems of a greater magnitude than generally associated with bituminous surface mining. Additionally, the proximity of potential anthracite mines to previously mined areas presents the potential for special problems related to drainage from the mine site into abandoned workings and to induced land subsidence. It is important to note that hydrogeological impacts will vary for each new anthracite mining site as a function of the local groundwater conditions, the extent and layout of abandoned workings, and the mitigative measures applied to each mine. As discussed in Section 5.2.2, the potential exists for significant environmental benefits to groundwater and other environmental elements as a result of new anthracite mining in previously worked areas.

Other differences between environmental effects associated with anthracite mining and bituminous mining are related to noise, erosion and sedimentation, and soils. The rock units present in the anthracite region are generally harder and more competent than those of bituminous regions. Thus, anthracite mining requires a greater amount of explosives, creating greater local noise and vibration impacts. The relatively steep slopes in the anthracite region dictate a greater potential for erosion of exposed surface areas and sedimentation problems. Finally, the soils of the anthracite region are generally more poorly developed

than those of the bituminous region, thus, less productive soil is available for revegetation of mined-out anthracite areas.

In summary, the technology applied to surface mining of anthracite and bituminous is similar; however, some differences in the potential for environmental impacts are brought about by differences in the geologic conditions present in anthracite versus bituminous regions. Although most factors are highly site-dependent, anthracite surface mining generally has environmentally-related advantages over bituminous surface mining with regard to surface area disturbance and work material storage and disposal. A somewhat greater potential for adverse environmental impacts to noise, erosion and sedimentation, and groundwater conditions is associated with anthracite mining. Special problems and environmental benefits may be associated with deep surface mining of anthracite in previously mined areas, and relatively stringent environmental monitoring and impact mitigation programs may be required in such areas. Environmental benefits that may be realized by mining of previously mined anthracite areas are discussed in the following section.

5.2.2 Potential Environmental Benefits

Increased anthracite production in Pennsylvania may bring about significant beneficial environmental effects by the following mechanisms: mining and reclamation of previously mined areas and generation of reclamation fees under the provisions of Title IV of the federal Surface Mining Control and Reclamation Act of 1977. Environmental elements that may be beneficially affected by new anthracite mining of previously mined areas include groundwater and surface water, air, visual quality, and landforms.

There is evidence that a significant portion of new anthracite mining in Pennsylvania would occur in previously mined areas. Approximately 225 to 450 million tons of recoverable anthracite are contained in refuse banks in Pennsylvania (Urban Services Group 1976) and approximately 60% of current anthracite mining involves reworking areas previously mined (Heine 1977). A computer simulation study (Manula et al. 1978) was conducted to identify sites in Pennsylvania where large-scale open pit anthracite mining is feasible. Five sites were identified, with a total

area of 32,265 acres, approximately 43% to 47% of which is previously mined land. These figures suggest that a revitalized anthracite industry in Pennsylvania would involve a considerable amount of new mining and reworking of previously mined land, thus creating the potential for abatement of existing surface and underground environmental problems.

Reworking and reclamation of culm banks may improve visual quality, abate sedimentation problems, and improve water quality conditions. Many existing culm banks are unsightly, readily erodible, and easily infiltrated by precipitation, thus promoting sedimentation and acid mine drainage. Reclamation efforts can be aimed at reseeding and stabilizing these banks and controlling surface drainage, with the ultimate result being an improvement in environmental quality. Current state requirements prohibit use of existing culm banks within 100 feet of a stream. If such regulations were to be revised to encourage reworking of such culm banks, this would afford a greater potential for environmental improvement as a result of increased anthracite production.

Deep open-pit anthracite mining will, in certain cases, require dewatering of old underground workings containing poor quality groundwater. (Pennsylvania law, reinforced by state Supreme Court Rulings, requires that the present operator must treat all acid mine drainage that flows through his operation, whether it originates in the present operation or from abandoned workings.) Assuming that the water pumped out during dewatering activities is properly treated and disposed of, environmental benefits would be realized in the form of improved groundwater and surface water quality. It is important to note that for the maximum environmental benefits to be realized, attention will have to be given to lining or other means of controlling leaching and drainage from new mine workings.

A detailed site-specific analysis (Manula et al. 1978) of a potential deep surface anthracite mine site in eastern Schuylkill County indicates the potential for substantial improvement of existing local water quality. It is estimated that the site area currently contributes the equivalent of 4,860 pounds of acid, 272 pounds of iron, and 8,190 pounds of sulphates per day to the Little Schuylkill River. The cost of abatement of this discharge has been estimated at \$2,186,069 or \$3,120 per acre. The Manula report concludes that the proposed anthracite mining and reclamation

plan for this site would dewater and eliminate the sources of acid drainage, thus saving millions of dollars of reclamation funds. The water generated during dewatering would be treated by a water treatment plant and would improve water quality beyond the requirements of the Pennsylvania Clean Streams Law (Manula et al. 1978).

Additional environmental benefits that would be brought about by mining of previously mined areas include elimination of culm bank and underground fires (and the attendant air quality impacts), correction of landform damage from past mining, and restoration of soil fertility to currently barren areas. Deep surface mining operations will also cut through old mine workings and reduce subsidence problems in the area of the new mine. In addition, reclamation efforts would improve the suitability of mined out areas for future industrial, commercial, residential, recreational, or agricultural use. However, the location of many of the potentially mined areas may be too remote for development, and land use benefits would be realized for the most part in terms of improved wildlife habitat.

In addition to the potential direct environmental benefits discussed above, revitalization of the anthracite industry in Pennsylvania would produce indirect environmental benefits under the provisions of the federal Sulfur Mining Control and Reclamation Act of 1977. Title IV of the Act, "Abandoned Mine Reclamation," provides for the establishment of State Abandoned Mine Reclamation Programs (SAMRP). These programs will be implemented using capital obtained from the institution of reclamation fees on mine operations; \$0.35 per ton on coal produced by surface mining and \$0.15 per ton on coal produced by underground mining. The Secretary of the Interior will collect these fees and disburse them to State abandoned mine reclamation funds (State funds) established in conjunction with the SAMRP. The Secretary must allocate 50% of the funds collected annually in any State to that State and has the discretionary authority to return the balance of such collections (the remaining 50%). These funds are to be used for reclamation or drainage abatement, as defined in Title IV, of lands and water "left in an inadequate reclamation status prior to the date of this Act, and for which there is no continuing reclamation responsibility under State or other Federal laws." (According to statistics of the U.S. Soil Conservation

Service presented in the House Report on the Act, as of January 1, 1974 there were 159,000 acres of land in Pennsylvania disturbed by coal surface mining and needing reclamation, for which reclamation was not required by existing law.) The funds would support the SAMRP and specific reclamation projects identified in the approved State Reclamation Plan.

Under the provisions of Title IV, reclamation fees collected from mine operators in Pennsylvania would be used to reclaim lands and waters suffering from environmental damage as a result of previous mining activity. Based on U.S. Bureau of Mines estimated production statistics for 1976, anthracite mining would have generated approximately \$2,050,000 in reclamation fees in that year, had the provisions of Title IV applied. At least half of this sum, or over \$1,000,000 would have been returned to Pennsylvania for reclamation of abandoned mine areas. Thus, if anthracite production were increased to 20,000,000 tons annually, reclamation fees totaling \$6,600,000 would be produced (assuming a continuation of present production methods, that is, surface mining accounting for slightly over 90% of all anthracite production). At least \$3,300,000 would be returned to Pennsylvania. The environmental benefits generated by expenditure of such funds would include elimination of some of the environmental problems caused by previous mining activities and would result in socioeconomic benefits due to the availability of previously mined lands for other uses.

In summary, available evidence suggests that given careful attention to mitigation of new impacts, increased anthracite production carries a great potential for environmental improvement in previously mined areas, particularly with regard to acid mine drainage, visual quality, and correction of landform damage. It is clear that potential adverse and beneficial impacts will vary substantially from site to site within the anthracite region, however one detailed site-specific analysis (Manula et al. 1978) concludes that significant water quality benefits would be realized with anthracite production in an area in eastern Schuylkill County. Reclamation fees collected during anthracite production would also contribute significantly to the improvement of environmental conditions in previously mined areas in Pennsylvania.

DRAFT

6. CONCLUSIONS

The primary constraints and incentives affecting the viability of increased anthracite production in Pennsylvania through use as a utility boiler fuel are related to (1) inherent advantages and disadvantages of anthracite versus bituminous coal, (2) geographical considerations, and (3) the existing and future state and federal regulatory framework.

Anthracite is inherently low in sulfur content (a nominal 0.7% versus 2.0% for bituminous coal) and thus is a resource capable of providing energy in a more environmentally beneficial manner than alternative coal resources. In addition, anthracite is characterized by a higher energy output (5% higher per pound) than bituminous coal. On the other hand, anthracite is difficult to mine because of its hardness and the geological environment where it occurs, and thus incurs an initial cost disadvantage relative to alternative fuels. Anthracite has a higher ignition temperature than bituminous coal and thus requires more costly boilers. Additionally, anthracite requires more costly particulate-removal systems than does bituminous and is also somewhat more costly to transport by rail. A potential major negative factor is the variability of sulfur content within anthracite deposits, as there is at present no means of mining for the average sulfur content. Pennsylvania Power and Light has recently abandoned its large-scale anthracite utilization plan, citing on-site sulfur content variability as a major constraining factor.

The geographic location of the anthracite region creates a number of economic and environmental advantages that influence the viability of increased anthracite production. Anthracite fields in Pennsylvania are within 150 miles of approximately one eighth of the U. S. population, making anthracite more favorable for mine-mouth power generation than bituminous coal. Pennsylvania anthracite fields are also in proximity to existing transportation systems. Moreover, the anthracite region is currently economically depressed and has been environmentally degraded by past mining activities. Much of the region is currently unsuitable for most nonmining uses. Thus, anthracite production carries with it a potential for local beneficial environmental and socioeconomic benefits (see Section 5).

Numerous Pennsylvania and federal laws affect the viability of increased anthracite production; however, regulatory considerations regarding the BACT requirements are likely to have the most bearing on the future of anthracite as an energy source. If the same NSPS percent SO₂ reduction regulations apply to anthracite as would apply to bituminous coal, anthracite will not be cost competitive for use in utility boilers with bituminous coal. A flexible interpretation of NSPS, requiring equal emission rates from anthracite and bituminous coal, would provide some economic incentive for utilities to use anthracite coal. As the percent removal required on anthracite decreases, a reduction in capital costs is realized as the number of scrubber modules is reduced. The total cost advantage to anthracite from a flexible interpretation of the reduced NSPS scenarios of 85% removal and 80% removal are 3.6 mills per kwh and 3.8 mills per kwh, respectively (see Section 4).

There are large uncertainties in the mining technique for anthracite and in the design and construction of the large anthracite boilers. It appears, however, that anthracite fired boilers are 30% more costly than bituminous fired boilers and that plant construction and mining costs are 10% to 15% higher for anthracite due to the need for heavier and more expensive crushers, conveyers, and burner designs than those required for a bituminous plant. The baghouses required on an anthracite plant are also 25% more expensive than the electrostatic precipitators on a bituminous plant (cost differential of 0.4 mills per kwh). However, due to reduced scrubbing costs under a flexible interpretation of the 90%, 85% or 80% NSPS scenarios, the cost of electricity from a mine-mouth anthracite-fueled power plant located in eastern Pennsylvania would be roughly equal to the cost of electricity from a bituminous-fueled power plant at the same location. Although this analysis concludes that a flexible interpretation of NSPS would provide some economic incentive for the construction of anthracite fuel power plants, it is not obvious that this incentive alone would ensure increased use of anthracite as a utility boiler fuel. The uncertainties involved in large-scale mining and use of anthracite must be viewed as a major impediment.

Other factors that make anthracite currently attractive for development as a new energy source are: (1) potential relief of a degree of unemployment in the anthracite mining area and (2) reclamation of previously mined land. Firstly, an estimated 700 to 973 workers will be employed by the mining operation. Although the revitalization of the anthracite industry will have a minimal job creating potential, substantial increases in anthracite production will result in major local tax benefits and increased wage, royalties, and union welfare payments per year (see Section 5). Secondly, reworking and reclamation of culm banks may improve visual quality, abate sedimentation problems, restore soil fertility, and improve water quality conditions. In addition, reclamation efforts would improve the suitability of many previously mined areas for future industrial, commercial, residential, recreational, or agricultural use (see Section 5.2.2).

Currently, the most important expansion market for anthracite is the electrical utilities/power generation area, where the major competitors are other forms of coal. Existing utility companies in the vicinity of the anthracite fields (PP&L, New York State Electric and Gas, Metropolitan Edison, Pennsylvania Electric, and Philadelphia Electric) are the most likely potential markets. However, the extent of expansion of anthracite into these areas of the energy market is difficult to assess given current market and technological uncertainties concerning new electric power plants. The (potential) significance of any energy user as an expansion market for anthracite will be a function of the comparative costs of other fuels, ensured long-term availability of anthracite at an attractive price, the degree of flexibility incorporated into the NSPS, and the degree of uncertainty inherent in new anthracite mining and use technologies.

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