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WATER TRANSPORTATION REQUIREMENTS FOR COAL MOVEMENT IN 1985

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16. Abstract

This study of transportation requirements for coal movements through 1985 is one of a series conducted for the U.S. Department of Transportation on identify and quantify future transportation requirements for energy materials.

This report presents the results of the study. The primary objectives of the study were to develop a scenario for 1985 coal production and consumption and to project water coal traffic columes and equipment and facilities requirements consistent with the scenario. A second objective was to identify the planning processes used by the water carriers to identify and prepare for future traffic. The third objective of the study was to identify potential constraints to and institutional issues impacting increases in water coal traffic and the ability of the water carriers to handle it profitably.

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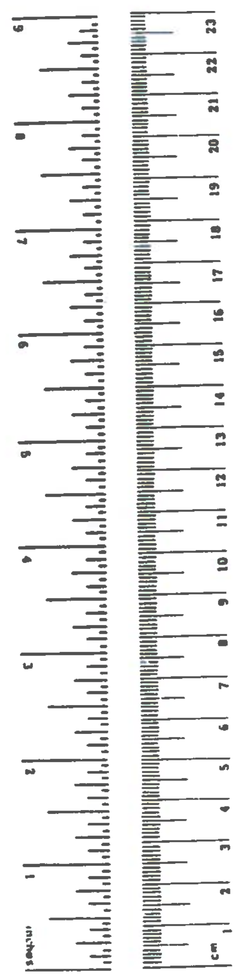
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

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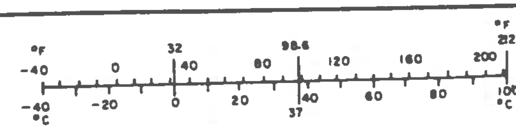
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This water-oriented coal transportation study is one of a series of studies conducted for the Department of Transportation to identify and quantify transportation requirements for energy materials. Information provided by these studies will be used by government and industry to examine and shape present and future transportation policies and related resource allocation decisions.

This report documents key findings of Input Output Computer Services, Inc. (IOCS) under Contract DOT-TSC-1282 to the U.S. Department of Transportation, Energy Policy Division and Transportation Systems Center. The study was performed during 1977 and reflects data available at that time.

In an undertaking that involved so many organizations and complex issues, the debts of the authors to others are quite extensive. Much help was derived from the published and nonpublished reports of others in the energy and transportation fields. We are indebted to the following organizations for providing valuable assistance in collecting and analyzing data and reviewing the report material. Without their help, this study could not have been successfully completed.

The American Waterways Operators, Inc.
The Lakes Carriers' Association

The officials within the barge industry and the AWO provided valuable insight into outstanding issues. In this connection we would like to thank Mr. J. R. Smith, Mr. N. Schuster, Mr. A. Kucera, Mr. D. Buchanan and Mr. M. Scheidt.

We also appreciate the inspiration and knowledge provided by Dr. David L. Anderson who was Chief, Industry and Policy Analysis Branch, Transportation Systems Center and Technical Monitor for most of the study. We also appreciate the guidance of Dr. Larry Vance, Technical Monitor for the later stages of the study. Both men provided advice and guidance and created the environment which allowed successful completion of the project.

Finally, the authors wish to express their gratitude to the many others whose considerable effort helped to bring this project to a successful conclusion.

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EXECUTIVE SUMMARY

INTRODUCTION

Since the U.S. embarked on the effort to become energy self-sufficient, it has been apparent that coal would be an increasingly important energy source. Subsequent events such as the critical shortages of natural gas during the winter of 1976-1977, the continuing public resistance to nuclear power and the delay in commercial development of breeder reactors indicate that the development of coal as the major "new" source of energy will occur. As with any undertaking of its magnitude, the formulation of plans and programs to develop and control the future energy mix in the U.S. is an extremely complex process. One integral part of the process is to determine the requirements for distributing the energy, in this case coal, from its source to points where it will be needed. Information presented in this study, along with others conducted by the U.S. Department of Transportation, Office of Intermodal Transportation,Energy Policy Division, will be a valuable aid in planning future national energy programs and assuring that resources are available to meet national energy goals.[1]

The focus of this study is 1985 requirements and issues related to water transportation of coal.

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[1] This study was performed before President Carter's energy policy announcement. The study coal forecasts and those in the President's energy plan are similar.

STUDY PURPOSE AND OBJECTIVES

The purpose of this study is to present information on the long range transportation requirements and related issues to those responsible for setting energy policy and developing energy programs. In support of this purpose there are four primary objectives.

- Develop a reasonable forecast of the volume of coal traffic and the traffic patterns in 1985.
- Develop transportation industry estimates of the equipment and facilities required to move the forecast coal tonnage.
- Identify and describe the long range planning processes and tools used by carriers to prepare for the expected increases in coal traffic.
- Identify and describe potential constraints, technologies and institutional considerations which will impact the transportation of coal in the future.

When possible, comparisons are made between 1975 coal traffic and 1985 coal traffic.

STUDY METHODOLOGY

The approach selected to perform this study was to present a forecast level of coal production and consumption to the water carriers through their respective associations and have them estimate the transportation requirements for the projected coal traffic. The study was designed to implement this approach in three steps. The first step was to identify and analyse coal production and consumption forecasts and the assumptions underlying them. This was accomplished by reviewing the most recent literature on future energy scenarios and by interviewing representatives of industry and government organizations. More than sixty scenarios were reviewed and analysed in light of industry and government expectations of events influencing future energy developments. These scenarios are discussed in section 4.1. The result of this process was a forecast of coal production and consumption by state for 1985.

The second step was to present the forecast coal production and consumption data to the water carrier associations. The associations then projected transportation requirements based on the coal forecasts. These associations are composed of the water carriers which operate on the inland waterways and Great Lakes. Because the information requested from the associations concerns the competitive positions of carriers vis-a-vis each other and with other modes for traffic, it is of an extremely sensitive nature. Therefore, each association must maintain the confidentiality of its members' information by submitting aggregate data for all member roads participating in the study.

The third step in the study design was to interview water carriers to develop information on the possible constraints, technological developments and institutional factors influencing their ability to generate and properly handle increased coal traffic.

The information gathered through these three steps has been evaluated and analysed and is presented in this report.

STUDY FINDINGS

The findings of this study presented in this report are the result of the best judgement of the authors. They were compiled from the best available data and insights of the water transportation industry, coal industry and others. It should be kept in mind, when reviewing these results, that they are based on a hypothetical scenario which may or may not represent reality in 1985. There are still many uncertainties surrounding the development of coal as the primary energy source for the U.S. whose resolution will significantly impact the projections presented in this report. Careful observation of future developments is required to gain maximum benefit from these findings.

- The U.S. consumption of energy continues to grow at a rate which cannot be sustained by the current mix of energy sources. Development of alternatives to oil and gas are mandatory. Coal, the most abundant fuel in the country, will fill much of the U.S. energy needs for the future.

- Most forecasts of 1985 coal production project about 1 billion tons. This represents an increase of about 400 million tons over 1975 production. The estimates used in this study were prepared prior to President Carter's policy. However, the coal production forecast of 1.1 billion tons for 1985 is very close to that of the President's plan.

- Due to a lack of a generally accepted comprehensive national energy plan and conflicting policies within the Federal government, coal producers and consumers face serious roadblocks in their efforts to expand coal development. Environmental protection standards for mining and burning coal which recognize the necessity for meeting energy demands economically will resolve many of the problems. Policies in these areas are still in debate in Congress and within the administration.

- Four carriers provided data representing coal movement on the Mississippi, Ohio, Tennessee, Kanawha and Green rivers. The carriers represented carried 39% of the coal tonnage originated on these waterways in 1975. The 1985 projected coal traffic on these rivers is 150 million tons assuming that current market shares continue.

- The increase in equipment required to handle projected 1985 coal traffic for the participating carriers is 1,120 barges, measured in 1500 ton barge equivalents. Towboat requirements above existing fleets are projected at 48 towboats for total horsepower increase of 121,900. Total investment estimated for towboats and equipment at 1976 prices is about $340 million.

- Since the navigation facilities are provided by the Federal Government, the water carriers only estimated shore facility requirements. Three new coal loading facilities were projected at a cost, at 1976 prices, of $19 million.

- There are several potential constraints to the growth of coal traffic on the inland waterways. The Upper Mississippi River has 27 locks and dams (L&D) including L&D 26 at Alton, Illinois. All of these facilities have small lock chambers by modern standards. Each is a potential bottleneck. The locks on the Tennessee River are also projected to become congested by 1980.

- User charges or tolls on the inland waterways will have some impact on the future growth of coal traffic. A recent Department of Transportation study and a study performed for the Army Corps of Engineers have estimated the impact on total traffic as a maximum reduction of about 10% in waterway traffic. The impact on coal traffic may be somewhat less because many coal receivers can only take coal by water.

- Great Lakes carriers project 1985 coal traffic at 27.5 million tons in domestic trade. This is about a 26% increase over 1975. Western Coal is expected to become a major segment of the lakes traffic. If the relationship between domestic and export traffic holds through 1985, export traffic would be 20 million tons.

- Total vessel requirements for 1985 Great Lakes Coal Traffic were provided in two configurations. First, 10 vessels of 1000 feet length and 60,000 tons capacity. (These vessels may be built to a length of 1100 feet.) Or, second, 16 vessels 610 feet long, 5 vessels 800 feet long and one 604 feet long. The total investment for the first option is $450 million and for the second over $500 million.

- As with the Inland waterways, navigation facilities are provided by the Federal Government. Lakes carriers estimate that at least one new transshipment facility will be needed on the eastern shore of Lake Erie. Also, expansion of existing facilities at Duluth and Lake Erie ports. The investment required could not be accurately estimated for these facilities.

- Potential constraints to increases in coal traffic on the Great Lakes are related to channel and harbor dredging. Environmental rulings require the Corps of Engineers to deposit dredged materials in special diked areas. Construction of these areas is time consuming and expensive. The effect is to severely limit the amount of channel and harbor maintenance performed each year.

- User charges will impact the Great Lakes traffic to some extent. The impact will depend on the form of tolls and on the comprehensiveness of the tolls. User charges are not expected to reduce current levels of Lakes traffic. They may have a marginal impact on growth of coal traffic where rail and water rates are similar. The western coal projected for 1985 will probably not decline due to user charges.

1985 Coal Forecast

The study design required selection of a 1985 coal production-consumption forecast as the basis for estimating transportation requirements. After review of over 60 forecasts, the Federal Energy Administration (FEA) Reference

Scenario was chosen. The Reference Scenario provided coal production forecasts by supply regions and consumption forecasts by Bureau of Census regions. Consumption data were also provided according to type of consumer. Discussions with the National Coal Association and with utilities about planned capacity expansion through 1985 lead to modification of the forecasts. The resulting production and consumption forecasts are shown by state in Table 1 and Table 2 respectively. Total 1985 production is projected to be 1.1 billion tons and consumption is projected to be 1 billion tons.

TABLE 1

1985 Coal Production Forecast

(thousand tons)

STATE	1985 COAL PRODUCTION	STATE	1985 COAL PRODUCTION
Alabama	34,570	Ohio	58,397
Alaska	766	Oklahoma	2,455
Arizona	14,299	Pennsylvania	101,801
Arkansas	632	Tennessee	9,200
Colorado	21,524	Texas	29,202
Illinois	106,830	Utah	17,110
Indiana	43,162	Virginia	39,570
Iowa	663	Washington	3,738
Kansas	1,107	West Virginia	164,814
Kentucky	184,622	Wyoming	183,346
Maryland	4,521		
Missouri	6,641	TOTAL	1,133,918
Montana	58,640		
New Mexico	19,297	TOTAL EAST	747,469
North Dakota	27,011	TOTAL WEST	386,449

[1] The totals for east and west are based on a division along the Mississippi River. This approximates the division between western railroads and eastern and southern railroads. As the data were developed on a state-by-state basis, aggregation by coal mining districts would have introduced inaccuracies from arbitrary allocation. Eastern coal production was not broken down further because of the overlap in areas served by eastern and southern districts.

TABLE 2

Estimated Total Coal Consumption 1985

(Thousand Tons)

CENSUS REGION	ELECTRIC UTILITIES	HOUSEHOLD/ COMMERCIAL	COKE & GAS	ALL OTHER	TOTAL
NEW ENGLAND	987	20	-	696	1,703
Connecticut	4	1	-	210	215
Maine	-	4	-	178	182
Massachusetts	17	15	-	262	294
New Hampshire	935	-	-	32	967
Rhode Island	18	-	-	14	32
Vermont	13	-	-	-	13
MID-ATLANTIC	58,880	254	33,077	26,946	119,157
New Jersey	2,256	5	-	483	2,744
New York	12,004	50	6,408	7,203	25,665
Pennsylvania	44,620	199	26,669	19,260	90,748
SOUTH ATLANTIC	99,771	987	10,180	37,240	148,178
Delaware	2,508	-	-	77	2,585
Florida	12,165	-	-	-	12,165
Georgia	16,812	30	-	1,043	17,885
Maryland	6,572	21	4,256	2,446	13,295
North Carolina	21,255	207	-	5,212	26,674
South Carolina	5,564	128	-	4,620	10,312
Virginia	3,870	354	-	8,141	12,365
Washington, D.C.	79	18	-	574	671
West Virginia	30,946	229	5,924	15,127	52,226
EAST NORTH CENTRAL	194,804	2,111	39,290	94,273	330,478
Illinois	43,556	540	3,596	15,208	62,900
Indiana	41,279	277	15,786	16,111	73,453
Michigan	24,744	246	4,449	15,543	44,982
Ohio	64,959	791	15,181	39,389	120,320
Wisconsin	20,266	257	278	8,022	28,823
EAST SOUTH CENTRAL	87,505	383	9,546	23,044	120,478
Alabama	26,623	19	7,729	8,183	42,554
Kentucky	37,104	187	1,621	7,249	46,161
Mississippi	1,545	-	-	168	1,713
Tennessee	22,233	177	196	7,444	30,050

TABLE 2

CENSUS REGION	ELECTRIC UTILITIES	HOUSEHOLD/ COMMERCIAL	COKE & GAS	ALL OTHER	TOTAL
WEST NORTH CENTRAL	91,558	452	1,177	16,030	109,217
Iowa	13,629	59	-	4,462	18,150
Kansas	16,830	2	-	486	17,318
Minnesota	20,485	166	842	3,420	24,913
Missouri	26,439	111	335	5,446	32,331
Nebraska	6,190	7	-	1,089	7,286
North Dakota	4,898	88	-	1,113	6,099
South Dakota	3,087	19	-	14	3,120
WEST SOUTH CENTRAL	41,399	3	1,019	9,051	51,472
Arkansas	8,448	-	-	392	8,840
Louisiana	4,320	-	-	-	4,320
Oklahoma	11,840	2	-	602	12,444
Texas	16,791	1	1,019	8,057	25,868
MOUNTAIN	84,134	357	3,503	7,371	95,365
Arizona	9,800	-	-	39	9,839
Colorado	18,044	53	1,286	1,709	21,092
Idaho		96	-	1,172	1,268
Montana	7,820	6	-	192	8,018
New Mexico	12,290	-	-	25	12,315
Nevada	12,476	1	-	435	12,912
Utah	10,311	184	2,217	2,139	14,851
Wyoming	13,393	17	-	1,660	15,070
PACIFIC	18,044	14	2,492	1,547	22,097
California	9,000	1	-	123	9,124
Oregon	2,000	6	-	490	2,496
Washington	7,044	7	2,492	934	10,477
EXPORT	-	-	-	-	80,000
TOTAL	677,082	4,581	100,284	216,198	998,145

1. INTRODUCTION

Since the U. S. embarked on the effort to become energy self-sufficient, it has been apparent that coal would be an increasingly important energy source. Subsequent events such as the critical shortages of natural gas during the winter of 1976-1977, the continuing public resistance to nuclear power and the ban on commercial development of breeder reactors indicate that the development of coal as the major "new" source of energy will occur. As with any undertaking of its magnitude, the formulation of plans and programs to develop and control the future energy mix in the U. S. is an extremely complex process. One integral part of the process is to determine the requirements for distributing the energy, in this case coal, from its source to points where it will be needed. Information presented in this report, along with others conducted by the U.S. Department of Transportation, Office of Intermodal Transportation, Energy Policy Division, will be a valuable aid in planning future national energy programs and assuring that resources are available to meet national energy goals.

The focus of this study is 1985 coal transportation requirements and issues.

2. STUDY PURPOSE AND OBJECTIVES

The purpose of this study is to present information on 1985 water transportation requirements for coal and related issues relevant to energy policy and programs. In support of this purpose there are four primary objectives:

- Develop a reasonable forecast of the volume of coal traffic and the traffic patterns in 1985.
- Develop transportation industry estimates of the equipment and facilities required to move the forecast coal tonnage.
- Identify and describe the long range planning processes and tools used by carriers to prepare for the expected increases in coal traffic.
- Identify and describe potential constraints, technologies and institutional considerations which will impact the transportation of coal in the future.

When possible, comparisons are made between 1975 and 1985.

3. STUDY METHODOLOGY

3.1 Study Approach and Design

The approach selected to perform this study was to present a forecast level of coal production and consumption to the water carriers through their associations and have the carriers estimate their coal traffic and the transportation requirements. The study was designed to implement this approach in three steps. The first step was to identify and analyse coal production and consumption forecasts and the assumptions underlying them. This was accomplished by reviewing the most recent literature on future energy scenarios and by interviewing industry and government organizations. More than sixty scenarios were reviewed and analysed in light of industry and government expectations of events influencing future energy developments. These scenarios are discussed in section 4.1. Data on planned capacity expansions and views on future expectations were also solicited from the National Coal Association, various electric utilities, the American Iron and Steel Institute and others. These data were used to analyze the scenarios and prepare the coal forecasts used in the study. The result of this process was a forecast of coal production and consumption by state for 1985.

The second step was to present the forecast coal production and consumption data to the water carrier associations. These associations are composed of the carriers which operate on The Inland Waterways and the Great Lakes. Based on these forecasts, the associations projected traffic flow and transportation requirements. Because the information requested from the associations concerns the competitive positions of carriers vis a vis each other and with other modes for traffic and their operating strategies, it is of an extremely sensitive nature. Therefore, each association must maintain the confidentiality of its members' information by submitting aggregate data for all member carriers participating in the study.

The third step in the study design was to identify and discuss possible constraints, technological developments and institutional factors influencing the ability to generate and handle increased coal traffic. In addition to carriers, equipment manufacturers and other industries involved in the coal distribution process were also contacted to determine their plans and capabilities and to estimate costs for components in the transportation system.

The information gathered through these three steps has been evaluated and analysed and is presented in this report.

3.2 Aggregation of Industry Estimates

The data supplied by the water transportation industries consists of estimates of the coal tonnage to be originated by participating members of each association and the equipment and facilities required to handle these flows. The tonnage estimates are based on forecasts of coal production and consumption in 1985 for each state. Several factors in this process dictate that these estimates be aggregated and evaluated. First, the time frame of the forecasts, 1985, requires that the estimates be based on information containing significant uncertainty regarding actual movements by individual carriers. There is competition among carriers serving each coal producing region and competition among regions to serve consumption markets. Therefore, the total of estimates of all regions may include double counting. Double counting occurs when more than one carrier projects that it will carry coal to a particular market. This is not a serious problem. The result of such duplication would be "over-preparedness" by the carriers. For example, if two carriers project coal traffic to the same market and take appropriate steps to prepare for it, one or both will plan for some excess capacity.

There is also expected to be some short haul truck and conveyor transportation to "mine mouth" consumption points. The percentage of coal production which will be consumed by utilities and coal conversion plants located close to mines and the resulting transportation impacts can not be estimated accurately. At one time, mine-mouth consumption plants were expected to be a major factor in the northern great plains region. However, environmental challenges to the construction of utility plants and technological problems in coal conversion processes have blocked the development of these facilities. The greatest problem is the availability of the large amounts of water required for these plants compared with the relatively small amounts needed to transport coal. Questions have also been raised about the relative costs of transporting coal and electricity.

Second, the coal forecasts which form the basis for the study and other data available to the participating carriers are from different sources developed at different times. Therefore, some inconsistencies are to be expected. In order to assess the extent of such inconsistencies, state production and state consumption estimates were to be compared with total rail and water carrier originations and terminations for each state. This analysis was frustrated by grouping of origin states and destination states in carrier supplied data. When originations from a single state appeared to exceed the expected tonnage, based on historical market shares, the carriers were requested to verify their projections. This process resulted in some modification in the estimates of originated tonnage. However, in other cases, the carriers were able to support their projections. Further, as all of the data used in the study - production, consumption, and transportation - are forecasts subject to uncertainty, it is not essential that all the projections meet absolute standards of comparability. The value of this study stems from the use of the best data available to those involved in the production, use and transportation of coal. These data have been aggregated and evaluated and represent the basis for the findings in this report.

4. 1985 COAL PRODUCTION AND CONSUMPTION

The transportation requirements estimates in this study are based on forecasts of coal production and consumption. This forecast represents an estimate selected from many forecasts and scenarios which have been developed since the original Project Independence* reports. Agencies of the Federal Government such as the Federal Energy Administration (FEA) and Bureau of Mines (BOM), States and private organizations have produced estimates, under various scenarios, of future supply and demand for energy. In all of these forecasts coal plays a significant role. The following sections describe forecasts of coal production and consumption for 1985 in the context of total energy, general supply and demand characteristics and other factors.

4.1 National Energy Outlook and Other Scenarios

4.1.1 Total Energy

In 1975, the U.S. consumed 73 quadrillion BTU[1] of energy. The sources of this energy were oil 46%, gas 30%, coal 18%, nuclear and other sources about 6%. Of the oil consumed, 37% was imported. In the years from 1960 to 1974, U.S. energy consumption grew nearly 65%, approximately the same growth in 14 years as in the preceding 40 years. Demand for electricity grew at a rate 175% of that for total energy

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* Project Independence has been renamed National Energy Outlook.

1 British Thermal Unit, the amount of heat required to raise one pound of water one degree fahrenheit.

demand. During this period petroleum became the largest single source of energy. Gross energy inputs[2] are divided among the sectors of the economy as follows: Household and Commercial 19%, Industrial 29%, Transportation 25%, and Electric generation 27%. This translated into 557 million tons of coal, 6 billion barrels of petroleum products, 22 trillion cubic feet of natural gas, 1.9 trillion kilowatt hours of utility electricity (distributed).[3] The trends in energy use were substantially altered in 1975; demand for oil was about 3 million barrels per day lower than continuation of pre-embargo trends would have yielded and coal began to increase its share of energy consumption.

The most important sector in terms of coal consumption is electrical generation. This sector consumed nearly 400 million tons of coal in 1974 and is expected to consume more than 435 million tons in 1976. U.S. electrical generating capacity is currently 482 gigawatts (10^9 watts) of which 186 gigawatts are coal fired, 150 gigawatts oil and gas, 37 gigawatts nuclear and 109 gigawatts other. The largest expected growth is in coal and nuclear plants in most forecasts. If utility industry plans are carried out on schedule,[4] generating capacity in 1985 would be 806 gigawatts, a 67% increase. Coal fired capacity would increase to 318 gigawatts, oil and gas to 170, nuclear to 177[5] and other to 139. There

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2. 1974
3. U.S. Department of the Interior, Bureau of Mines.
4. There is little likelihood of this occurring due to postponements caused by lack of demand and financial problems.
5. The Nuclear Regulatory Commission estimate now sets nuclear generating capacity at about 155 gigawatts by 1985.

is great uncertainty in these estimates. In the last two years, growth in demand for electricity has been substantially below previous levels. Consequently, many utilities have postponed or cancelled planned capacity addition. There are continued problems with the installation of nuclear power plants which have recently resulted in a temporary licensing suspension. Financial constraints have also hampered utility expansion plans.

The second most important coal consuming sector is the industrial sector composed primarily of the use by the steel industry, and other industries using coal as a boiler fuel and coal derivatives as raw materials. Exports may be considered as insutrial use since most export coal is metallurgical or premimum quality coking coal. There are two main issues involved in the future use of coal for industrial purposes. The Environmental Protection Agency has ruled that coke ovens and industrial boilers must meet clean air standards. This ruling has cast doubt on the future expansion of these uses until technology becomes available to meet EPA requirements. One method the steel industry has available is the use of electric furnaces which would reduce direct use of coal. A second issue is the competition between utilities, industry and coke production for available low-sulfur Appalachian coal. This coal is generally of metallurgical grade yet it is now being used by utilities for mixing with high-sulfur high-BTU coal to meet EPA requirements. The increased demand by utilities may reduce the attractiveness of this coal for industrial uses through price increases. Some growth is, however, expected in use of metallurgical coal by the steel industry. Efforts by the FEA to promote large industrial boiler conversion to coal have not met with much success. There have been considerations in both Congress and the Administration of mandatory conversion programs. If these programs are effected, estimates of coal consumption in 1985 range as high as 2 billion tons.

The transportation, household and commercial sectors do not substantially affect the consumption of coal. In 1974, they consumed only about 9 million tons.[6] The only effects of these sectors are secondary from the conversion from oil and gas to electricity.

4.1.2 Historical Perspectives

At the turn of this century, coal supplied 90% of U.S. energy consumption. Since that time, coal has been increasingly displaced by other fuels. The major markets for coal also changed during this time period. Railroads, retail sales and industrial uses at one time consumed nearly all coal production. Today, electrical generation is the largest market for coal, with industrial use, exports, and coke and gas plants dividing the remainder. Retail sales and railroad use are relatively insignificant. Utility consumption of coal represents the only growth market during the past 20 years with the exception of some growth in exports. Even in the utility sector, however, coal has been losing its market share - primarily to fuel oil and to a lesser extent to nuclear power. Some areas of the country have shown a drastic decline in utility coal consumption between 1960 and 1974. For instance, in 1960, coal produced 50% of electrical generation

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6. Transportation sector consumption is zero.

in New England. In 1974, it produced 7%. Similarly in the Middle Atlantic region, coal decreased from 69% to 43%, in the South Atlantic region from 66% to 55%. Even in the East North Central region, which produces substantial amounts of coal, the utility share dropped 11.5% between 1960 and 1974 with oil and nuclear power increasing about equally. The major factors influencing the decline in the coal market share are the availability of cheap foreign oil, especially after the lifting of oil import quotas, and development of commercially viable nuclear power. The eastern seaboard, New England and the Middle Atlantic states, converted to cheap, easy to handle, low sulfur imported oil. Space heating throughout the country converted to oil, gas, and more recently, electricity. The industrial sector similarly converted to these fuels from former dependence on coal. The OPEC oil embargo, declining domestic oil and gas production and higher prices have caused changes in the fuel use patterns and stabilized oil and gas conversions.

4.1.3 Coal Demand Characteristics

Due to the specialized equipment required to use coal as boiler fuel (its primary use), the market for coal is fixed at any given point in time. That is, there is a coal burning capacity in place with only a few facilities able to shift to coal from other fuels on short notice. Therefore, a decrease in the price of coal will not result in substantial increased demand in the short term. Utilities owning both coal and non-coal burning capacity are able to shift their generating load to the coal fired plants, increasing demand somewhat. However, these shifts are marginal in terms of total tonnage. The demand for coal is primarily a function of long-term utility capacity planning. Demand for electricity grew at about 7% per year until 1974. For the past two years the growth has been very small, about 2% per year. The future pattern in demand for electricity is one of the questions in the demand picture for coal.

Coal demand is expected to grow somewhat due to utilities replacing existing capacity as it becomes obsolete or uneconomic to operate. However, the largest portion of coal demand growth is expected to come from new generating capacity. The Regional Electric Reliability Councils expect growth to resume in the 1975 to 1985 period at an annual rate of 6.2% only slightly below historic rates. Other sources suggest rates of 5.5% and lower. At a growth rate of 5.5%, utility coal consumption would be 8 million tons less than the Reliability Councils' estimate by 1980. The other major consumers of coal are industrial users and exports. Industrial uses include use as boiler fuel and in the steel industry. The steel industry uses primarily anthracite and metallurgical quality bituminous coal, neither of which is generally used as a primary boiler fuel.

The price of coal, relative to oil and nuclear power, has an impact on the demand for coal in the long run. Utilities will base planning decisions on the expected price of available fuel. If oil or nuclear power appear less expensive than coal, and fuel supplies can be assured, under contract, the utility will probably plan oil-fired or nuclear generating capacity. However, once coal-fired capacity is installed, the price of coal will have relatively little effect on short-term demand. This is due to the trade practice of purchasing fuel supplies on very long-term contracts. Most, if not all, contracts, executed in today's market, have escalator or renegotiation clauses included which simultaneously allow the price of coal to rise to offset cost increases and allow the utility improved information on how costs will vary. Therefore while the price of coal for new contracts and existing contracts may rise, the demand will remain stable for the duration of the contract period except under extraordinary circumstances.

4.1.4 Coal Supply Characteristics

Coal is not a homogeneous commodity. It has ranges of values on a variety of scales. Some of the quality scales are BTU/lb., volatile content, grind (hardness), ash content and sulfur content. Coals vary from anthracite to bituminous to sub-bituminous to lignite in different sections of the country and may even vary within a particular coal field. Each type of coal requires a particular boiler configuration for optimal burning. Therefore, the substitutability of coal from one region for that of another is limited. There are three principal coal producing regions: the eastern or Applachian coal region, the midwest and the western region. The coal and mining methods vary from region to region. The Appalachian region produces most of the coal in the U.S. In 1972, the Appalachian coal fields produced 65%, the Mid-west 26%, and the West 8%. Appalachian coal tends to be high BTU/lb. coal but also high in sulfur content. Western coal is lower in BTU and in sulfur content. The low sulfur content and relatively low price per ton have stimulated increased demand for western coal in the past few years.

Most coal produced in the U. S. is sold on long-term contract. These contracts vary in length from 5 to 30 years with the average around 20 years. The reasons for this are straightforward. First, opening a coal mine, whether deep or surface, requires a large investment in land and equipment. Mine operators are not likely to make such large investments on speculation. Second, utilities must design and build their boilers to meet fuel specifications in terms of sulfur content, heat rate, grindability, ash content and other factors. The utility must have an assured supply of fuel to meet its demand for the life of the plant. Similarly, because of the regulated nature of the utility industry, utilities must know in advance the cost of fuel for pricing purposes. According to industry sources, in the current atmosphere of uncertainty about EPA regulations and other government policies, mine operators only begin development of new mines after negotiating a contract covering substantially the life of the mine.

The lead-time for both mines and utility plants ranges from four to seven years. A recent survey of mine operators indicates plans to develop approximately 500 million tons of new coal mine capacity by 1985. Production in the west is expected to grow more rapidly than in the east. Planned new mines and major expansions of existing mines indicate new production in the west of 275 million tons and in the east of 224 million.[7] The division between surface and deep mining is 315 million tons and 193 million tons respectively. The actual new capacity additions which are developed by 1985 may be less than planned due to

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7. The east total includes 83 million tons of metallurgical coal. The west total includes 2 million tons metallurgical. Source: National Coal Association.

uncertainty about new regulations on surface mining and pollution controls. Much of the eastern mine expansions are in areas which produce relatively high sulfur content coal. If the full impact of the air quality standards is felt, in terms of expiration of variances, requirements for stack gas scrubbers on all plants, and non- deterioration in its strictest application, the eastern coal may be unburnable given current scrubber technology or the demand for western coal may be reduced. Similarly, if strip mining laws are enacted which severely limit the ability of coal operators to strip coal economically, future generating capacity may be designed for other fuels - oil or nuclear. One other major factor affecting the opening of new mines is the growth in demand for electricity. Many utility plants planned to come on-line in the 1976-1985 time period have been postponed or cancelled due to lack of demand, financial difficulties or licensing problems related to site location or environmental considerations. If these factors continue to prevail, the growth of coal production will also be postponed beyond 1985.

4.1.5 Factors Influencing Future Coal Use

The factors which will influence the future consumption of coal as a primary energy source can be grouped into three categories. The first group is governmental policies and regulations. These consist of environmental regulations on the mining and burning of coal as boiler fuel; coal land leasing policies and the need for a national energy policy.

The second group of factors consists of technological developments. The most influencial technological factor over the next ten years will be the acceptability of nuclear power generating plants. FEA has estimated that for every thousand megawatts of nuclear capacity installed in the future, coal consumption estimates decrease by about 2.8 million tons per year. Stated another way, for each 10% change in the nuclear capacity estimate, 1985 coal consumption changes about 40 million tons. This illustrates the direct trade-off nature of power plant fuel selections. If nuclear power shows promise of becoming socially acceptable by 1985 or 1990, some utilities may defer expanding capacity in coal fired plants or possibly plan nuclear facilities for future needs. If the problems currently besetting nuclear power generation persist or worsen, new coal fired capacity will probably be installed where possible.

Other technological developments related to coal are the developments of commercially viable, competitively priced synthetic gas and liquid fuel from coal. This could conceivably consume significant tonnages of coal. Most likely coal consumption for synthetic fuel will be minor by 1985 due to the long testing and development period required to bring synthetic fuel on the market. With massive Federal involvement, however, these fuels would reach commercial viability more rapidly, although 1985 production would still be small. More efficient utility boiler design and fuel utilization may reduce the consumption of coal per unit of electricity produced. However, these techniques are not widespread today and are expected to have little effect by 1985. Other forms of energy such as geothermal, solar or nuclear fusion will have marginal impacts on coal consumption by 1985. These energy sources have not reached a technological level where they are viable for commercial application or are restricted to limited regions of the country.

The third group of factors are market factors. The relative price of fuels still is a dominant factor in the fuel selection process. The price of fuels on an as burned basis, including handling, pollution control costs, ash removal and other factors, varies from region to region. In order for coal to penetrate successfully the New England or Pacific fuel markets, the price of oil or nuclear power would need to rise to very high levels or the fuels to become unavailable. However, in most of the central U.S., coal is competitively priced with oil and may be more acceptable, socially, than nuclear power. The market mechanism can be short circuited by government regulations such as FEA orders to utilities requiring the use of coal or by very strict environmental requirements which increase the cost of using coal. Proposed taxes on coal mining (severance taxes) at the State or Federal level can also reduce the cost competitive position of coal in the market for future utility capacity.

4.1.6 Forecasts

The most comprehensive analysis of future energy scenarios has been performed by FEA and published in the 1976 National Energy Outlook. The analysis of future energy supply and demand is performed using updated versions of the Project Independence Evaluation System (PIES) models. These models and the assumptions underlying them are described in the Project Independence Report published by FEA, November 1974, and in the 1976 National Energy Outlook also published by FEA. While this report is not the appropriate vehicle for a detailed description of these models, a brief outline of the concepts is provided as contrast with approaches used by others. Basically, PIES is comprised of econometric models - a demand model, a collection of supply models and an integrating model based on a perfectly competitive energy economy - which seek equilibrium supply and demand solutions based on market clearing prices. Many of the variables used in the models can be altered to predict results of uncertainties, government policies and other exogenous occurrences.

Of more interest in the context of transport requirements are the variables in the scenarios which affect coal production[8] forecasts. Ten FEA scenarios and their associated coal forecasts are displayed in Table 4-1. As can be seen from Table 4-1, the coal forecast does not move in coincidence with total energy forecasts. Rather, the coal forecasts appear to track with a different set of variables. In some cases, the differences are difficult to explain, i.e., the Reference Case has lower total BTU forecast but a higher coal forecast than the accelerated supply scenario. Both scenarios use the same demand scenario. Similarly, the highest and lowest coal forecasts share virtually the same total energy forecast. The variables affecting coal forecasts are primarily those affecting electrical generation fuel choices. Synthetic fuel production and substitution of coal for natural gas

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8. Coal production was chosen rather than consumption because it is felt that consumers tend to hold inventories more than producers and, therefore, excess production would require transportation. Exports also require transportation to ports.

TABLE 4-1

Coal Scenarios 1985

SCENARIO	TOTAL ENERGY INPUTS (quadrillion BTU)		COAL PRODUCTION (million tons)	
	$13 oil	$16 oil	$13 oil	$16 oil
1 Reference Case (BAU Supply + Demand)	98.9	97.3	1039	1085
2 Conservation Case (BAU supply)	93.1	92.5	1006	1096
3 Accelerated Case (with conservation)	96.1	96.6	1013	1018
4 Accelerated Supply Case (without Conservation)	101.8	101.1	1017	1027
5 $7.50 Regulation Case (BAU demand)	101.3	99.7	975	1022
6 $9 Regulation Case (BAU demand)	101.1	99.5	995	1024
7 Electrification Case (Accelerated coal-nuclear supply)	101.6	100.5	1258	1280
8 Regional limitaiton Case (with conserva-tion demand)	91.9	90.7	925	1084
9 Regional limitation (BAU demand)	98.1	96.0	958	1158
10 Supply Pessimism Case (?)	100.2	98.7	910	959
11 BOM(1)	103.5		923	

(1) Oil prices do not apply.

SOURCE: 1976 National Energy Outlook, Federal Energy Admistration; and Energy Through the Year 2000, Bureau of Mines.

as industrial boiler fuel also affect the coal forecasts.

In the electrical generation sector, the variables most affecting coal are demand for electricity, nuclear capacity, oil prices and environmental regulations. The PIES models are based on relative total cost of using coal in competition with other fuels. For instance, the cost of nuclear power generation and coal fired generation are very close. Therefore, increases in the cost of burning coal, due to requirements for stack gas desulfurization or high environmental costs for mines, would shift generation capacity to nuclear or oil fired plants reducing the demand for coal. The two other factors, coal for gas substitution and synthetic fuel production, are non-price variables. They are exogenous demands specified as inputs to the scenarios based on policy assumptions. The treatment of important issues in the different scenarios is shown in Table 4-2. The forecast coal consumption under various scenarios is shown in Table 4-3.

Several organizations other than FEA have made energy forecasts to 1985. One of these was prepared by the Bureau of Mines, U.S. Department of the Interior, and published in United States Energy Through the Year 2000 (Revised), December 1975. This forecast is based on analysis of historical trends in energy use, gross national product, energy supply, and judgment. The results of this method are not radically different from a number of FEA scenarios, however, the method is. While the PIES models are primarily price based, the Bureau of Mines (BOM) model does not explicitly take price into consideration. The assumptions used in making the forecast cover the same areas as those used by FEA, although not always in the same way. For instance, BOM assumes an evolutionary increase in the utilization of fuel (i.e., more efficient boilers) while FEA varies utility plant load factors. Also, BOM uses only one scenario to produce one forecast while

TABLE 4-2

1985 Coal Scenarios

Treatment of Issues

ISSUE \ SCENARIO	REFERENCE CASE	REGIONAL LIMITATION CASE	REGULATION CASE $9	CONSERVATION CASE	ACCELERATED CASE	BUREAU OF MINES
Technology	Small amounts of synthetic fuels available, insignificant solar + geothermal energy	Synthetic fuels not available insignificant solar + geothermal energy	insignificant	insignificant	commercially viable solar and geothermal energy, tertiary oil recovery	Federal R+D support for synthetics development solar, fusion not significant
Stripmining	low land reclamation charges	30% severance tax on western coal and high land reclamation charge on all coal	low land reclamation charges	low land reclamation charges	low land reclamation charges	moderate regulation with reclamation, no production deterrent
Air Pollution	scrubbers for high sulfur coal only	only low sulfur coal with stack scrubbers	scrubbers for high sulfur coal only	scrubbers or low sulfur coal	scrubbers or low sulfur coal	emission standards will be met
Federal Leasing	current situation	reduced oil leasing	current situation	current situation	optimistic	accelerated leasing of off-shore, shale, coal and geothermal lands
Price Controls	deregulation of new gas and decontrol of old oil	-	all domestic oil-gas regulated including intrastate gas	decontrol old oil, deregulate new gas	decontrol old oil and deregulate new gas	complete deregulation of oil and gas
Nuclear Power	will grow to almost 26% of electric generation 8% of total BTU	moratorium on nuclear plant construction 6% of total BTU	8.7% of total BTU	7.7% of total BTU	9% of total BTU	35% of electrical generation 11% of total BTU
Boiler Fuel Conversion	current FEA program conversion	current FEA program conversion	current FEA program conversion	conversion of plants currently able under existing FEA program	conversion of plants currently able	-

TABLE 4-3

Coal Consumption Under Various Scenarios
1985, $13 Oil Imports
(Million Tons)

Sector	Reference	$9.00 Regulation	Regional Limitation	BAU Supply With Conservation	Accelerated Supply With Conservation	Electrification
Household/Commercial	5	5	5	5	5	5
Industrial	224	218	219	217	208	284
Electrical Generation	715	679	640	655	673	841
Synthetics	16	16	16	16	53	53
Exports	80	80	80	80	80	80
Total	1,040	998	960	973	1,019	1,263

SOURCE: 1976 National Energy Outlook, Federal Energy Administration

FEA has fifty-four scenarios and forecasts. The base FEA scenario, called the Reference Case, and the Bureau of Mines scenario are presented below.

4.1.7 Reference Case

The FEA Reference Case represents the base for comparison of variable changes and policy effects in other FEA scenarios. The Reference Case consists of "Business as Usual" supply and demand conditions. Business as usual refers to the level of government intervention in the energy conservation area and assumes that none of the conservation legislation proposed in 1975 and early 1976 will be enacted. Along with the assumption of non-intervention by government, each scenario is specified by a set of conventions which determine the supply of each energy source. These conventions are described in detail for each fuel in The 1976 National Energy Outlook, Appendix E, and are both more detailed and more technical than required here. However, a brief description of the coal convention is useful.

The coal supply convention has two states - Regular and Restricted. Under the regular convention, scrubbers would be required only where high sulfur coal is burned with low sulfur coal without scrubbers as an alternative. All new, and some existing plants can choose between low sulfur coal and high sulfur coal with scrubbers. All other existing plants burn the least cost coal. Surface mine reclamation costs would be $.25 per ton both in the east and west. Under the Restricted convention, all new plants would require scrubbers and only low sulfur coal would be allowed. The surface mine reclamation cost would rise to $.40 to $1.40 per ton in the west and $.85 to $2.10 per ton in the east. The Restricted convention also includes a severance tax of 30% of mine mouth price for western coal. The reference scenario uses three imported oil prices - $8, $13, $16 per barrel - with the $13 case being the basis for all comparisons. The Reference scenario coal consumption forecast is shown in Table 4-4. As can be seen from this table, electric utilities will consume the majority of coal production. Regional coal prices in 1985 for the electric utility sector are shown in Table 4-5 with predicted contract prices. As can be seen, areas which are currently heavy coal users will continue as such. However, projected growth is expected in areas such as West South Central where coal has not been a traditional boiler fuel. (This development can be seen both in planned utility capacity and in the fact that FEA issued orders to several utilities in the region requiring that their new plants burn coal.)

The coal supply forecast for 1985 under the Reference scenario is shown in Table 4-6 with mine mouth prices and type of mining. This shows the greatest growth occurring in the Western Northern Great Plains states. Surface mining will continue to grow more rapidly than deep mining in both the East and the West.

The Reference scenario does not take into account the governmental policy questions concerned with stripmining legislation, coal land leasing and environmental controls. Similarly, transportation, labor and capital are all assumed to be available in sufficient quantities that they do not represent a constraint to coal production or consumption.

4.1.8 The Bureau of Mines Scenario

The Bureau of Mines (BOM) Scenario was developed using a different methodology than those developed by

TABLE 4-4

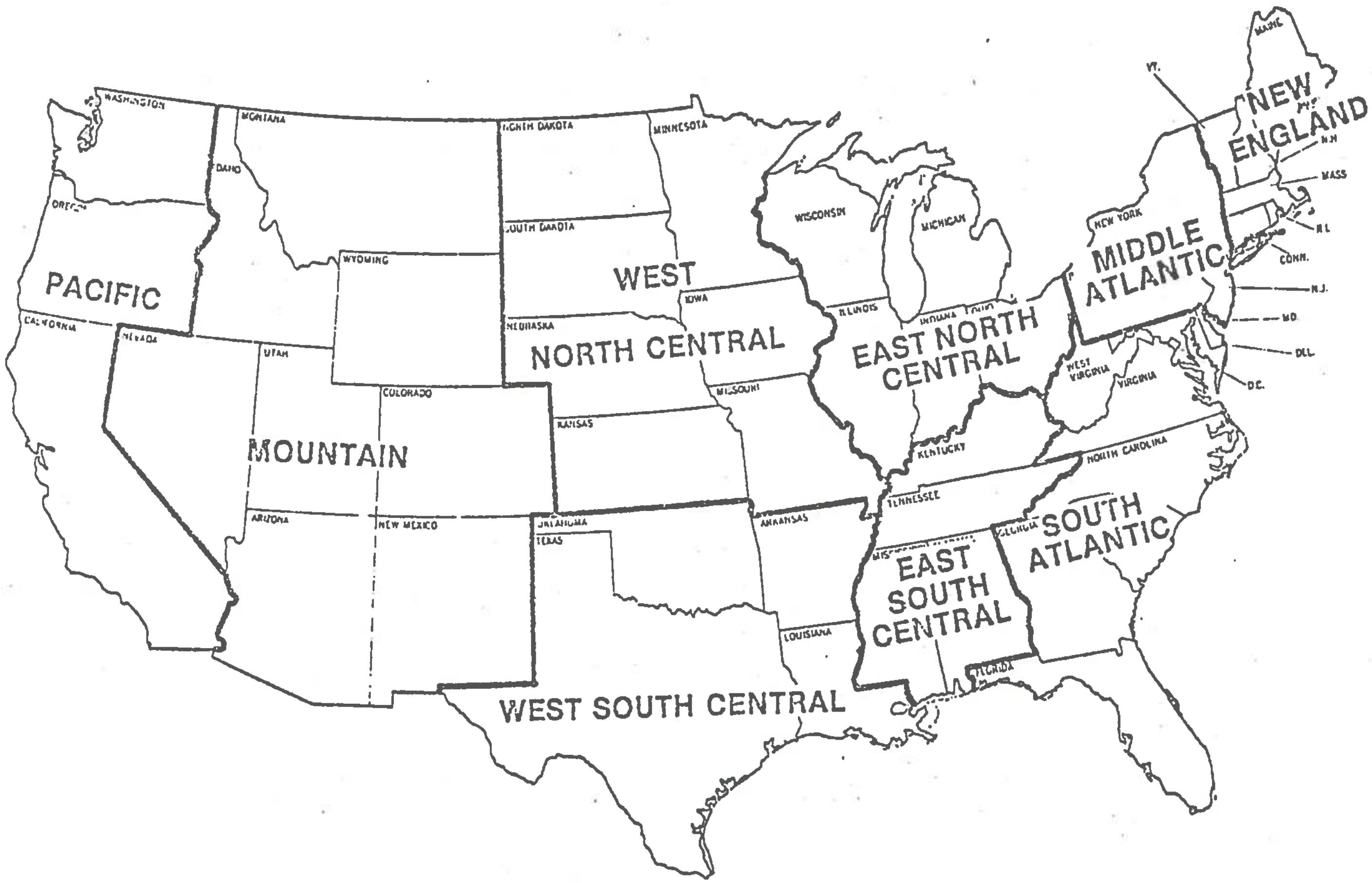
1985 Coal Consumption Reference Scenario, $13 Oil Imports

(million tons)

Sector	1974	1985	Absolute Increase	Compound Annual Percent Growth Rate
Electric Utilities	388	715	+327	5.7
Household/Commercial	9	5	- 4	-5.5
Industrial	64	124	+ 60	6.2
Coke and Gas	90	100	+ 10	1.0
Synthetics	-	16	+ 16	-
Exports	60	80*	+ 20	2.6
Total	611	1,040	+429	5.0

* Assumed values; not estimated endogenously by model.

SOURCE: 1976 National Energy Outlook, FEA.



SOURCE: 1976 National Energy Outlook, FEA

FIGURE 4-1. Census Regions

TABLE 4-5

Long-Term Contract Delivered Coal Prices to the Electric Utility Sector
1985 Reference Scenario, $13 Oil Imports

($/million BTU, 1975 dollars)

Regions	1985 Low Sulfur	1985 High Sulfur	Average Contract Price, August 1975*
Northeast	1.40	.90	1.21
Middle Atlantic	1.25	.75	1.05
South Atlantic	1.25	.80	1.01
East North Central	1.15	.65	.80
East South Central	1.15	.60	.77
West North Central	.95	.65	.57
West South Central	1.00	.70	.24
Mountain	.55	.45	.32
Pacific	--	.80	.59

* Source: FPC Form 423.

SOURCE: 1976 National Energy Outlook, FEA

TABLE 4-6

Coal Production by Region -- Reference Scenario, $13 Oil Imports

(million tons)

	1974	1980	1985	1990
Northern Appalachia	171	163	183	199
Central Appalachia	184	269	297	322
Southern Appalachia	20	24	25	24
Midwest	135	96	156	176
Total East	510	552	661	721
Central West	9	9	9	10
Gulf	8	17	21	21
Eastern Northern Great Plains	8	14	31	45
Western Northern Great Plains	35	185	274	464
Rockies	14	16	19	21
Southwest	14	5	21	21
Northwest	4	1	4	4
Alaska	1	*	*	*
Total West	93	247	379	586
National	603	799	1,040	1,307

* Less than 500,000 tons.

Prices by Region and Coal Type -- 1985 Reference Scenario, $13 Oil Imports ($/Ton FOB Mine, 1975 Dollars)

Region	Low Sulfur Coal	High Sulfur Coal
Northern Appalachia	24.90	12.90
Central Appalachia	24.10	12.60
Southern Appalachia	26.00	14.50
Midwest	22.80	10.80
Central West	-	11.35
Gulf	-	4.80
Eastern Northern Great Plains	6.30	4.40
Western Northern Great Plains	4.90	3.80
Rockies	10.00	-
Southwest	8.00	4.40
Northwest	-	5.40
Alaska	6.60	-

SOURCE: 1976 National Energy Outlook, FEA.

FEA. The scenario is specified in terms of energy inputs and consumption as it relates to Gross National Product (GNP), population and energy conversion efficiency. Conversion efficiency has to do with the energy loss in converting from primary sources, such as coal, to secondary sources, such as electricity. Table 4-7 shows historical trends in energy, economic and demographic indicators used in preparing this scenario. Tables 4-8 and 4-9 show 1974 actual and projections to 2000 of energy consumption by each sector of the economy. Table 4-11 summarizes the sources of energy supply. The forecast is based on annual growth rates of 3.8% and 1.1% for GNP and population (1974-1985) respectively. Other assumptions used are that strip mining will be allowed but environmental protection will be required; the Federal government will lease offshore oil areas at an accelerated rate, and will lease western coal lands, oil shale lands and "known geothermal resource areas"; the government will support research and development of coal gasification and liquification and development of commercially viable methods for controlling sulfur oxide emissions from coal burning. Increases in the efficiency of energy utilization is assumed even though conversion losses are expected to rise substantially due to increased end use of secondary energy sources (see Table 4-11). The major technological event expected in this scenario is the introduction of the breeder reactor. This event is tentatively scheduled for 1985, however, delays are continuing and the probability of introduction by the target date is low. (If the breeder reactor is not commercially viable by 1986, it may still have an impact on future utility capacity selections through perceptions of increased future fuel supplies). Solar energy is not

TABLE 4-7

Selected United States Economic Demographic, and Energy Indicators

(1947-1975)

Year	Gross energy input 1/ (Quadrillion Btu)	Net energy input 2/ (Quadrillion Btu)	Population (Millions)	Gross National Product (Billion $ 1958)	Gross Energy per GNP (Thousand Btu)	Gross energy per capita (Million Btu)	Net energy per capita (Million Btu)	Conversion Efficiency (Percent) 3/
1947	33.0	29.2	144.1	309.9	106.4	229.0	202.8	88.5
1948	33.9	29.1	146.6	323.7	104.7	231.2	198.6	85.8
1949	31.5	27.3	149.2	324.1	97.2	211.1	182.7	86.5
1950	34.0	29.7	152.3	355.3	95.7	223.2	194.8	87.3
1951	36.8	32.1	154.9	383.4	96.0	237.6	206.9	87.1
1952	36.5	31.6	157.6	395.1	92.4	231.7	200.6	86.6
1953	37.6	32.6	160.2	412.8	91.1	234.7	201.1	85.7
1954	36.3	31.2	163.0	407.0	89.2	222.7	191.5	86.0
1955	39.7	34.3	165.9	438.0	90.6	239.3	206.7	86.4
1956	41.7	35.8	168.9	446.1	93.5	246.9	211.7	85.7
1957	41.7	35.6	172.0	452.5	92.2	242.2	206.9	85.4
1958	41.7	35.5	174.9	447.3	93.2	238.4	202.8	85.1
1959	43.1	36.4	177.8	475.9	90.6	242.4	205.0	84.6
1960	44.6	38.2	180.7	487.7	91.4	246.8	211.5	85.7
1961	45.3	38.7	183.8	497.2	91.1	246.5	210.6	85.8
1962	47.4	40.5	186.5	529.8	89.5	254.1	217.2	85.5
1963	49.3	42.0	189.2	551.0	89.5	260.5	222.0	85.2
1964	51.2	43.6	191.8	581.1	88.1	266.9	227.3	85.5
1965	53.3	45.3	194.3	617.8	86.3	274.3	233.1	85.0
1966	56.4	47.6	196.6	658.1	85.7	286.9	242.1	84.4
1967	58.3	49.4	198.7	675.2	86.3	293.4	248.6	84.7
1968	61.7	52.2	200.7	706.6	87.3	307.4	260.1	84.6
1969	65.0	54.4	202.7	725.6	89.6	320.7	268.4	83.7
1970	67.1	56.0	204.9	722.5	92.9	327.5	273.3	83.6
1971	68.7	57.0	207.0	746.3	92.0	331.9	275.4	83.0
1972	72.1	59.5	208.8	792.5	91.0	345.3	285.0	82.6
1973	74.7	61.3	210.4	839.2	89.0	355.0	291.3	82.1
1974	73.1	59.9	211.9	821.2	89.0	345.0	282.7	81.9
1975 e/	72.2	NA	213.4	NA	NA	338.0	NA	NA

e/ Estimated.
1/ Gross energy is the total of inputs into the economy of the primary fuels (petroleum, natural gas, and coal, including imports) or their deriviatives, plus the generation of hydro and nuclear power converted to equivalent energy inputs.
2/ Net energy is the sector inputs (household and commercial, transportation, and industrial), and consists of direct fuels and purchased electricity.
3/ The conversion efficiency factor is the percent of total gross energy going into the final consuming sector.

SOURCE: United States Energy through the Year 2000 (Revised), Bureau of Mines, U. S. Department of the Interior.

TABLE 4-8

United States Consumption of Energy Resources by Major Sources and Consuming Sectors, 1974 Preliminary and Projected to the Year 2000

(Trillion Btu)

Consuming Sector	Coal	Petroleum	Natural Gas	Oil Shale	Nuclear Power	Hydropower and Geothermal	Total Gross Energy Inputs	Synthetic Liquids Distributed	Synthetic Gas Distributed	Utility Electricity Distributed	Total Net Energy Inputs
1974											
Household & Commercial	291	6,390	7,116	--	--	--	13,797	--	--	3,687	17,484
Industrial 1/	4,208	6,044	11,129	--	--	34	21,415	--	--	2,665	24,081
Transportation	2	17,608	664	--	--	--	18,274	--	--	16	18,290
Electrical generation	8,668	3,448	3,328	--	1,173	3,018	19,635	--	--	--	--
Synthetic gas	--	--	--	--	--	--	--	--	--	--	--
Synthetic liquids	--	--	--	--	--	--	--	--	--	--	--
Total	13,169	33,490	22,237	--	1,173	3,052	73,121	--	--	6,368	59,855
1980											
Household & Commercial	100	7,600	8,000	--	--	--	15,700	--	110	5,790	21,600
Industrial	4,800	7,500	10,000	--	--	--	22,300	--	--	3,600	25,900
Transportation	--	20,700	600	--	--	--	21,300	--	--	60	21,360
Electrical generation	12,250	5,100	2,000	--	4,550	3,800	27,700	--	--	--	--
Synthetic gas	--	140	--	--	--	--	140	--	--	--	--
Synthetic liquids	--	--	--	--	--	--	--	--	--	--	--
Total	17,150	41,040	20,600	--	4,550	3,800	87,140	--	110	9,450	68,860
1985											
Household & Commercial	100	7,880	8,500	--	--	--	16,480	120	210	7,810	24,620
Industrial	4,930	8,370	9,500	--	--	--	22,800	130	240	5,620	28,790
Transportation	--	23,040	600	--	--	--	23,640	360	--	80	24,080
Electrical generation	15,700	6,200	1,500	--	11,840	3,850	39,090	--	--	--	--
Synthetic gas	520	140	--	--	--	--	660	--	--	--	--
Synthetic liquids	--	--	--	870	--	--	870	--	--	--	--
Total	21,250	45,630	20,100	870	11,840	3,850	103,540	610	450	13,510	77,490
2000											
Household & Commercial	--	7,960	9,000	--	--	--	16,960	940	1,940	14,740	34,580
Industrial	5,910	10,370	9,000	--	--	--	25,280	1,230	2,260	14,680	43,450
Transportation	--	28,170	600	--	--	--	28,770	3,330	--	100	32,200
Electrical generation	20,700	4,700	1,000	--	46,080	6,070	78,550	--	--	--	--
Synthetic gas	6,000	--	--	--	--	--	6,000	--	--	--	--
Synthetic liquids	2,140	--	--	5,730	--	--	7,870	--	--	--	--
Total	34,750	51,200	19,600	5,730	46,080	6,070	163,430	5,500	4,200	29,520	110,230

1/ Miscellaneous and unaccounted energy assigned to this sector. For 1974 this was 219 trillion Btu of petroleum products.

SOURCE: United States Energy through the Year 2000 (Revised), Bureau of Mines

TABLE 4-9

United States Consumption of Energy Resources by Major Sources, 1974 Preliminary and Projected to the Year 2000 (in standard physical units)

Consuming Sector	Coal million short tons 1/	Petroleum million barrels 2/	Natural Gas billion cubic feet	Oil Shale million barrels equivalent	Nuclear Power billion kWh	Hydropower & Geothermal billion kWh	Synthetic Liquids distributed million barrels	Synthetic Gas distributed billion cu. ft.	Utility Electric distributed billion kWh
1974									
Household & Commercial	10.9	1,115.0	6,970	--	--	--	--	--	1,080
Industrial 3/	154.9	1,137.1	10,900	--	--	3	--	--	781
Transportation	.1	3,274.7	650	--	--	--	--	--	3
Electrical generation	390.6	554.0	3,260	--	110	291	--	--	--
Synthetic gas	--	--	--	--	--	--	--	--	--
Synthetic liquids	--	--	--	--	--	--	--	--	--
Total	556.5	6,080.8	21,780	--	110	294	--	--	1,864
1980									
Household & Commercial	4	1,376	7,770	--	--	--	--	120	1,695
Industrial	185	1,358	9,700	--	--	--	--	--	1,057
Transportation	--	3,750	580	--	--	--	--	--	17
Electrical generation	547	924	1,940	--	427	343	--	--	--
Synthetic gas	--	25	--	--	--	--	--	--	--
Synthetic liquids	--	--	--	--	--	--	--	--	--
Total	736	7,433	19,990	--	427	343	--	120	2,769
1985									
Household & Commercial	3	1,427	8,250	--	--	--	22	230	2,290
Industrial	190	1,516	9,220	--	--	--	23	270	1,647
Transportation	--	4,174	580	--	--	--	65	--	23
Electrical generation	704	1,123	1,460	--	1,139	391	--	--	--
Synthetic gas	26	25	--	--	--	--	--	--	--
Synthetic liquids	--	--	--	157	--	--	--	--	--
Total	923	8,265	19,510	157	1,139	391	110	500	3,960
2000									
Household & Commercial	--	1,442	8,740	--	--	--	170	2,160	4,320
Industrial	228	1,878	8,740	--	--	--	225	2,510	4,302
Transportation	--	5,103	580	--	--	--	605	--	28
Electrical generation	941	851	970	--	5,120	605	--	--	--
Synthetic gas	300	--	--	--	--	--	--	--	--
Synthetic liquids	91	--	--	1,040	--	--	--	--	--
Total	1,560	9,274	19,030	1,040	5,120	605	1,000	4,670	8,650

1/ Includes anthracite, bituminous, and lignite.
2/ Petroleum products refined and processed from crude.
3/ Miscellaneous and unaccounted energy assigned to this sector. For 1974 this was 37.9 million barrels of petroleum product.

SOURCE: United States Energy through the Year 2000 (Revised), Bureau of Mines

TABLE 4-10

United States Gross Consumption of Energy Resources by Major Sources, 1974 Preliminary and Projected to the Year 2000

	1974	1980	1985	2000
Petroleum				
Million barrels	6,080.8	7,433	8,265	9,274
Trillion Btu	33,490	41,040	45,630	51,200
Percent of total gross inputs	45.8	47.1	44.1	31.3
Natural Gas				
Billion cubic feet	21,780	19,900	19,510	19,030
Trillion Btu	22,237	20,600	20,100	19,600
Percent of total gross inputs	30.5	23.6	19.4	12.0
Coal (all ranks) 1/				
Million short tons	556.5	736	923	1,560
Trillion Btu	13,169	17,150	21,250	34,750
Percent of total gross inputs	18.0	19.7	20.5	21.3
Oil Shale				
Million barrels	--	--	157	1,040
Trillion Btu	--	--	870	5,730
Percent of total gross inputs	--	--	.8	3.5
Hydropower & Geothermal				
Billion kWh	291	343	391	605
Trillion Btu	3,052	3,800	3,850	6,070
Percent of total gross inputs	4.1	4.4	3.8	3.7
Nuclear Power				
Billion kWh	110	427	1,139	5,120
Trillion Btu	1,173	4,550	11,840	46,080
Percent of total gross inputs	1.6	5.2	11.4	28.2
Total Gross Energy Input				
Trillion Btu	73,121	87,140	103,540	163,430

1/ Does not include coal exports.

SOURCE: United States Energy through the Year 2000 (Revised), Bureau of Mines

TABLE 4-11

Conversion Efficiencies and Losses for the Secondary Energy Sources, 1974 Preliminary and Projected to the Year 2000[1]

(Trillion Btu)

	1974	1980	1985	2000
Electrical Sector				
Inputs	19,635	27,700	39,090	78,550
Output	6,368	9,450	13,510	29,520
Losses	13,267	18,250	25,580	49,030
Conversion Efficiency, percent	32.4	34.1	34.6	37.6
Synthetic Liquid Sector				
Inputs	--	--	870	7,870
Output	--	--	610	5,500
Losses	--	--	260	2,370
Conversion Efficiency, percent	--	--	70.1	70.0
Synthetic Gas Sector				
Inputs	--	140	660	6,000
Output	--	110	450	4,200
Losses	--	30	210	1,800
Conversion Efficiency, percent	--	78.6	68.2	70.0
Total				
Inputs	19,635	27,840	40,620	92,420
Output	6,368	9,560	14,570	39,220
Losses	13,267	18,280	26,050	53,200
Conversion Efficiency, percent	32.4	34.3	35.9	42.4

1/ Secondary energy sources are electricity, synthetic liquids, and synthetic gas.

SOURCE: United States Energy through the Year 2000 (Revised), Bureau of Mines

a major factor and nuclear fusion is considered too far in the future for inclusion. The BOM scenario does not specifiy regional energy supply or demand breakdowns.

The coal forecasts in both the FEA and BOM scenarios are based on growth rates of relevant variables, assumed choices by consumers and other indirect estimating procedures. There are data available on the plans of coal producers and the electric utilities on their plans for the future. While these data share some of the uncertainties of the scenarios described above, they represent the best estimate available at this time (1977) of the future production and consumption of coal.

4.2 Industry Estimates

Several major surveys of coal producers and electric utilities have been conducted in the past year. The methods used by all of these are generally the same, direct contact with coal producers and utility companies. The Federal Power Commission (FPC) also collects data on coal deliveries to utilities and future contracts on a regular basis. The FPC data are collected under statutory authority while the other studies depend on voluntary participation. For this reason, there may be differences in the completeness of the data.

4.2.1 Coal Production

Two studies were conducted by the survey method in 1976 of planned new coal mining capacity through 1985. One was performed by the National Coal Association.[9] The other was performed under contract to FEA.[10] These studies indicate that additions and expansions of coal mine capacity from 1975 to 1985 will be between 400 and 500 million tons. The expansion in the western regions is expected to be between 230 and 275 million tons with eastern capacity additions ranging from 180 and 230 million tons. The total production capacity in 1985 assumes no significant mine retirements. Discussions with the National Coal Association indicate that some slippage can be expected in the dates for mine expansion. The procedures gear production capacity additions to the start up date for their customers' facilities. When power plants are delayed,

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9. A Study of New Mine Additions and Major Expansion Plans of The Coal Industry, National Coal Association, Washington, D.C., 1976.

10. Final Report Coal Mine Expansion Study, May 1976, Submitted to the Office of Coal, Federal Energy Administration, prepared by ICF Incorporated.

the mine expansion may also be delayed. There are also small mine operators who produce only when the price of coal is high and stop production when prices fall. The production capacity of these operators is difficult to judge at any given time.

4.2.2 Electric Utilities

The Presidential Task Force on Power Plant Acceleration of the Federal Energy Administration prepared a report on the status of significant power plants.[11] This report was not intended to compile data on all future power plants in the U.S. at a particular time period. It is a listing of the current (July 1976) status of major[12] power plants in planning or under construction. As such, it provides a guide to the future geographic distribution of generating stations and the mix of fuels. The report provides information for each project on the utility company, capacity, fuel type, on-line dates, slippage and types of problems encountered, if any. The report was used, with average annual coal consumption rates per megawatt of capacity, as an aid to estimating the geographic distribution of utility sector coal consumption in 1985.

A second report was produced by the FPC on the status of coal contracts and utility generating plans.[13] This

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11. Status: Significant U.S. Power Plants In Planning or Construction, Presidential Task Force on Power Plant Acceleration, Federal Energy ADministration, Washington, D.C. 20461, July 1, 1976.

12. Major power plants are defined as larger than 200 megawatts originally planned to come on line prior to 1990, and generally not gas or oil fired.

13. Status of Coal Supply Contracts For New Electric Generating Units 1976-1985, Staff Report by the Bureau of Power, Federal Power Commission, Washington, D.C., January, 1977.

report was compiled from data submitted by all utilities covering their planned capacity, fuel type, fuel source and contract status in compliance with FPC reporting requirements. These data represent the utilities' current plans and firm commitments. Table 4-12 represents the projected generating mix for 1975, 1980, and 1985 with the resulting fossil fuel requirements for the nation as a whole. Table 4-13 shows regional utility coal demand for 1975 and 1985. The projections in this report differ somewhat from those used as a basis for the study. There are two reasons for this. First the study forecast is tied to the FEA Reference Case Scenario with only minor modifications; and second, the FPC data are more recent than those used to prepare this study. In both the FPC projections and the forecast used in the study, there are uncertainties about the timing of generating capacity installation, the types of coal which will be used and the prospects for nuclear power generation.

4.2.3 The Study Forecast

The 1985 forecasts of coal consumption and production used in this study are based on the FEA Reference Case Scenario. However, information in the reports on electric utility and coal mine capacity expansion conflicted with some aspects of the scenario. The principal conflicts were in the geographic distribution of utility coal consumption. The Reference Scenario projected 1985 New England utility coal consumption at 15 million tons. Discussions with utilities in New England indicated that there are no coal fired plants currently planned which could come on line by 1985. Increases in capacity are expected to be nuclear plants. Similar discrepancies were noted in the Northern

TABLE 4-12

Projected Generation Mix, 1980 and 1985, In Billion Kilowatt-Hours

Type Generation	1975 Actual		1980		1985	
	kwh	%	kwh	%	kwh	%
Coal	852.7	44.50	1227	46.87	1690	48.47
Oil	288.6	15.06	465	17.76	465	13.34
Gas	299.6	15.64	255	9.74	205	5.88
Nuclear	171.4	8.94	380	14.51	807	23.14
Hydro	300.5	15.68	285*	10.89	300	8.60
Other	3.4	0.18	6	0.23	20	0.57
Total	1916.2	100.00	2618	100.00	3487	100.00

* Median conditions; 1975 was an above-normal hydro year.

SOURCE: Status of Coal Supply Contracts for New Electric Generating Units 1976 - 1985, Bureau of Power, Federal Power Commission, January, 1977.

TABLE 4-13

Regional Coal Demand for New Units Scheduled for Service 1976-1985

	1975	1985		
	Shipments to Utilities (1000 Tons)	Total Demand For New Units (1000 Tons)	Quantities Assured For New Units (1000 Tons)	% Assured
Eastern Regions				
New England	1,274	-	-	-
Middle Atlantic	45,037	18,100	7,300	40.3
East North Central	144,742	47,004	23,623	50.3
South Atlantic	79,216	23,792	8,377	35.2
East South Central	70,830	23,249	12,063	51.9
Sub Total	341,099	112,145	51,363	45.8
Western Regions				
West North Central	43,471	67,330	56,775	84.3
West South Central	9,146	124,207	95,343	76.8
Mountain	32,856	52,889	38,364	72.5
Pacific	4,200	1,200	1,200	100.0
Sub-Total	89,403	245,626	191,682	78.0
Total	430,502*	357,771	243,045	67.9

*Of the 430.5 million tons of coal delivered to the utilities in 1975, 406 million tons were consumed; 24.5 million tons were added to stock piles.

SOURCE: Status of Coal Supply Contracts for New Electric Generating Units 1976 - 1985, Bureau of Power, Federal Power Commission, January, 1977.

Great Plains and Pacific regions. In the case of the Great Plains area, the scenario underestimated actually planned capacity. After discussions with FEA, utilities and DOT, the Reference Scenario coal forecasts were modified to reflect the new information. The resulting forecasts were prepared on a state by state basis. The forecasts used in the study are shown in Tables 4-14 and 4-15. It should be noted that these forecasts are not certainties even though they reflect the plans of producers and consumers. Many unresolved factors will change those plans over time.

TABLE 4-14

1985 Coal Production Forecast

(thousand tons)

STATE	1985 COAL PRODUCTION	STATE	1985 COAL PRODUCTION
Alabama	34,570	Ohio	58,397
Alaska	766	Oklahoma	2,455
Arizona	14,299	Pennsylvania	101,801
Arkansas	632	Tennessee	9,200
Colorado	21,524	Texas	29,202
Illinois	106,830	Utah	17,110
Indiana	43,162	Virginia	39,570
Iowa	663	Washington	3,738
Kansas	1,107	West Virginia	164,814
Kentucky	184,622	Wyoming	183,346
Maryland	4,521		
Missouri	6,641	TOTAL	1,133,918
Montana	58,640		
New Mexico	19,297	TOTAL EAST	747,487
North Dakota	27,011	TOTAL WEST	386,431

[1] The totals for east and west are based on a division along the Mississippi River. This approximates the division between western railroads and eastern and southern railroads. As the data were developed on a state-by-state basis, aggregation by coal mining districts would have introduced inaccuracies from arbitrary allocation. Eastern coal production was not broken down further because of the overlap in areas served by eastern and southern districts.

TABLE 4-15

Estimated Total Coal Consumption 1985
(Thousand Tons)

CENSUS REGION	ELECTRIC UTILITIES	HOUSEHOLD/ COMMERCIAL	COKE & GAS	ALL OTHER	TOTAL
NEW ENGLAND	987	20	-	696	1,703
Connecticut	4	1	-	210	215
Maine	-	4	-	178	182
Massachusetts	17	15	-	262	294
New Hampshire	935	-	-	32	967
Rhode Island	18	-	-	14	32
Vermont	13	-	-	-	13
MID-ATLANTIC	58,880	254	33,077	26,946	119,157
New Jersey	2,256	5	-	483	2,744
New York	12,004	50	6,408	7,203	25,665
Pennsylvania	44,620	199	26,669	19,260	90,748
SOUTH ATLANTIC	99,771	987	10,180	37,240	148,178
Delaware	2,508	-	-	77	2,585
Florida	12,165	-	-	-	12,165
Georgia	16,812	30	-	1,043	17,885
Maryland	6,572	21	4,256	2,446	13,295
North Carolina	21,255	207	-	5,212	26,674
South Carolina	5,564	128	-	4,620	10,312
Virginia	3,870	354	-	8,141	12,365
Washington, D.C.	79	18	-	574	671
West Virginia	30,946	229	5,924	15,127	52,226
EAST NORTH CENTRAL	194,804	2,111	39,290	94,273	330,478
Illinois	43,556	540	3,596	15,208	62,900
Indiana	41,279	277	15,786	16,111	73,453
Michigan	24,744	246	4,449	15,543	44,982
Ohio	64,959	791	15,181	39,389	120,320
Wisconsin	20,266	257	278	8,022	28,823
EAST SOUTH CENTRAL	87,505	383	9,546	23,044	120,478
Alabama	26,623	19	7,729	8,183	42,554
Kentucky	37,104	187	1,621	7,249	46,161
Mississippi	1,545	-	-	168	1,713
Tennessee	22,233	177	196	7,444	30,050

TABLE 4-15 (Continued)

CENSUS REGION	ELECTRIC UTILITIES	HOUSEHOLD/ COMMERCIAL	COKE & GAS	ALL OTHER	TOTAL
WEST NORTH CENTRAL	91,558	452	1,177	16,030	109,217
Iowa	13,629	59	-	4,462	18,150
Kansas	16,830	2	-	486	17,318
Minnesota	20,485	166	842	3,420	24,913
Missouri	26,439	111	335	5,446	32,331
Nebraska	6,190	7	-	1,089	7,286
North Dakota	4,898	88	-	1,113	6,099
South Dakota	3,087	19	-	14	3,120
WEST SOUTH CENTRAL	41,399	3	1,019	9,051	51,472
Arkansas	8,448	-	-	392	8,840
Louisiana	4,320	-	-	-	4,320
Oklahoma	11,840	2	-	602	12,444
Texas	16,791	1	1,019	8,057	25,868
MOUNTAIN	84,134	357	3,503	7,371	95,365
Arizona	9,800	-	-	39	9,839
Colorado	18,044	53	1,286	1,709	21,092
Idaho		96	-	1,172	1,268
Montana	7,820	6	-	192	8,018
New Mexico	12,290	-	-	25	12,315
Nevada	12,476	1	-	435	12,912
Utah	10,311	184	2,217	2,139	14,851
Wyoming	13,393	17	-	1,660	15,070
PACIFIC	18,044	14	2,492	1,547	22,097
California	9,000	1	-	123	9,124
Oregon	2,000	6	-	490	2,496
Washington	7,044	7	2,492	934	10,477
EXPORT	-	-	-	-	80,000
TOTAL	677,082	4,581	100,284	216,198	1,078,145

4.3 Uncertainties and their Effects

There are many uncertainties associated with the forecasts of future coal use and with the estimates of transportation requirements. These uncertainties stem from government policy decisions yet to be made, technological developments and market factors.

4.3.1 Government Policy

Most of the uncertainties in government energy policies are well known. The most pervasive policy question outstanding is that of environmental limitations on mining and burning coal. The forecast of coal production used in this study requires that coal production increase by more than 40 million tons per year from 1975 through 1985. The increases in production from 1974-1976 have been in the range of 24 million tons per year (average). While it is likely that production will increase more rapidly after 1980, the current shortfall is partially attributable to environmental problems in mining and burning coal.

Due to an apparent ambivalence to coal development on the part of the federal government and Congress, there has been little solid action to reduce the uncertainties in the long term market outlook for coal. The net result is delays in construction of coal burning facilities and coal mines.

4.3.2 Technology

Technological developments over the next few years will have a substantial impact on the mix of fuels used in the U. S. These developments center on the development of nuclear energy, coal burning and mining technology and alternate energy sources. There is direct competition between nuclear power and coal for electrical generating capacity. Therefore, should nuclear power become socially acceptable, many utilities may shift their expansion or replacement capacity away from using coal. Commercial development of the fast breeder reactor may have a similar result.

Since fuel selection by utilities, and others, is basically still an economic one, the cost of burning coal is still the dominant factor in the competition among energy sources. Government regulations may change factors in the economic equation. Such changes will have a significant impact on future coal consumption, both regionally and in total. If clean air standards are enforced, efficient methods of burning coal and cleaning stack gas will be necessary. The present technology for desulfuring stack gas is not sufficient to allow burning much of the eastern coal at economic costs. If this technology does not advance at a rapid rate, nuclear power will be the most likely choice of utilities faced with strict air quality standards and those distant from low sulfur coal sources.

There are some technological developments in coal burning which may reduce the cost of burning coal. One such prospect is magnetohydrodynamics. This system depends on the development of fluidized bed combustion or some other high temperature combustion technique. The resulting efficiency in electrical generation could be as high as 50% from a given quantity of coal. This system will probably not be commercially available until the year 2000. However, its development may encourage construction of coal fired generating facilities in the interim.

4.3.3 Market Factors

When all is said and done, the future use of coal as a primary energy source will depend largely on its competitive position in the marketplace for fuels. It is in this area where the uncertainties of technology, government policy and costs have their impact. Even if government policies promoting coal use are promulgated and the technologies required to mine and burn coal are developed, the cost to the user will determine where and how much coal is consumed. Therefore, the potential producers and consumers of coal must see a reasonable certainty that coal will be the least expensive fuel for substantially the life of their facilities in order to undertake the investment in coal fired plants. Similarly, transportation companies must be reasonably assured of their markets for transportation services before they can make major investments in equipment and facilities for distributing coal.

5. INLAND WATERWAYS

5.1 Overview

The inland waterway system is an integral part of the U. S. transportation network. In 1975, the barge and towing industry, operating on the 25,000 mile inland waterway network, carried 582 million tons of freight.[1] This is about 65% of all domestic marine transportation. The waterway network consists of three principal sections. The Mississippi River and tributaries and the Gulf Intracoastal Waterway are the main commercial links in the system, providing a continuous waterway accounting for nearly 60% of inland waterway mileage and more than 90% of inland waterway ton-miles.[2] Table 5-1 shows the lengths and depths of various waterways in the system. The Atlantic coast waterways and Pacific coast waterways complete the system. The waterways on the coasts are not interconnected but form individual transportation links.

Approximately 1,800 companies operate on the inland waterways. These companies range from large full service transportation companies which own towboats and barges to small companies which provide only harbor or fleeting service.[3] In 1975, these companies operated over 4,000 towboats and more than 26,000 barges. Table 5-2 shows the distribution of vessels on the waterways for 1975.

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1 1975 Inland Waterborne Commerce Statistics, The American Waterways Operators, Inc., Arlington, VA, April 1977.

2 U. S. Army Corps of Engineers, Waterborne Commerce Statistics of the United States, 1975.

3 Fleeting is the process of placing barges into groups (tows) or removing them from groups which are lashed together into a single unit. Each unit, or tow, is pushed by a towboat. The harbor (or switch) boats are generally small compared to line haul towboats.

TABLE 5-1

Commercially Navigable Waterways Of The United States by Lengths and Depths 1/

Group	Length in Miles of Waterways					
	Under 6 ft.	6 to 9 ft.	9 to 12 ft.	12 ft. 14 ft.	14 ft. & over	Total
Atlantic Coast Waterways (exclusive of Atlantic Intra-coastal Waterway from Norfolk, Va. to Key West, Fla.)	1,426	1,241	584	938	1,581	5,770
Atlantic Intracoastal Waterway from Norfolk, Va. to Key West, Fla.	-	65	65	1,104	-	1,234
Gulf Coast Waterways (exclusive of the Gulf Intracoastal Waterway)	2,055	647	1,133	79	378	4,292
Gulf Intracoastal Waterway from St. Marks, Fla. to the Mexican Border, including Port Allen-Morgan City Alternate Route	-	-	-	1,137	-	1,137
Mississippi River System	2,020	969	4,957	740	268	8,954
Pacific Coast Waterways	730	498	237	26	2,084	3,575
Great Lakes	45	89	-	8	348	490
All Other Waterways	76	7	-	1	7	91
GRAND TOTAL	6,352	3,516	6,976	4,033	4,666	25,543

1/ The mileages in this table represent the lengths of all navigable channels of the United States, including those improved by the Federal Government, other agencies, and those which have not been improved but are usable for commercial navigation.

SOURCE: 1975 Inland Waterborne Commerce Statistics, The American Waterways Operators, Inc., April 1977.

TABLE 5-2

Number of Towing Vessels and Barges of the United States Operated for the Transportation of Freight as of January 1, 1976 1/

Types of Vessels	Mississippi River System and the Gulf Intracoastal Waterway	Atlantic, Gulf and Pacific Coasts	Great Lakes System	Total
SELF-PROPELLED				
Towboats and Tugs				
Number of Vessels	2,541	1,554	145	4,240 2/
Horsepower	3,574,850	1,860,026	151,015	5,585,891
NON-SELF-PROPELLED				
Dry Cargo Barges and Scows				
Number of Vessels	18,049	4,917	198	23,164
Cargo Capacity (net tons)	22,255,050	4,565,839	314,447	27,135,336
Tank Barges				
Number of Vessels	2,979	577	67	3,623
Cargo Capacity (net tons)	6,295,236	2,056,813	157,967	8,510,016
Total Non-Self-Propelled				
Number of Vessels	21,028	5,494	265	26,787
Cargo Capacity (net tons)	28,550,286	6,622,652	472,414	35,645,352

1/ From Corps of Engineers, U.S. Army

2/ U.S. Coast Guard reports, as of January 1, 1975, 6309 documented vessels of the United States having a service of towing. The vessels reported by the Corps of Engineers are those used only in the performance of transportation services

The principal commodities carried on the inland waterways are shown in Table 5-3. Coal is the largest single commodity moving on the waterways[4] with 127.6 million tons in 1975.[5] Coal is a major commodity on only a few rivers in the system. Table 5-4 shows 1975 coal traffic for the most important coal carrying rivers. Table 5-5 shows coal as a percentage of total tonnage carried on major coal carrying rivers for 1975. These tonnage figures differ from those in 5-4 because they include traffic moving on the river which originated elsewhere. These figures indicate that coal traffic is of greater importance than the amount originated implies. Figures 5-1 through 5-7 depict the major coal carrying waterways.

The majority of waterborne coal moves from transshipment facilities to utility generating plants located on the waterways. Coal moves to the transshipment facilities from mines by truck, conveyor or rail. With the increasing penetration of water served markets in the midwest by western coal, rail-water combinations may increasingly replace truck-water moves. The distance between western coal fields and midwestern markets dictates use of rail transportation. However, many of the plants currently served by truck-water routes do not have facilities to take rail delivered coal. The investment in such facilities is high and would frequently not yield an attractive return. In other cases, the power plants lack the necessary land to build rail receiving equipment such as loop tracks for unit trains or storage tracks for multiple car deliveries. For these reasons, plants currently served by water will probably continue to be. However, the water move will be preceded by rail.

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[4] Petroleum and petroleum products are larger as a group.

[5] 1975 Inland Waterborne Commerce Statistics, The American Waterways Operators, Inc., Arlington, VA, April 1977.

TABLE 5-3

Principal Commodities Transported on the Inland Waterways Of the United States (Exclusive of the Great Lakes) In Net Tons of 2,000 Pounds Calendar Years 1974 and 1975

Commodity	1974	1975
Grain and grain products	28,996,456	34,302,575
Soybeans	10,146,772	9,429,582
Fresh fish and shellfish	1,730,336	1,989,015
Marine shells, unmanufactured	18,141,196	15,334,659
Iron ore and concentrates	5,310,655	3,526,102
Manganese ores and concentrates	1,177,751	1,116,792
Bituminous coal and lignite	119,079,932	127,567,743
Crude petroleum	50,342,945	51,848,423
Limestone	3,111,875	2,488,134
Sand, gravel and crushed rock	70,426,812	63,177,608
Clay and structural clay products	1,831,456	1,521,102
Sulphur, dry and liquid	5,503,790	4,766,372
Nonmetallic minerals, n.e.c.	5,272,723	5,067,946
Sugar	901,046	774,892
Molasses	728,045	935,756
Rafted logs	19,589,784	18,152,096
Pulpwood, log	1,685,195	1,375,284
Lumber and lumber products	2,329,378	2,245,073
Pulp	1,090,853	1,004,039
Paper and paper products	1,862,868	1,670,519
Sodium hydroxide	4,010,813	3,135,305
Crude tar, oil, gas products	2,848,506	2,288,531
Alcohols	2,495,340	2,060,550
Benzene and toluene	3,242,926	2,977,767
Sulphuric acid	3,104,101	2,253,219
Basic chemicals and products, n.e.c.	13,485,070	12,079,233
Fertilizer and fertilizer materials	6,832,207	6,510,494
Miscellaneous chemical products	370,494	425,001
Gasoline	39,307,688	39,233,564
Jet fuel	5,910,331	5,262,600
Kerosene	1,915,427	1,572,942
Distillate fuel oil	40,918,639	38,986,678
Residual fuel oil	66,463,965	62,283,142
Lubricating oils and greases	2,400,242	1,946,499
Naphtha petroleum solvents	1,887,548	1,569,761
Asphalt tar and pitches	4,964,292	4,677,920
Coke, petroleum coke	2,214,370	2,198,061
Liquefied gases	958,382	1,171,950
Other petroleum and coal products	1,632,566	1,879,420
Building cement	4,272,741	3,714,435
Iron and steel products	7,691,279	6,437,754
Iron and steel scrap	1,968,057	1,378,857
Total - principal commodities	568,154,852	552,337,395
All other commodities	31,064,702	29,874,087
GRAND TOTAL	599,219,554	582,211,482

SOURCE: 1975 Inland Waterborne Commerce Statistics, The American Waterways Operators, Inc.

TABLE 5-4

1975 Waterborne Coal Tonnage Originated

River	Tons (thousands)
Mississippi	12,900
Ohio	42,100
Tennessee	4,600
Green & Barren	15,800
Kanawha	5,700
Monongahela	26,600
Illinois	5,800
TOTAL Shown	110,500
Total All Waterways	127,600
Percent of Total	86.6%

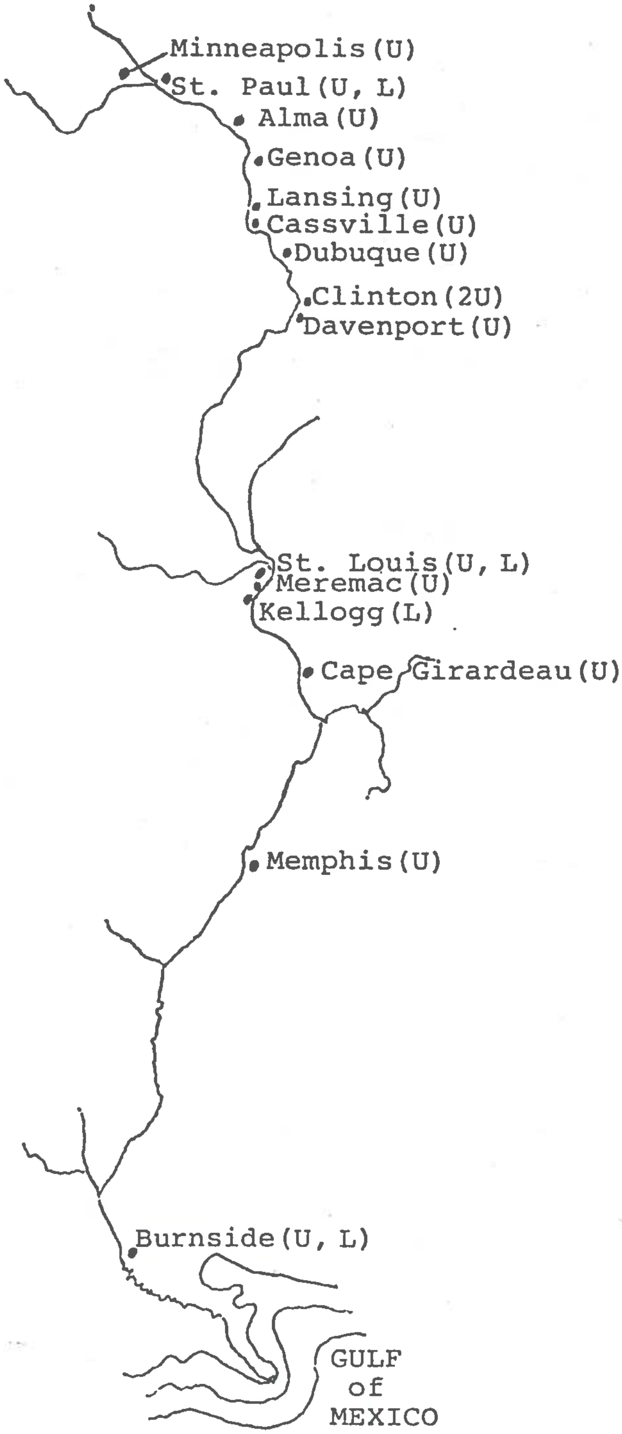
Source: Waterborn Commerce of the United States, 1975, Part V National Summaries, U. S. Army Corps of Engineers.

TABLE 5-5

1975 Coal Tonnage Moved on Selected Waterways

WATERWAY	COAL TRAFFIC (thousands of tons)	TOTAL TRAFFIC (thousands of tons)	COAL % OF TOTAL
Mississippi	25,002	187,914	13
Ohio	72,958	140,038	52
Illinois	7,670	45,832	17
Monongahela	30,130	37,268	81
Kanawha	6,435	12,449	52
Green and Barren	15,798	15,894	99
Tennessee	12,044	28,312	43
TOTAL	170,037	467,707	36

NOTE: The coal tons and total tons are tons carried on each river regardless of point of origination. Duplications do exist, however, tonnage moved on a river is an indication of its importance to a commodity and vice versa.



The Mississippi River rises in northern Minnesota and flows in a southerly direction to the Gulf of Mexico. Navigation extends from Minneapolis, Minn. to the mouth of the Passes.

Total Mileage--2,360

Navigation Mileage--1,837

Project Depth--9 feet to 40 feet

Project Width--300 to 1,100 feet

Lock Dimensions--56' by 400', 110' by 600', 110' by 1,200 feet (30 locks and dams)

Navigation Season--Minneapolis to mouth of Missouri: end of March through first week of December; mouth of Missouri to Head of Passes, 12 months

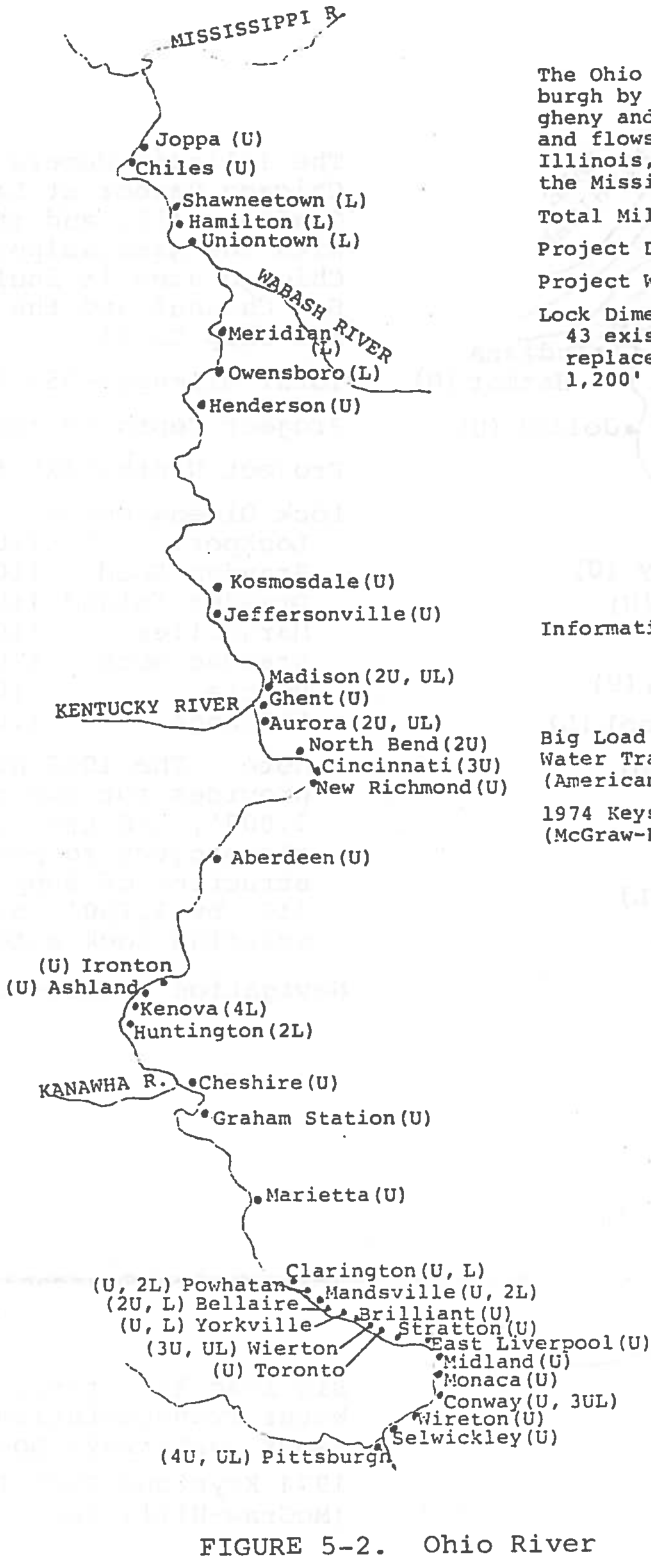
Average Max. Tow Size:
Upper Mississippi: 15 barges
Lower Mississippi: 40 barges

Information Sources:

Big Load Afloat--U. S. Domestic Water Transportation Resources (American Waterways Operators, Inc

1974 Keystone Coal Industry Manual (McGraw-Hill, Inc.)

FIGURE 5-1. Mississippi River



The Ohio River is formed at Pittsburgh by the junction of the Allegheny and the Monongahela Rivers and flows southwesterly to Cairo, Illinois, and its confluence with the Mississippi River.

Total Mileage--981

Project Depth--9 feet

Project Width--100 to 600 feet

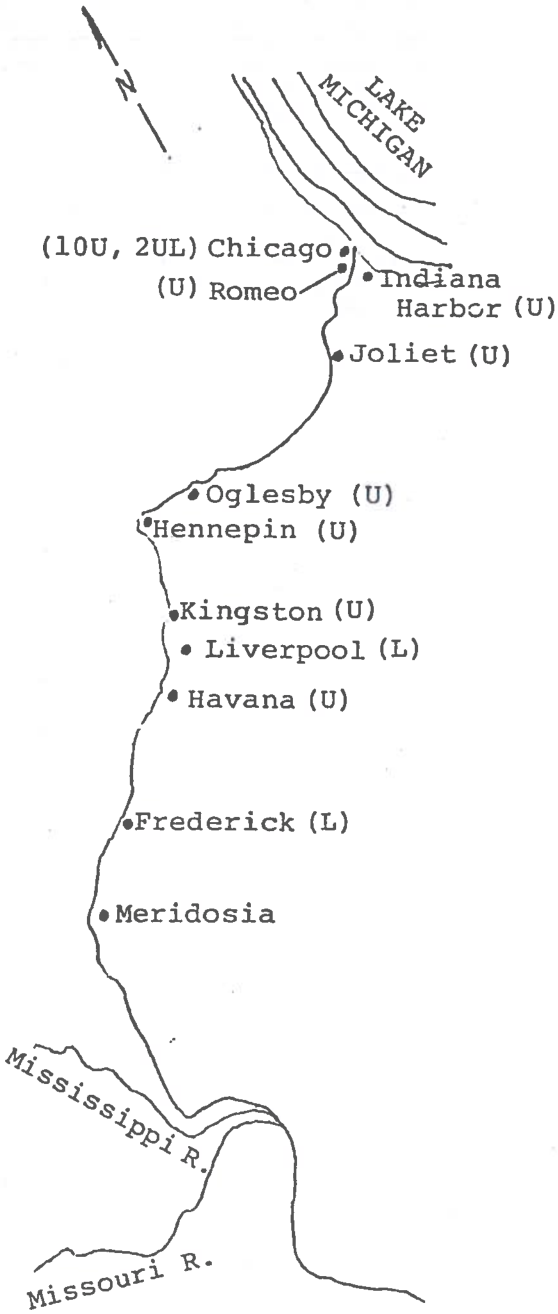
Lock Dimensions--
43 existing--110' by 600' to be replaced by 19 locks--110' by 1,200'

Information Sources:

Big Load Afloat--U. S. Domestic Water Transportation Resources (American Waterways Operators, Inc.)

1974 Keystone Coal Industry Manual (McGraw-Hill, Inc.)

FIGURE 5-2. Ohio River



The Illinois Waterway extends from Chicago Harbor at Lake Michigan to Grafton, Ill. and its confluence with the Mississippi River. In the Chicago area it includes the Calumet Sag Channel and the Chicago Sanitary and Ship Canal.

Total Mileage--353.6

Project Depth--9 feet

Project Width--225 feet

Lock Dimensions--

Lockport	110' by 600'
Brandon Road	110' by 600'
Dresden Island	110' by 600'
Marseilles	110' by 600'
Starved Rock	110' by 600'
Peoria	110' by 600'
LaGrange	110' by 600'

Note: The 1962 Authorization Bill provides for two new locks 110' by 1,000', and the modification of the project to provide for construction of supplemental locks, 110' by 1,200', of the seven existing lock sites.

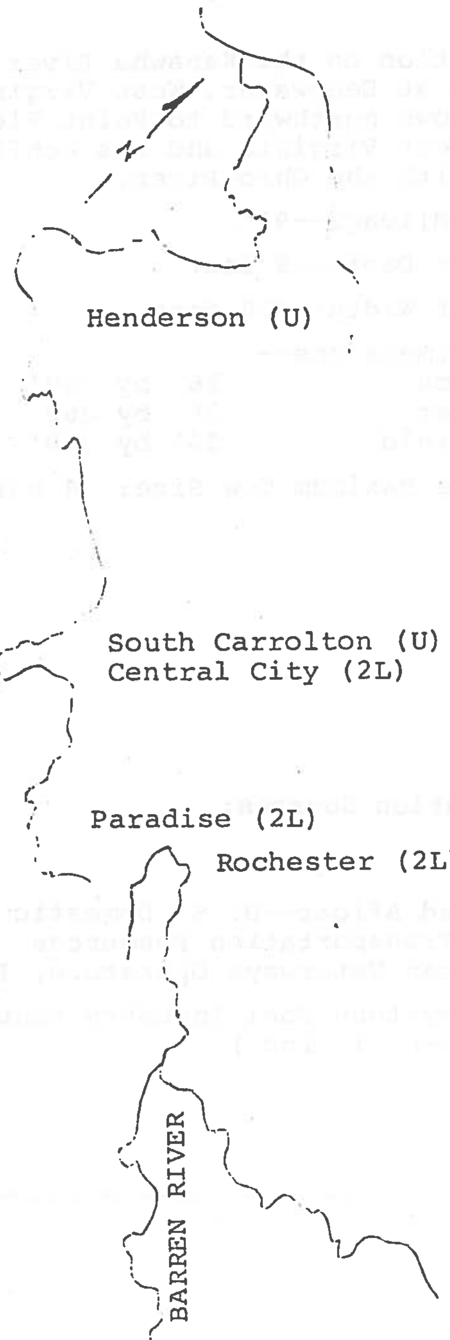
Navigation Season--12 months

Information Sources:

Big Load Afloat--U. S. Domestic Water Transportation Resources (Amer. Waterways Operators, Inc.)

1974 Keystone Coal Industry Manual (McGraw-Hill, Inc.

FIGURE 5-3. Illinois Waterway



The Barren River flows northwesterly from Bowling Green, Kentucky to its confluence with the Green River at Woodbury for a distance of 30 miles. The Green River flows northwesterly for a distance of 150 miles where it empties into the Ohio River eight miles above Evansville, Indiana.

Total Mileage--180

Project Depth--5.5 to 9 feet

Project Width--100 to 200 feet

Lock Dimensions--

No. 1 Green River	84' by 600'
No. 2 Green River	84' by 600'
No. 3 Green River	35.8' by 137.5'
No. 4 Green River	35.8' by 138'
No. 1 Barren River	56' by 360'

Navigation Season--12 months

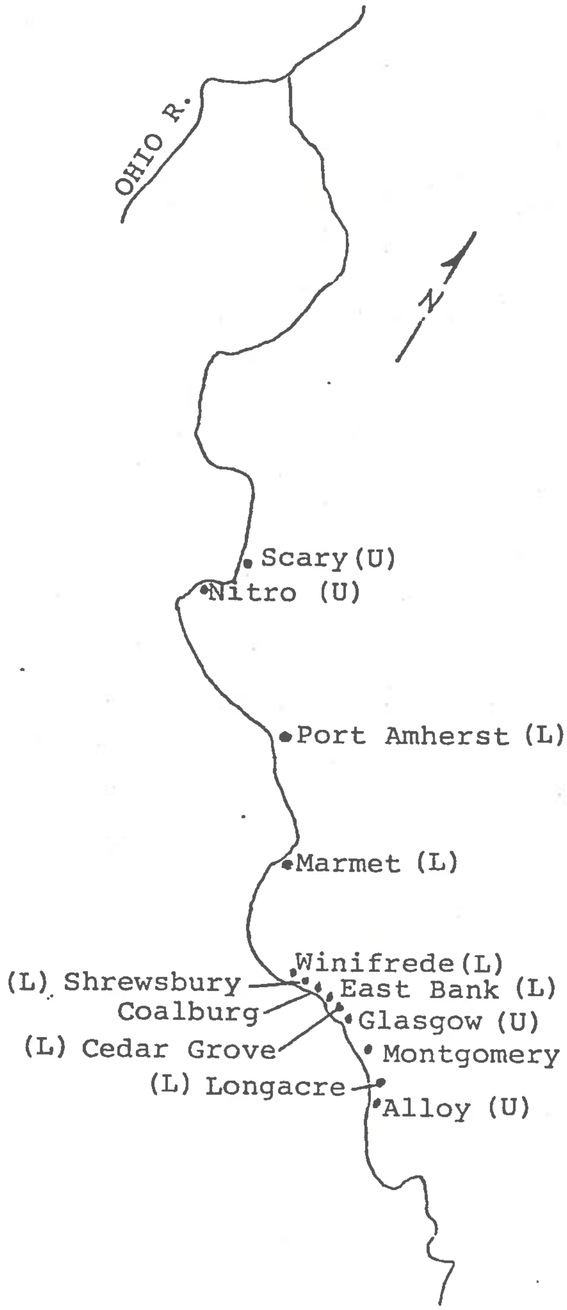
Average Maximum Tow Size: 9 barges

Information Sources:

Big Load Afloat--U. S. Domestic Water Transportation Resources (American Waterways Operators, Inc.)

1974 Keystone Coal Industry Manual (McGraw-Hill, Inc.)

FIGURE 5-4. Green River



Navigation on the Kanawha River begins at Deepwater, West Virginia and flows northward to Point Pleasant, West Virginia and its confluence with the Ohio River.

Total Mileage--91

Project Depth--9 feet

Project Width--300 feet

Lock Dimensions--

London	56' by 360'
Marmet	56' by 360'
Winfield	56' by 360'

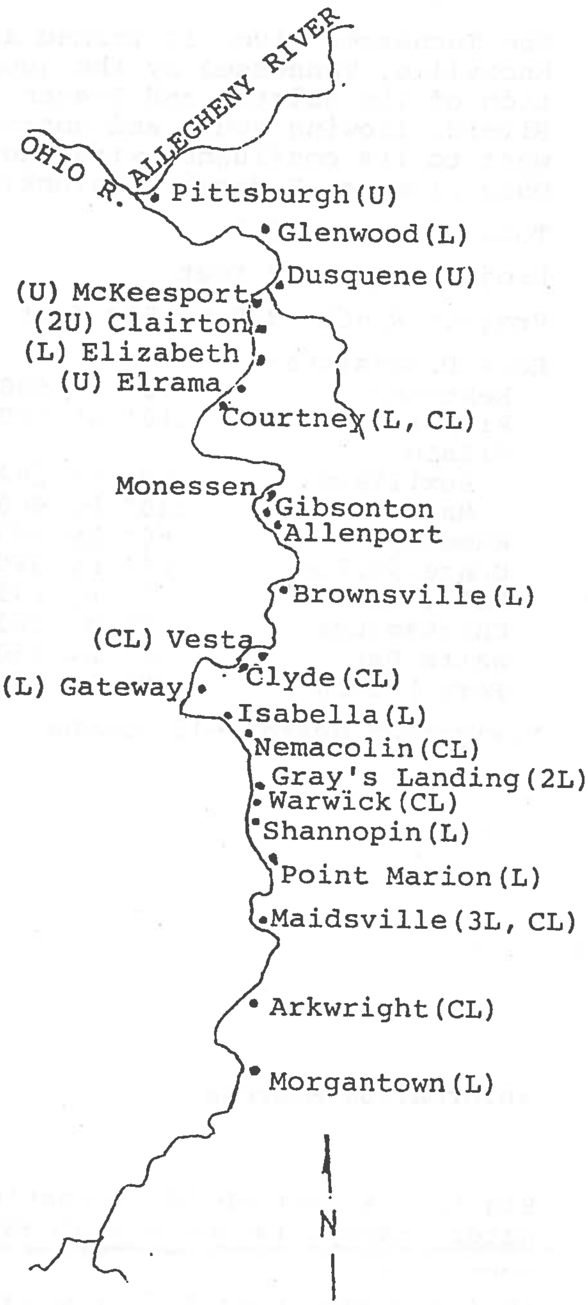
Average Maximum Tow Size: 4 barges

Information Sources:

Big Load Afloat--U. S. Domestic Water Transportation Resources (American Waterways Operators, Inc.

1974 Keystone Coal Industry Manual (McGraw-Hill, Inc.)

FIGURE 5-5. Kanawha River



The Monongahela River flows northwesterly from Fairmont, West Virginia to its confluence at Pittsburgh with the Allegheny River to form the Ohio River.

Total Mileage--129

Project Depth--7 to 9 feet

Project Width--300 feet

Lock Dimensions--

No. 2 (2 chambers)	56' by 360'	
	110' by 720'	
No. 3 (2 chambers)	56' by 360'	
	56' by 720'	
No. 4 (2 chambers)	56' by 360'	
	56' by 720'	
No. 5 (2 chambers)	56' by 360'	
No. 6 (2 chambers)	56' by 360'	
No. 7	56' by 360'	
No. 8	56' by 360'	
No. 14	56' by 182'	
No. 15	56' by 182'	
Maxwell (to replace No. 4)	84' by 720'	
Morgantown	84' by 600'	
Hildebrand	84' by 600'	
Opeskiska (to replace Nos. 14 and 15)	84' by 600'	

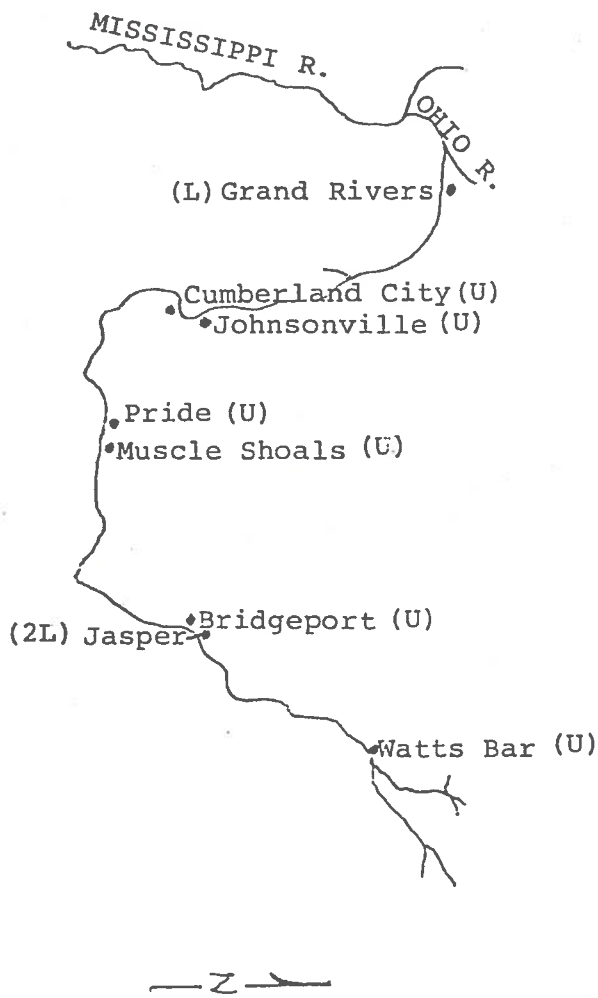
Navigation Season--12 months

Information Sources:

Big Load Afloat--U. S. Domestic Water Transportation Resources (American Waterways Operators, Inc.)

1974 Keystone Coal Industry Manual (McGraw-Hill, Inc.)

FIGURE 5-6. Monongahela River



The Tennessee River is formed at Knoxville, Tennessee by the junction of the Holston and French Rivers, flowing south and southwest to its confluence with the Ohio River at Paducah, Kentucky.

Total Mileage--652

Project Depth--9 feet

Project Width--300 to 500 feet

Lock Dimensions--

Kentucky	110' by 600'
Pickwick	110' by 600'
Wilson:	
Auxiliary	60' by 292'
Main	110' by 600'
Wheeler	60' by 400'
Guntersville	60' by 360'
Hales Bar	60' by 265'
Chickamauga	60' by 360'
Watts Bar	60' by 360'
Fort Loudon	60' by 360'

Navigation Season--12 months

Information Sources:

Big Load Afloat--U. S. Domestic Water Transportation Resources (American Waterways Operators, Inc

1974 Keystone Coal Industry Manual (McGraw-Hill, Inc.)

FIGURE 5-7. Tennessee River

5.2 1985 Coal Traffic

The water carriers operating on the inland waterways are unregulated when dealing in bulk commodities such as coal. Transportation is provided on long term contract, short term contract and single shipment basis. Some exchange of traffic occurs between carriers. For instance, a loaded barge may not wait for a towboat belonging to the same company. Instead it may be put in the first tow available going to the same destination area. The company actually moving the barge is paid a towing fee by the company whose barge carried the shipment. Many users of water transportation own barges and buy towing services from water carriers. In these cases, there is no opportunity for a backhaul load. The equipment is dedicated to moving the owners' freight. Both coal companies and utility companies own or lease barges. Army Corps of Engineers data indicate that 15% of inland waterway coal traffic is private carriage.

Rates for exempt, for hire water transportation are negotiated between shipper and carrier and fluctuate over a wide range. Seasonal fluctuations occur during peak traffic periods, such as grain harvest months, when rates rise substantially. During slack traffic times, rates fall. Other factors also impact rates including considerations of availability of backhaul loads at the destination, competition, presence of congested areas on the route and others. Because of the nature of water transportation, it is frequently difficult to forecast traffic in total for waterways carriers; much less forecasting a particular commodity. Consequently, the American Waterways Operators, Inc., (AWO) could provide information on a limited portion of the industry. The AWO data represent four carriers. These companies carried 39% of the coal tonnage originated on the five waterways on which they operate. The

1985 forecast is based on the proposition that these companies will maintain their market share. This assumption allows a forecast to be made for each of the rivers listed below and in Table 5-6 by scaling up the projections by a factor of 2.6.

The AWO was able to provide data on projected coal traffic on the Mississippi, Ohio, Tennessee, Kanawha and Green and Barren Rivers. Based on the data provided and assuming that market shares remain constant through 1985, the coal traffic on the five rivers will be 150 million tons, an increase of about 85%. Table 5-6 shows 1985 tonnages by river.

There are expected to be some continuing changes in the patterns of coal traffic on the inland waterways. Western coal is expected to be loaded on the upper Mississippi and move south, replacing, to some extent, coal moving north from lower sections of the Mississippi River and from other rivers. These shifts in traffic patterns make simple addition of projected tonnages to current traffic incorrect. While the traffic on the river system is expected to grow in total tonnage, the origins and destinations may change. Similarly, the number of ton-miles of coal transportation on some rivers increases at a rate less than total tonnage.

The AWO provided data on the growth of non-coal traffic on the five rivers. Traffic on Upper Mississippi could increase anywhere from 5% to 100%. Traffic on the Ohio is estimated to increase about 15%, the Illinois up to 50%, the Lower Mississippi up to 200% and the Tennessee about 20%. The wide range of growth estimates reflects three factors. First, the difficulty in forecasting waterborne commerce in general. Second, there are several locks and dams which are at or approaching capacity limitations. Locks and Dam 26

TABLE 5-6

Projected 1985 Coal Traffic Origination On Selected Waterways

River	1985 Tons (thousands)	1975 Tons (thousands)
Mississippi	25,800	12,900
Ohio	71,900	42,100
Tennessee	9,200	4,600
Kanawha	11,400	5,700
Green	31,600	15,800
TOTAL	149,900	81,100

NOTE: The 1985 projections are based on data representing 39% of 1975 total coal tonnage originated on these rivers and the assumption of constant market shares through 1985.

at Alton, Illinois is the most critical at this time. It is also the subject of several court suits and congressional and policy debate. The controversy is discussed in detail in Section 5.5.

The third factor is the possibility of imposition of user charges on the inland waterways. Water carriers now pay no fee for use of federally provided channels and facilities. There is a high probability that user charges designed to recover some portion of federal expenses will be imposed. The U. S. Senate has passed a bill including user charges and the Administration is actively pressing for their implementation. The impact of these three factors is great uncertainty in the future growth of inland waterway transportation, particularly on the Mississippi River.

5.3 Equipment

The waterways carriers use a variety of barge sizes and types in the conduct of their business. In the past few years a few barge sizes and types have become more popular. This has brought some measure of standardization to the industry. The most common types in use on the Mississippi River system are hopper barges, either covered or open. Hopper barges are basically a steel box in a rectangular vessel with a rake at each end. The most common size is 195 feet long and 35 feet wide. These barges have a loaded capacity of 1,500 tons. This is the standard coal barge. The second most common size is 175 feet by 26 feet with a capacity of 1,000 tons. There are many other sizes in use. One of the potential efficiencies which can be achieved by waterways operators is the standardization of barge sizes to facilitate building tows.

The carriers participating in the study estimated the barge requirements for handling the coal traffic they projected for 1985. These have been converted to 1500 ton equivalent barges and expanded to represent the five rivers covered by the traffic forecasts. As in the coal forecast, 39% of the traffic is represented by these carriers. Therefore, the barge projection was expanded by a factor reflecting the market share of each carrier and based on other carrier supplied information. Projected additional barge requirements for 1985 coal traffic are 1120 barges, measured as 1500 ton equivalents. This represents an investment of $168 million at 1976 prices.

Like barges, towboats are made in a variety of types and sizes. Each company has certain features it wants on its towboats. The sizes range from harbor boats of a few hundred horsepower up to towboats of 10 and 12 thousand horsepower capable of pushing as many as 45 loaded barges on the Lower Mississippi. It is virtually impossible to estimate the total towboat fleet required to perform all the transportation functions for moving coal. Many towboats provide harbor or fleeting services to all users of a port. Others move a wide variety of commodities in mixed tows on the larger rivers. Many shippers and receivers of barge traffic have towboats for positioning barges in loading and unloading operations. Based on the AWO data, 48 new towboats are required above the existing fleet to handle 1985 coal traffic on the five rivers covered. The investment in these boats is estimated at between $150 and $200 million at 1976 prices. Table 5-7 shows the breakdown by towboat sizes. The total horsepower addition is 121,900 horsepower. These projections are expansions of the base data representing 39% of originated coal traffic in 1975.

TABLE 5-7

Projected Towboat Requirements for
1985 Coal Traffic

Size (Horsepower)	Number	Total Horsepower
6,600	3	19,800
4,200	3	12,600
4,000	6	24,000
2,500	1	2,500
1,800	35	63,000
TOTAL	48	121,900

NOTE: These are towboats required above existing fleets.

5.4 Facility Requirements

The waterways, on which the barge and towing industry operate, are provided by the federal government for anyone to use. Therefore, the waterway operators do not estimate any requirements for waterway investment as such. A discussion of the waterway requirements is included in Section 5.5.

Shore facilities are generally the responsibility of private enterprise.[6] These facilities include loading and unloading facilities, fueling stations and others. In general, only loading and unloading facilities are dedicated to specified commodities. Other facilities serve diverse traffic and vessels. The AWO data estimates that the increased coal traffic will require at least 3 new coal loading facilities at a cost, at 1976 prices, of $19 million.

Loading and unloading facilities are an important part of the barge transportation system. Most loading facilities are transshippment facilities since coal is brought to the rivers by rail or truck for loading onto barges. Barge loading systems generally consist of a loading device, usually a chute from an elevated hopper fed by conveyors, and a system for positioning barges. Barges are placed either by a small towboat or by a cable arrangement as shown in Figure 5-8. After initial positioning by a towboat, one or more barges are attached to a cable, bow and stern, which runs through blocks fixed to pilings at either side of the loading dock. There is a power driven winch in the cable system which can move the barge(s) in either direction as loading progresses. There are variations on the design of the system such as

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6 There are many municipal docks and other facilities, however, those facilities handling the majority of coal traffic are private.

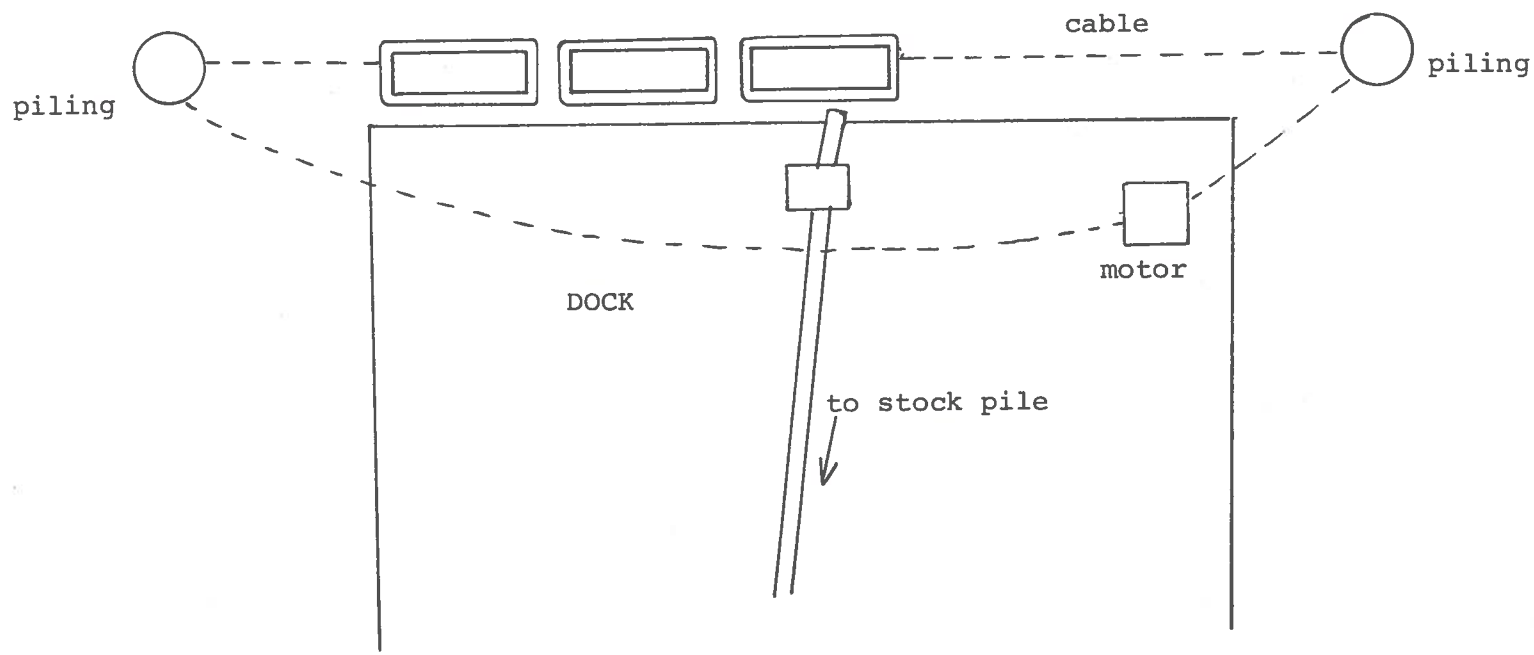

FIGURE 5-8. Barge Positioning System

using only one piling. But the basic principle is the same. Unloading systems are very similar to loading with the principal difference in the equipment between barge and elevated hopper. Unloading is accomplished with clamshell buckets or continuous conveyors which dump into an elevated hopper which feeds conveyors to storage or immediate use. Loading and unloading facilities are an area singled out by waterway carriers as needing improvement.

A second area of potential improvement cited by waterway operators is communications systems. Currently, the radio-telephone is the basic means of communication between operating companies and their towboats and between towboats and lock personnel and each other. There are potential operating benefits to be gained from better communications among operating companies for the purpose of scheduling. Two areas are susceptible to improved scheduling. First is arrivals of tows at locks. Frequently, several tows will arrive at a lock within a short time period. The result is congestion and waiting times of up to 12 hours to lock through. Scheduling of traffic to stagger arrivals could reduce some delays and the resulting costs of waiting.

The second scheduling improvement relates to scheduling traffic to optimize tow capacity utilization. There is some intercompany interchanging of traffic now. An increase in the amount of traffic which moved on the first available tow, with provision for proper revenue accounting, could improve towboat and barge utilization. Similarly, interchanging equipment among carriers would have the same effect. Traffic scheduling requires a sophisticated information and communication system among carriers operating on the major waterways.

5.5 Waterway System Constraints

Several current and potential constraints on future waterway traffic growth have been identified by the water carriers. The most controversial and most critical of these is Locks and Dam 26 at Alton, Illinois (L&D26). L&D26 is located just south of the confluence of the Upper Mississippi River and the Illinois Waterway just north of St. Louis, Misouri. The facility consists of a dam and two locks, one 600 feet long by 110 feet wide and one 360 feet long by 110 feet wide. The facility was constructed in 1938 and is in a deteriorated condition. The Army Corps of Engineers (Corps) proposed in 1974 to construct a new facility two miles south of the present dam with two locks, each 1200 feet long by 110 feet wide. On August 6, 1974, 21 railroads and 2 environmental conservation groups filed suite in federal court to halt construction. An injunction was issued and no construction has begun. Since that time, the Corps has made at least three studies, the Department of Transportation has made two studies, railroads have made studies, and congressional committees have held hearings and made studies. Still, little progress has been made in resolving the issues.

Due to its location L&D26 must pass through the traffic of both the Illinois Waterway and the Upper Mississippi River. The main issues involved in the controversy center around the expansion of the capacity on these waterways which would result from the expansion of L&D26. In 1975, more than 54 million tons of cargo passed through L&D26, the AWO and Corps forecast that by 1987 73 million tons will need to use the locks and that by the year 2000 more than 110 million tons would be using the facility. Waterway operators argue that delaying construction of new locks or merely repairing the existing structure would create a permanent bottleneck in the system which would limit the traffic growth on both the Mississippi and Illinois waterways. The traffic projections and other arguments put forth by the Corps and waterway carriers are not universally accepted. The Department of Transportation has produced two reports which refute the Corps' assertions both as to future traffic requirements and to the present capacity of L&D26.

The controversy has broadened from its initial objection to the replacement of L&D26 to encompass the entire question of national transportation policy with regard to regulation and subsidization of modes and to the methods used by the Corps and Congress to evaluate water transportation investment. Issues of modal competition, market competition among regions, regional development, as well as costs of transportation across modes have entered the problem.

The current prospects for a rapid decision on L&D26 have been clouded by the prospect of approval of a replacement being tied to the institution of a user charge for waterway operators. Currently, there is no cost to users for use of the federally provided navigable waterways. Proposals have been made regularly since the 1930's for recovery of federal expenditures on inland waterways. All efforts have been unsuccessful to date. However, the institution of user charges was made part of a national transportation plan by the Secretary of Transportation in 1976 and was specifically included in President Ford's 1977 budget presented to Congress. In hearings before the House and Senate in May of 1977, the user charge and L&D26 issues were connected and made contingent upon each other. Several recent studies have estimated that user charges designed to recover federal operations, maintenance and repair (OM&R) expenses could produce a loss of up to 10% of coal traffic on the inland waterways. The impact on future traffic growth is less certain. However, it is likely that any user charges will be passed on to shippers in some form.

Other waterway constraints identified by the waterway operators were the Upper Mississippi River and the Tennessee River. The Upper Mississippi has 27 locks and dams, L&D26 being one of them. All of these facilities have lock chambers less than 1200 feet long except L&D27 which is the southern most. Traffic growth over the next ten years is projected by water carriers to create unacceptable congestion conditions on this waterway.

The Tennessee River has nine locks and dams on its 650 mile length. Two of these, Pickwick Lock and Kentucky Lock, are cited as potential congestion points. The water carriers estimate that by 1980 these facilities will experience congestion of critical proportions. Because of L&D26, user charges and other controversial waterway projects (such as the Tennessee-Tombigbee Waterway), a federally sponsored study of all waterway transportation is to be undertaken by the Corps of Engineers. The study will take approximately three years and should resolve many of the non-political controversies surrounding the development of inland waterway transportation.

6. GREAT LAKES

The Great Lakes transportation system consists of the Lakes, the St. Mary's River connecting Lake Superior and Lake Huron; The St. Clair River, Lake St. Clair and the Detroit River connecting Lake Huron and Lake Erie and the Welland Canal connecting Lake Erie with Lake Ontario. The St. Lawrence Seaway provides access to the Atlantic. There are four locks in the St. Mary's Channel (Soo Locks) and eight locks in the Welland Canal. The Soo Locks have three lock chambers with a limit of 760 feet on vessel length and one lock with a limit of 1,100 feet. The Welland Canal has a vessel limit of 730 feet length and 76 feet beam. Channel depths, and, therefore, drafts of lakes vessels, generally are 26 to 28 feet.

The depth of the lakes channels varies with several factors such as annual precipitation and dredging activity levels. Figure 6-1 shows the Great Lakes, connecting channels and major coal ports.

6.1 Lake Carriers and Traffic

The Great Lakes are used by both U. S. and Canadian vessels for the movement of freight and passengers. In 1975, the fleets engaged in commercial cargo operations numbered 166 U. S. vessels with a carrying capactiy of 2.6 million tons and 147 Canadian vessels with a carrying capacity of 2.2 million tons.[1] Table 6-1 shows the U. S. and Canadian vessel Registries by number, principal trade and type of vessel.

The vessels used in Lakes commerce are generally self propolled bulk carriers.[2] The vessels vary in size

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[1] Lakes Carriers' Association.

[2] There are a few tug-barge operations

Lake Port Coal Loading Facility	Railroad Serving
Chicago	Belt
Toledo*	C&O, PC
Sandusky	N&W
Lorain	B&O
Ashtabula	PC
Conneant	B&LE
Superior	BN

* several docks

FIGURE 6-1. Great Lakes and Coal Transfer Facilities

TABLE 6-1

U.S. and Canadian Vessels - 1975

Number, Trade, Type:	UNITED STATES REGISTRY Total Ships	Gross Registered Tons	Gross Tons Carrying Capacity	CANADIAN REGISTRY Total Ships	Gross Registered Tons	Gross Tons Carrying Capacity
Bulk Freight Vessels In Iron Ore, Coal, Grain, Stone Trades						
118 Steam; 23 M/V; 1 Tug/Barge	142	1,408,376	2,412,361			
66 Steam; 30 M/V.				96	1,361,423	1,891,800
Bulk Freight Vessels in Mixed Trades:						
CEMENT						
6 Steam; 1 M/V; 2 Barge.	9	42,861	61,800			
3 M/V.				3	12,382	13,750
SAND						
2 M/V.	2	5,555	5,800			
1 Steam.				1	2,015	2,500
COAL, GRAIN, WOOD						
1 Barge.	1	2,850	4,500			
**22 M/V.				22	85,762	113,888
CHEMICALS, SCRAP						
*1 Steam.	1	4,883	6,900			
TANKERS						
3 Steam; 7 M/V; 1 Barge.	11	36,089	59,850			
7 Steam; 18 M/V.				25	94,472	147,400
RAILROAD CAR FERRIES						
7 Steam; 2 M/V.	9	30,534				
1 Steam; 1 M/V.				2	6,067	
PASSENGER AND AUTOMOBILE FERRIES						
1 M/V.	1	2,860				
PASSENGER VESSELS						
2 Steam.	2	17,045				
Steam, M/V.						
	178	1,551,053	2,551,211	149	1,562,121	2,169,338

*Crane equipped

**Canal Types & Package Freighters Included.

SOURCE: Annual Report of the Lakes Carriers' Association, 1975, p. 35.

from 600 feet in length to 1,100 feet and have carrying capacities ranging from 20 thousand to more than 60 thousand tons. The trend in vessel construction is toward larger vessels. The Poe Lock, the largest of the Soo Locks, is authorized to handle vessels up to 1,100 feet. The operating costs of vessels in the 70 foot range are approximately the same as for vessels in the 1,000 foot range except for fuel consumption. The fuel consumption of 1,000 foot vessels is less than twice that of 700 foot vessels while the cargo capacity is somewhat more than double[3] when carrying coal.

Another trend in lakes shipping is toward self-unloading vessels. The economies of vessel operation are primarily time related on the cost side. This means that unproductive time must be minimized if operators are to successfully compete for traffic. The primary objective of vessel operators is to keep the vessels loaded and moving in revenue service at all times. Many new lakes vessels designed for bulk cargoes are self-unloaders. These vessels have unloading rates up to 10,000 tons per hour. Older vessels are also being converted to self-unloaders.

In the domestic (U. S.) trades there are three types of business: private, or captive, operations, contract carriage and spot carriage. Private or captive fleets are primarily operated by the large steel companies. These vessels account for about 50% of lakes traffic annually. The remainder of the traffic is moved by about 40 steamship lines. Total bulk traffic on the Great Lakes in 1975 was 191 million tons[4] of which 129 million[5] were

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[3] Industry sources. Iron ore is denser than coal. Therefore, smaller vessels carry more ore than coal and the net gain of larger vessels is proportionately less than for coal.

[4] Lake Carriers' Association.

[5] U. S. Army Corps of Engineers.

domestic lakewise traffic. Table 6-2 shows Lake Bulk Freight Commerce for the four largest volume commodities.

TABLE 6-2

Lake Bulk Freight Commerce by Years

	Iron Ore Gross Tons	Soft and Hard Coal Net Tons	Grain of Various Kinds Net Tons	Stone Net Tons	Total Net Tons
1945	75,714,750	55,246,197	18,717,773	16,318,193	175,082,683
1946	59,356,716	53,726,531	10,197,850	17,551,555	147,955,458
1947	77,898,087	58,059,884	11,409,228	20,891,130	177,606,099
1948	82,937,192	60,563,530	9,876,880	22,282,425	185,612,490
1949	69,556,269	40,929,565	12,542,565	20,322,136	151,697,287
1950	78,205,592	57,640,222	9,327,450	23,395,011	177,952,976
1951	89,092,012	50,945,656	13,150,144	25,871,319	189,750,172
1952	74,910,798	46,284,192	15,214,778	23,277,942	168,677,006
1953	95,844,449	51,034,713	14,317,229	26,999,207	199,696,932
1954	60,793,697	46,367,167	11,866,241	24,975,440	151,297,789
1955	89,169,973	53,378,385	10,787,786	29,722,293	193,758,833
1956	80,195,929	57,374,685	14,319,650	30,753,412	192,267,187
1957	87,278,815	56,779,772	11,234,810	30,439,375	196,206,230
1958	54,787,479	44,949,995	12,625,829	22,496,239	141,434,040
1959	51,450,731	47,228,449	13,609,452	26,159,660	144,622,380
1960	73,073,053	46,701,235	14,134,959	27,179,458	169,857,471
1961	60,897,367	43,969,565	16,607,745	25,418,364	154,200,725
1962	63,085,330	46,184,285	15,918,950	24,730,834	157,489,639
1963	67,298,000	51,642,796	18,777,164	28,547,128	174,440,849
1964	78,115,327	52,142,742	21,637,255	30,771,477	192,040,640
1965	78,627,591	54,574,092	21,875,439	30,819,351	195,331,784
1966	85,273,676	55,585,464	25,013,943	34,021,957	210,127,881
1967	80,605,929	52,890,668	17,616,863	31,716,614	192,502,786
1968	83,631,0[illegible]	48,861,866	16,325,298	33,093,501	191,947,440
1969	86,307,605	46,924,447	16,594,713	36,083,477	196,267,146
1970	87,018,233	49,683,710	23,820,347	38,477,439	209,531,517
1971	78,162,234	43,341,847	25,239,080	33,998,558	190,131,586
1972	81,158,094	43,235,484	26,692,466	37,345,901	198,170,916
1973	94,545,275	39,604,341	26,536,921	42,888,052	214,920,023
1974	87,577,977	34,989,243	19,589,153	43,096,337	195,762,067
1975	79,966,250	39,192,505	24,511,214	37,681,469	190,947,386

SOURCE: Annual Report of the Lakes Carriers' Association, 1975.

6.2 Coal Traffic

Coal traffic on the Great Lakes in 1975 totaled 39.2 million tons. U. S. domestic coal traffic was 21.9 million tons with the remainder destined for Canada. Coal traffic is an important cargo to Lakes Carriers. It is second in tonnage only to iron ore in domestic trades and has historically provided backhaul traffic for ore carriers. Iron ore from U. S. origins generally moves eastward from ports on Lake Superior while coal traffic moves generally westward from Lake Erie ports. Table 6-3 shows ports and major coal shipping patterns. These shipping patterns are beginning to change. Coal shipments to the Duluth Superior area on Lake Superior have decreased from 3.6 million tons in 1965 to less than 850 thousand tons in 1975. Coal shipments from Lake Superior ports (primarily Duluth Superior) nearly doubled from 1974 to 1975 to 2.1 million tons. This tonnage is moved eastward, the same direction as ore traffic. The Canadians will also be moving coal eastward across the lakes from Thunder Bay, on the northwest shore of Lake Superior. This will be western Canadian coal moving to destinations on the eastern lakes.* Lake Erie is still the largest coal originating area on the Great Lakes. However, the Lakes Carriers expect western coal to become a major segment of the coal trade very soon.

Great Lakes Carriers estimate that 27.5 million tons of coal will move in domestic trade in 1985. This represents an increase in domestic trade of 26%. Table 6-4 indicates the 1985 tonnage by origin and destination states. The

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* As this study does not cover Canada, tonnages moving on this trade were not determined.

TABLE 6-3

Bituminous Coal Shipments to United States Ports from Lake Erie

	To Lake Superior	To Sault	To Lake Huron	To Lake Michigan	To Lower Rivers	To Lake Erie	Total
Toledo	1,370,004	44,442	301,878	1,427,757	7,254,639	823,954	11,222,674
Sandusky	725,539	40,590	100,090	45,857	511,177	78,742	1,502,004
Lorain	---	---	161,507	---	887,688	215,759	1,264,954
Ashtabula	234,241	---	192,244	267,976	37,494	---	731,955
Conneaut	616,644	18,965	109,965	613,214	155,557	---	1,514,345
Total 1975	2,946,428	103,997	865,693	2,354,804	8,846,555	1,118,455	16,235,932
Percent 1975	8.88	.31	4.06	7.10	26.67	3.37	48.94
Total 1974	2,521,287	232,090	1,210,502	2,568,195	9,576,237	725,396	16,833,707
Percent 1974	8.46	.78	4.06	8.62	32.14	2.43	56.49

Bituminous Coal Shipments to Canadian Ports from Lake Erie

	To Lake Superior	To Sault	To Lake Huron	To Lower Rivers	To Lake Erie	Thru Welland Canal	Total
Toledo	25,710	1,992,674	41,843	19,135	32,839	1,319,745	3,431,946
Sandusky	---	---	---	---	51,005	2,785,050	2,836,055
Lorain	---	---	---	---	---	---	---
Ashtabula	78,449	---	---	943,606	943,737	1,887,061	3,852,853
Conneaut	---	---	---	1,937,872	2,781,988	2,098,794	6,818,654
Total 1975	104,159	1,992,674	41,843	2,900,613	3,809,569	8,090,650	16,939,508
Percent 1975	.31	6.01	.13	8.74	11.48	24.39	51.06
Total 1974	229,145	1,791,127	48,269	3,151,810	1,487,482	6,259,219	12,967,052
Percent 1974	.77	6.01	.16	10.58	4.99	21.00	43.51

SOURCE: Annual Report, Lake Carriers' Association, 1975.

TABLE 6-4

Projected 1985 Domestic Great Lakes Coal Traffic

ORIGIN STATE	DESTINATION STATE	TONS (thousands)
Montana & Wyoming	Michigan	15,000
Montana	New York	3,200*
Illinois & Kentucky	Wisconsin	1,500
Wyoming	Wisconsin	100
Wisconsin & Ohio	Michigan	3,650
E. Kentucky	Ohio	4,000
TOTAL		27,450

* NOTE: Unsubstantiated tonnages up to 25 million have also been reported. These are considered too speculative for inclusion.

tonnage originating in the states of Wyoming and Montana will enter the lakes at the Duluth Superior area. The eastern coal will continue to enter at Lake Erie ports. The increase in traffic from western ports is nearly 900% while domestic traffic loadings at Lake Erie ports may decrease by 40%.*

The reduction in loading at Lake Erie ports may not occur for two reasons. First, traffic totaling 25 million tons which could not be substantiated sufficiently to be included in the Lake Carriers' estimates is possible. The origins and destinations are unknown for this traffic. Second, the energy program advocated by President Carter may increase the use of eastern coal and slow the penetration of western coal into eastern markets. The proposed requirement for scrubbers on all coal burning generating stations may reduce the economic advantage of western coal.

Export traffic on the Great Lakes in 1975 was 16.9 million tons to Canada. If the market share of Canadian exports of total exports continues through 1985, Lakes export tonnage will be about 20 million.

6.3 Vessel Requirements

The Lakes Carriers determined vessel requirements for domestic coal traffic estimated for 1985. Two vessel mix possibilities were estimated. The first consisted of 10 vessels each 1000 feet long and with 105 foot beam. Each

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* Domestic traffic originates and terminates in the U. S. and is 49% of Lake Erie coal loading tonnage.

vessel would have a carrying capacity of 60,000 tons. The second possibility consists of 16 vessels 610 feet by 60 feet, 5 vessels 800 feet by 75 feet and one vessel 604 feet by 60 feet. Other mixes are possible using variations in size of vessels. It is also possible that the 1000 foot vessels may be built with 1100 feet since vessels of this size are now permitted to transit Poe Lock. The total carrying capacity of the fleet required to move 1985 coal traffic is about 600,000 tons. This is a 24% increase in carrying capacity of the existing United States fleet. The 1975 average cargo turnover for the Great Lakes fleet was 41 loaded trips per year.* This yields an average annual capacity in 1985 of 24.6 million tons. The actual annual carrying capacity will probably be higher than indicated by the average due to better than average utilization rates. The reason for better than average utilization is that many of the vessels in the coal trade will be dedicated to that trade serving facilities dedicated to loading and unloading coal. Less port time can be expected for these vessels because of the reasons mentioned above and because they will be self-unloading vessels. Such vessels can unload at rates as high as 10,000 tons per hour.

The projected coal carrying capacity of 24.6 million tons for 1985 represents total required capacity. The incremental capacity can not accurately be measured because of the fact that many lake vessels are not dedicated to one commodity. The rate at which new vessels are being built; the growth in other commodities in lakes traffic, and technological improvements in new vessels indicate that most, if not all the projected tonnage will be constructed.

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* Calculated by dividing total fleet carrying capacity into total bulk cargo carried per year.

The investment required for U.S. vessels to handle 1985 coal traffic is projected to be about $450 million at 1976 prices. This represents the lowest cost option consisting of 10 vessels 1000 feet by 105 feet at a cost of $45 million each. The second option consists of 22 vessels to do the same job as 10 larger vessels. While the smaller vessels cost between $20 and $30 million each, the requirement for 22 would bring the investment over $500 million at 1976 prices. Vessel construction contracts are written with escalation clauses to cover cost increases which make estimates of actual costs difficult. Also, specifications for ships with the same basic hull can vary. Specifications such as type of propulsion (simple diesel, multiple diesel, horsepower per engine, etc.), type of control, electronics, internal contours and bracing patterns and other considerations will seriously affect the cost of a vessel. Therefore, the estimates indicate a range of investment values.

6.4 Facility Requirements

The facilities used by Lakes carriers are of two types - shore facilities such as docks and loading/unloading facilities and navigation facilities such as locks, channels and harbors. Shore facilities used for coal traffic are generally provided by shippers, railroads or transshipment facility operators. Navigation facilities are provided by the governments of the U. S. and Canada.

Shore facilities required to handle the expected coal traffic in 1985 could be only partially estimated by the Lakes Carriers. New shore facility requirements are for at least one unloading facility on the eastern shore of Lake Erie in New York State at an estimated cost of $20 - $30 million. There is an unknown probability that more than one such installation would be required. If this were the case, some multiple of the estimated investment would be necessary.

Expansion of existing facilities will also be required. Lake Carriers estimate that increased storage area for coal loading will be necessary at Superior, Wisconsin and at Lake Erie loading ports. Expansion of dock facilities, particularly at Lake Erie ports, is also necessary. These facilities are presently unable to load the number of smaller vessels required or the new larger vessels coming into service. An indication of the size increase of new vessels is the comparison of the average carrying capacity of the U. S. fleet* in 1975 and the capacity of new vessels. The 1975 average was 15,369 gross tons** while most new bulk carriage ships have 59,000 gross tons capacity. The amount of improvement and expansion necessary at coal loading ports cannot be estimated sufficiently accurately to determine investment requirements.

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* Calculated by dividing total carrying capacity by number of vessels in bulk freight service.

** Gross tons = 2200 lbs. (long tons).

6.5 Constraints on the System

Increases in traffic and the resulting increase in shipping activity may be hampered in the future by several constraints. First, if lake coal traffic from eastern origins is to continue at present levels or grow in the future, environmental issues must be resolved. The current expectation, indicated by forecast 1985 traffic patterns, is that western coal will dominate lakes traffic and eastern coal will decrease by as much as 50% in domestic trade.

Second, depth of water in the lakes is not sufficient for maximum loading of large vessels in all ports and channels. There are two causes of this problem. One is low water level from lack of precipitation. The other cause is the inability of the Army Corps of Engineers (Corps) to dredge to authorized project depths. Because of pollutants in the material removed from many harbors, EPA has prohibited the Corps from dumping the material in other parts of the lakes. Consequently, the Corps has built dikes to retain the dredged material. Construction of these diked disposal areas has been slow and expensive ($26 million in fiscal year 1975) and has inhibited routine channel and harbor maintenance.

A third potential constraint is the lead time required for the Corps to receive authorization for new projects and shifts in priority. If, for example, a new coal receiving facility is to be constructed on the eastern shore of Lake Erie, some channel and harbor improvements will be necessary. The construction time for such a facility may be as short as two years. It is unlikely that authorization and construction of harbors and channels could be accomplished in this short a time. As a result, some carriers are encouraging shippers and receivers to take over maintenance of their harbors and channels.

A fourth constraint is the vessel size limitation on the Welland Canal. Vessels larger than 730 feet length 76 feet beam cannot transit the canal. This effectively blocks the use of larger vessels from serving eastern Lake Ontario. If coal consuming facilities are planned for upper New York State or northern New England to burn western coal, access by the new large lakes vessels would provide an efficient delivery system.

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8. APPENDIX

REPORT OF NEW TECHNOLOGY

The work performed under this contract did not result in any inventions, discoveries or innovations, which are reportable under the contract patent clause. However, this study does represent an improvement in technical knowledge about water carrier estimates of the additional equipment and fixed facility expansion needed to handle increased coal traffic in 1985. Therefore, the invention or development of new devices was not expected.

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