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AN ASSESSMENT OF THE COMPETITIVE POSITION OF GREAT LAKES PORTS IN THE INTERNATIONAL STEAM COAL MARKET

by

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Abstract

Increasing oil prices during the 1970s improved the relative price position of steam coal generating expectations of growing international steam coal trading. U.S. ports responded to expected increases in steam coal exporting by planning port capacity and harbor depth expansions. While falling oil prices and the worldwide recession have deflated the expectations of booming steam coal trade, steady but slower coal trade growth is still anticipated.

This report, using a linear programming model to minimize total delivered world steam coal costs, analyzes future coal trade flows. Assessing the possibility of exporting Northern Great Plains coal through the St. Lawrence via the twin ports of Duluth, Minnesota and Superior, Wisconsin is the main goal of the study. World steam coal trade flows are projected for the years 1985, 1990 and 2000 through the linear programming model. The model includes demand from 25 coal importing nations and supply from 19 coal producing regions around the world. Two levels of coal demand are utilized in the assessment.

The potential for exporting Northern Great Plains coal through Duluth/Superior appears low unless world demand increases substantially over the next fifteen years. The market position of Northern Great Plains coal shipped through the Great Lakes is hurt by relative high inland transportation costs. Several developments which might favor Great Plains coal over less expensive coal, such as higher relative rail rates for Eastern coal or disruption of South Africa coal production, improve the market positions of Great Plains coal. But without expanded steam coal demand, significant steam coal exporting through Great Lakes ports seem unlikely before 2000.

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Introduction

Renewed interest in coal as a major energy source developed during the 1970s as oil prices rose and uncertainty over adequate oil supplies and future nuclear power generation levels increased. Interest in coal as a substitute for oil was particularly strong in the market-oriented industrialized nations of the world. Heavy reliance on oil imports from OPEC producers by the developed countries provided the stimulus for expanding coal usage.

Prior to the 1980-83 worldwide recession and the recent stabilization of oil prices, expectations for strong world coal consumption and related coal trade growth were commonly held. In the United States, expectations of rapid growth in coal exports were buoyed by sharp increases in coal exports during both 1980 and 1981. The near doubling of U.S. coal exports between 1979-81 resulted in shipping congestion at several East Coast ports, generating numerous expansion and investment plans at ports across the nation. The recent recession combined with the drop in oil prices has slowed coal trade growth, deflating the bright predictions of a U.S. coal export boom. Still, as the world economy recovers and economic growth resumes, some coal consumption and trade increases are anticipated.

Higher world coal demand during the last ten years has expanded international coal trading, as worldwide coal exports have increased from 160 million short tons in 1973 to approximately 270 million short tons in 1984.[1/] Most of the coal trade expansion has been in steam or thermal coal, coal which is burned for electric power generation. In 1973, steam coal accounted for one-fifth of total coal traded. Last year, almost one-half of coal traded was steam coal. Steam coal trade is expected to continue to widen while metallurgical coal trade (that coal utilized in iron smelting) is expected to only marginally expand.

This report focuses on the potential of Great Lakes ports, in particular the twin ports of Duluth, Minnesota and Superior, Wisconsin, to capture a share of the anticipated world steam coal trade growth. The twin ports of Duluth and Superior, referred to throughout this report as the port of Superior, offers to the coal producers of Montana and Wyoming a feasible transportation route to the coal markets of Western Europe via the St. Lawrence Seaway. Several million tons of Northern Great Plains (NGP) coal are already transported by coal unit train to Superior, loaded onto lake vessels and shipped to Michigan power plants.

While coal shipping from Superior is a relatively new development, coal has historically been a major cargo for Great Lakes vessels. United States Great Lakes ports annually handle over 30 million short tons of which over one-half is exported to Canada. Capacity shortages, congestion and vessel demurrage problems at East Coast ports in 1981 allowed Great Lakes ports to participate in overseas coal export. Northern Appalachian coal has been moving through the Lake Erie ports of Toledo, Erie, Sandusky, Conneaut and Ashtabula to consumers in Japan, Belgium, France and West Germany since 1981. Effective excess overseas coal exporting capacity for U.S. ports on the Great Lakes currently totals between 30 and 40 million short tons.[2/] The port of Toledo is included in the coal model utilized in this assessment as a proxy for all other U.S. coal terminals on the Great Lakes besides Superior. In addition, the possibility of shipping a mixture of low Btu Great Northern Plains coal with high Btu coal from Appalachia is analyzed with the model by including a dummy Great Lakes port at Toledo where an even blend of the two coals is mixed.[3/]

Three alternative shipping modes from the Great Lakes ports to overseas customers are considered:

- Direct overseas service by 25,000 dwt ocean vessels that are topped off from land storage once through the St. Lawrence Seaway (direct option).

- Transshipping of coal from lake vessels to 100,000 dwt ocean vessels through ground storage at Quebec City (transshipping option).

- Direct transloading onto 150,000 dwt ocean bulkers by self-unloading laker vessels in the lower Gulf of St. Lawrence area (transloading option).

The cost of delivering total world steam coal under two levels of demand for three years (1985, 1990 and 2000) are minimized using a linear programming model and the resulting trade flows analyzed. Trade routes between 52 importing ports, representing import demand for 25 countries, and 65 exporting ports, including 40 U.S. ports, are incorporated in the model. The model strives to simulate current and probable steam coal trading activity under the assumptions that the world steam coal market and ocean shipping sector are highly competitive. Under such assumptions, market actions will produce delivered coal prices which reflect minimum costs. In addition to generating the least cost coal trade pattern for the two baseline demand scenarios, the model is used to analyze key factors influencing future U.S. coal exports. Changing railroad rates, possible waterway user fees, emissions controls, U.S. port development, and South African export stability are analyzed with the model.

Background information on world coal reserves, coal production and recent coal trade movements comprise the initial sections of this report.

Coal demand projections along with probable steam coal suppliers are discussed in the following sections. The model, its framework and data sources are outlined in the ensuing sections. Following the outline of the model, results obtained are analyzed and some conclusions are drawn.

World Coal Resources and Reserves

In order to better understand future steam coal trade, some background information on coal types and their spatial distribution is needed. Coal is not a homogeneous resource, but is instead characterized by wide variations in calorific content and chemical composition. Coals are commonly classified by rank according to their degree of hardness, which usually corresponds with thermal value. The lowest rank of coal is lignite, followed by sub-bituminous coals, bituminous coals and anthracite. Differentiation of coal deposits into hard or brown coals is another classification scheme. Hard coal is coal with energy content above 10,250 Btu/lb. (primarily bituminous coals and anthracite) while brown coal includes all coals of lower heating value (sub-bituminous coals and lignite).

Coal quality is also determined by sulphur and ash content. Sulphur content is of prime importance to most coal users since control of sulphur emissions is required by law in most countries. National policies differ widely regarding emissions standards, but in general, importers favor coal of high thermal value (primarily bituminous coals) with sulphur contents below the 1.5 percent by weight level. If world coal demand expands sufficiently, sub-bituminous coals and higher sulphur coals may become more acceptable in the international market if advances in coal burning technology are adopted. The substantial coal demand levels projected under the high demand scenario in this report implicitly assumes that such technology will develop, thereby expanding steam coal supplies to include sub-bituminous and high sulphur coals. The acceptance of lower grade coal and the development of appropriate coal burning technology should occur as coal buyers seek to avoid demand induced price increases of higher grade coal. Some have suggested that the low sulphur coals, such as the coal reserves of Montana and Wyoming, may become more attractive to buyers seeking to reduce the costs of complying with emissions standards. The model is utilized to address this possibility after completing baseline runs by adding additional costs to high sulphur coals which reflect the costs of complying with emissions standards.

Coal is the most abundant and widely distributed fossil fuel. Estimated world coal resources total over 12,000 billion tonnes of which seven percent or 880 billion tonnes are presently classified as reserves.[4/] Worldwide distribution of reserves, summarized in Table 1, at first appear to be highly concentrated with over 90 percent of world reserves located in only ten countries. But in reality, spatial distribution of reserves are more extensive in relationship to current and future consumption levels. Nations which possess reserves equal to small fractions of the more endowed nations actually hold substantial amounts of coal since aggregate world reserves are so massive. The less endowed countries, especially several Third World developing countries, where coal exploration has accelerated with higher oil prices have adequate reserves to become steam coal exporting sources.

TABLE 1

World Coal Reserves
(billion tonnes)

	Anthracite and Bituminous	Sub-bituminous and Lignite
Major Exporters		
Australia	25.4	33.9
Canada	1.7	4.3
China	99.0	0.1
Poland	27.0	12.0
South Africa	25.3	0.0
U.S.A.	107.2	116.1
U.S.S.R.	104.0	129.0
Other Major Producers		
Colombia	1.0	0.0
Germany (Fed. Rep.)	24.0	35.2
India	12.6	1.6
Mexico	1.2	0.4
Spain	0.4	0.6
United Kingdom	45.0	0.0
Rest of World		
Africa	7.2	0.2
Asia	2.3	3.4
E. Europe	3.1	53.2
Latin America	0.3	2.2
Oceania	0.0	0.2
W. Europe	1.1	1.7
TOTAL	487.8	394.1

SOURCE: Survey of Energy Resources. World Energy Conference, 1980.

Despite the plentiful reserves of the well-endowed nations, coal production in these countries will be limited at least initially by capital, infrastructure, social and environmental constraints as coal production expands. Given the strong coal demand scenario assumed at one point in this analysis, countries besides the current major exporters are likely to develop into coal exporters. For this reason, several nations which are not currently coal exporters have been included in the model as potential coal exporters in the model.

World Coal Production

World coal production totaled roughly 3,974 million metric tonnes in 1982, accounting for 29 percent of world energy output that year. Coal's position as the second leading source of energy has been gradually reinforced during the rising oil price years of the 1970s. Coal along with nuclear power have been the major beneficiaries of higher priced petroleum. Table 2 displays the changing energy production picture.

TABLE 2

Percentages of Total World Primary Energy Production

	Oil	Natural Gas	Coal	Hydro Power	Nuclear Power
1973	47.8	19.3	26.5	5.5	0.9
1982	39.7	20.8	29.3	6.8	3.4

SOURCE: 1982 International Energy Annual, Energy Information Administration, Department of Energy, September 1983.

While part of the gain in coal's share of total energy production can be attributed to the drop in oil production, a steady expansion in coal production has also occurred. Coal production increased by 26 percent between 1973 and 1982, at an annual compound rate of 2.6 percent. Three countries (the U.S.S.R., U.S.A., and China) lead the world in coal production accounting for 54 percent of world output in 1982. Another 34.8 percent of 1982 output was mined by the next eight largest producers. In total, the top eleven coal producing countries accounted for 88.7 percent of the coal mined in 1982. As the production figures show in Table 3, the concentration of coal mining in the top producing nations is historical.

Careful study of the production figures suggest that certain countries have mature or declining coal industries while other countries' coal industries are emerging as major producers. South Africa, India, Australia and Canada stand out as expanding coal producers. Western European countries, on the other hand, show signs of stagnating coal industries as low cost high grade deposits are exhausted. The mismatch between regions of the world with expanding coal production and regions with heavy energy requirements and few energy resources has produced the increased activity in international coal trading.

A significant proportion of the increase in coal production during the last decade has been coal extracted from surface mines as opposed to underground mines. Underground mining is still the prevailing mining practice, despite the growing number of surface operations. Surface mining, in general, is more productive, less costly, and more capital intensive. Underground mining is more labor intensive, requiring a highly skilled workforce. In the United States, coal production from surface mines has exceeded production from deep mines since the mid-1970s. The shift to surface mining reflects the

TABLE 3

World Coal Production
(million metric tonnes)

	1973	1982	Annual Percent Increase
North America			
Canada	20.9	42.6	8.2
Mexico	4.5	7.3	5.5
United States	567.8	760.1	3.3
TOTAL	593.2	810.0	3.5
Central and South America			
Brazil	1.8	5.4	12.9
Colombia	3.6	6.3	6.4
Other	1.8	1.8	--
TOTAL	7.2	13.5	7.2
Western Europe			
Belgium	9.1	6.4	-3.9
France	28.1	20.0	-3.9
West Germany	215.9	224.0	0.4
Greece	12.7	28.1	9.2
Spain	12.7	42.6	14.4
Turkey	10.9	17.2	5.2
United Kingdom	129.7	121.5	-0.7
Yugoslavia	32.7	54.4	5.8
Other	7.3	6.4	-1.5
TOTAL	459.1	520.6	1.4
Eastern Europe			
Albania	0.9	1.8	8.0
Bulgaria	27.2	31.7	1.7
Czechoslovakia	108.8	125.2	1.6
East Germany	246.7	266.7	0.9
Hungary	26.3	26.3	0.0
Poland	195.7	226.8	1.6
Romania	24.5	37.2	4.7
U.S.S.R.	667.8	717.5	0.8
TOTAL	1297.9	1433.2	1.1
Middle East, Far East and Oceania			
Australia	85.3	146.0	6.2
China	471.7	665.8	3.9
India	80.7	132.4	5.7
Japan	22.7	17.2	-3.1
South Korea	37.2	50.8	3.5
North Korea	13.6	18.1	3.2
Taiwan	3.6	2.7	-3.2
Other	9.8	18.1	7.1
TOTAL	724.6	1051.1	4.2

TABLE 3 (cont.)

Africa			
South Africa	62.6	139.7	9.3
Zimbabwe	2.7	2.7	0.0
Other	2.7	2.7	0.0
TOTAL	68.0	145.1	8.7
WORLD TOTAL	3150.0	3973.5	2.6

SOURCE: 1982 International Energy Annual, Energy Information Administration, Department of Energy, September 1983.

expanding coal production activities in Midwest and Western states.

International Coal Trade

Despite the significance of coal as a leading energy source for the world, only a small proportion of total coal production is traded internationally. In 1980, over 90 percent of coal production was consumed in the country where mined. High transportation costs have until recently limited the geographical size of steam coal markets. With the sharp oil price increases of the 1970s, new interest in steam coal as an imported energy fuel began to surface. Previously international coal movements consisted primarily of metallurgical coal. Met coal, or coking coal as it is also termed, has a more limited geographical distribution than steam coal as only high grade coals with specific chemical and physical properties qualify as coking coal. Following the worldwide expansion in steel production capacity during the 1960s and 1970s, the trade in metallurgical coal grew robustly.

Trade in steam coal had stagnated during the era of cheap oil. Although some steam coal was being shipped long distances, most of the steam coal trade prior to higher priced oil era was intra-regional. Steam coal markets existed within the European Economic Community, among Centrally Planned Economy countries, and between the United States and Canada. Steam coal trading expanded sharply as coal became more cost competitive with oil. Trade totals listed below in Table 4 summarize coal trading trends.

TABLE 4

World Coal Trade
(million metric tonnes)

	Metallurgical	Steam Coal	Percent Steam	Total Trade
1960	51.5	51.5	50.0	103.0*
1970	128.0	67.0	34.4	195.0**
1980	142.0	116.0	45.0	258.0***
1984	155.8	148.9	48.9	304.7****

SOURCES: * Coal--Bridge to the Future, World Coal Study, 1980.
** "Economics of Ocean-borne Coal Transportation," Ron Hettena in Critical Issues in Coal Transportation Systems, National Research Council, 1979.
*** Constraints on International Trade in Coal, Ray Long, International Energy Agency, December 1982.
**** The Coal Situation, Chase Manhattan Bank, Vol. 5, No. 2, March 1985.

Currently the major coal exporters, in order, are the United States, Australia, Poland, South Africa, U.S.S.R., and Canada. The world's major coal importing nations are Japan, France, Italy, Canada, West Germany, Belgium, Luxemburg, Denmark, and South Korea. Western European import needs are primarily filled by coal from South Africa, the United States, and Poland. Canada, the United States, and Australia are the major suppliers for Japan and the rest of the Pacific Rim countries. Exports from Poland, the U.S.S.R., and Czechoslovakia meet most of the import demand of Eastern European countries. Table 5 lists 1980 imports and exports by region.

Prior to the recent world recession and Poland's resurgence in the market, United States' coal exports had been briskly increasing following the strike-induced low production year of 1978. Table 6 displays past U.S. coal export activity.

TABLE 5

1980 World Coal Trade
(million tonnes)

	Exporting Areas			
	Total	Coking Coal	Thermal	Seaborne Thermal
Western Europe	26	14	12	--
United States	83	57	26	15
Canada	16	14	2	2
Australia	43	35	8	8
South Africa	29	2	27	27
Colombia	2	--	2	2
Eastern Europe	31	6	25	4
U.S.S.R.	26	14	12	12
China	2	--	2	2
TOTAL	258	142	116	72

	Importing Areas			
	Total	Coking Coal	Thermal	Seaborne Thermal
Western Europe	112	45	67	55
Canada	17	6	11	--
Japan	68	62	6	6
Other Asia	20	10	10	10
South America	7	6	1	1
Eastern Europe	34	13	21	--
TOTAL	258	142	116	72

SOURCE: Constraints on International Trade in Coal, Ray Long, International Energy Agency, December 1982.

TABLE 6

U.S. Coal Exports
(million metric tonnes)

	Metallurgial Coal	Steam Coal	Total
1960			34.5*
1965			47.3
1970			65.7
1975			60.6
1978			37.0
1979	46.0	12.8	58.8**
1980	57.2	24.3	81.5
1981	59.2	40.8	100.0
1982	58.6	36.9	95.5
1983	45.5	25.1	70.6***
1984	51.7	22.2	73.9

SOURCE: * Quarterly Coal Reports, Energy Information Administration, Department of Energy, various issues.
** Port Deepening and User Fees: Impact on U.S. Coal Exports, Energy Information Administration, Department of Energy, May 1983.
*** The Coal Situation, Chase Manhattan Bank, Vol. 5, No. 2, March 1985.

Between 1960 and 1979, U.S. exports averaged about 49 million metric tonnes annually. Except for steam coal shipments on the Great Lakes to Canada, the majority of coal exports were met coal mined in the Appalachian coal fields and exported from East Coast ports. The upswing of steam coal exports starting in 1980 resulted from foreign buyers turning to U.S. producers in lieu of their regular suppliers, Australia and Poland. Both countries suffered production cutbacks due to labor troubles. Japan substituted U.S.

coal for Australian coking coal while Western European countries increased coal purchases from the U.S. to compensate for Poland's shortfall. The 25 percent drop in U.S. coal exports since 1981 can be contributed to the rebound of Australia and Poland's coal production, the worldwide recession, falling oil prices, and the strong value of the dollar. Table 7 details developments in U.S. steam coal exports over the last few years.

TABLE 7

U.S. Steam Coal Exports by Country
(million tonnes)

	1979	1980	1981	1982	1983	1984
Japan	.4	.9	3.5	3.1		
Canada	10.5	9.8	10.9	12.6		
Italy	--	.9	3.1	3.3		
France	.2	2.7	4.1	4.4		
Belgium/Luxemburg	.2	1.3	1.1	1.1		
Netherlands	.1	1.7	3.4	2.6	N.A.	N.A.
Spain	.2	1.0	3.0	2.4		
Denmark	.1	1.4	3.0	2.4		
United Kingdom	--	1.8	.5	--		
Brazil	--	.1	.1	--		
Other	1.0	2.7	8.1	5.0		
TOTAL	12.7	24.3	40.8	36.9	25.1	22.2

SOURCE: Port Deepening and User Fees: Impact on U.S. Coal Exports, Energy Information Administration, Department of Energy, May 1983.
The Coal Situation, Chase Manhattan Bank, Vol. 5, No. 2, March 1985.

Future World Steam Coal Trade

Underlying this analysis is the acceptance of projections which surmise steady expansion in steam coal trading. The optimistic forecasts for steam coal trade rest squarely on the belief that steam coal prices will continue to remain low relative to alternative fuel sources. Such a belief is based on the following developments over the next two decades:

- Future economic growth will require additional energy consumption as in the past, but through conservation measures required energy consumption per unit of economic growth will be considerably lower than in the past.

- Oil and natural gas supplies will not expand sufficiently, if at all, to meet the additional energy demands.

- Nuclear power will contribute substantially to world energy needs, but will not develop to the extent that was once envisioned.

- Renewable energy sources, including hydro electricity, will continue to grow, but will remain relatively minor to total energy supply.

- Substantial growth in coal consumption, in particular steam coal, will be necessary if economic growth is to be sustained.

Table 8 lists eight different projections of steam coal trade out to the year 2000. These projections represent the most comprehensive research efforts that have been carried out to date on steam coal trade prospects. Three of the projections are based on one-time studies [WOCOL-A, WOCOL-B and OCED] while the other projections are the latest available work from researchers involved with ongoing coal trade study. The most conservative projection [NCA-M] expects steam coal trade to more than double by 2000. The most optimistic projection [WOCOL-B] predicts steam coal trade to increase sevenfold within the next fifteen years. U.S. steam coal exports are anticipated to more than double over the next two decades in the lowest projection [NCA-L] as opposed to expanding nearly ninefold in the most favorable forecast [IEA].

TABLE 8

Comparison of Steam Coal Trade Projections
(million tonnes)

	U.S. Export Projections			World Trade Projections		
	1985	1990	2000	1985	1990	2000
EIA (1982)	46.2	72.6	137.9	172.8	285.4	518.4
IEA (1982)	--	--	228.0	--	--	689.0
WOCOL-A (1978)	21.0	31.5	68.3	110.3	--	315.0
WOCOL-B(1978)	31.5	63.0	136.5	157.5	--	714.0
OECD (1976)	13.2	19.5	61.5	84.0	93.5	353.9
NCA-L (1984)	28.1	40.8	69.8*	--	--	--
NCA-M (1984)	30.8	48.1	80.7	115.1	171.4	282.0
NCA-H (1984)	40.8	62.6	100.6	--	--	--

* 2000 projections for NCA are 1995 levels extrapolated out to 2000.

EIA: (Energy Information Administration) U.S. Coal Exports: Projections and Documentation, Energy Information Administration, U.S. Department of Energy, March 1982.

IEA: (International Energy Agency) Constraints on International Trade in Coal, Economic Assessment Service, International Energy Agency, December 1982.

WOCOL A/B: (World Coal Study) Coal--Bridge to the Future, Wilson, Carroll L., 1980.

OCED: (Organization for Economic Cooperation and Development) Steam Coal--Prospects to 2000, International Energy Agency, 1978.

NCA-L/M/H: (National Coal Association) Coal Markets in the Future, National Coal Association, March 1984.

The three one-time study projections were completed before 1980, thus these projections are based on the state of energy markets prior to the slackening in oil prices. The other projections, released in 1982 or after, are based on information which includes recent energy market conditions. Despite the recent drop in oil prices and weakening of steam coal demand, the more recent projections continue to forecast solid steam coal trade expansion in the coming years. The reason behind the consistently favorable forecasts seem to be that all of the researchers adhere to the occurrance, in the long run, of the general energy market developments as previously outlined. Most important, oil prices are expected to increase relative to steam coal prices as oil supplies remain limited and energy demand accelerates in the mid or late 1980s.

The specific steam coal demand projections utilized in this analysis are the WOCOL-A and EIA forecasts. Table 9 displays the projected steam coal imports by country for the two projections used. The WOCOL-A forecast, or low demand scenario as it will be referred to in the study, represents a moderate case of increased coal usage. Given the current oil market situation, the low demand scenario may be the most likely. The EIA forecast, or high demand scenario, predicts steam coal trade levels almost double that of the low demand case. For steam coal trade to reach the high demand levels, major shifts in the pattern of energy consumption would be required. The high demand scenario represents the best case for steam coal producers and at this time seems overly optimistic. While steam coal trade may eventually reach the high demand level, such demand will probably not occur until after the year 2000.

TABLE 9

Steam Coal Import Demand Scenarios
(million metric tonnes)

	1985		1990		2000	
	EIA	WOCOL-A	EIA	WOCOL-A	EIA	WOCOL-A
North America						
Canada	10.9	6.3	10.9	7.4	10.9	8.4
United States	-	2.1	--	2.1	--	5.3
SUB TOTAL	10.9	8.4	10.9	9.5	10.9	13.7
Latin America						
Argentina	--	--	--	--	3.3	3.2
Brazil	1.8	1.8	--	--	--	--
Venezuela	--	1.6	--	0.5	--	2.1
Others	1.7	0.1	0.8	0.2	0.2	0.4
SUB TOTAL	3.5	3.5	0.8	0.7	3.5	5.7
Europe						
Austria	4.4	1.9	5.7	1.4	15.5	1.6
Belgium/Luxemburg	11.5	3.2	15.7	4.2	26.0	6.3
Denmark	11.5	11.2	14.6	14.4	19.9	9.9
Finland	4.8	3.6	5.3	6.8	7.3	8.1
France	19.9	11.6	22.0	14.7	32.4	27.3
Germany, F.R.	13.0	9.5	20.0	18.9	35.5	21.0
Greece	1.5	--	3.2	--	4.2	--
Ireland	2.0	0.8	3.6	0.6	6.4	3.8
Italy	15.7	10.8	33.4	11.0	41.7	17.3
Netherlands	6.0	7.4	13.7	10.3	29.9	20.9
Norway	0.7	--	0.8	--	2.8	0.8
Portugal	1.1	0.8	2.0	1.3	4.9	3.7
Romania	1.8	--	1.8	--	1.8	--
Spain	6.3	3.4	8.3	3.1	22.0	3.7
Sweden	3.1	3.1	5.4	5.4	15.1	15.0
Switzerland	0.6	--	0.9	--	1.5	--
United Kingdom	--	--	--	--	--	--
SUB TOTAL	103.9	67.3	156.4	92.1	266.9	139.4
North Africa and Middle East						
Egypt	0.3	--	0.4	--	0.4	--
Israel	4.5	--	10.9	--	13.6	--
Turkey	2.7	4.2	7.3	5.9	9.9	10.6
SUB TOTAL	7.5	4.2	18.6	5.9	23.9	10.6

TABLE 9 (cont.)

Far East Asia						
Japan	29.0	6.3	55.8	25.2	98.6	55.7
Hong Kong	4.2	0.3	8.3	0.7	10.4	2.5
South Korea	8.3	3.4	14.6	8.6	45.9	29.6
Malaysia	--	--	--	0.2	3.2	1.3
Philippines	0.9	--	3.6	0.5	12.6	5.4
Singapore	1.5	--	2.1	0.2	4.9	1.9
Taiwan	3.2	1.6	14.6	8.5	37.6	22.7
SUB TOTAL	47.1	11.6	99.0	43.9	213.2	119.1
TOTAL	172.9	95.0	285.7	152.1	518.4	288.5

SOURCE: See Table 8.

Future Exporters

Future steam coal export activity is anticipated to be dominated by three countries: Australia, South Africa, and the United States. Each of these countries possess ample coal reserves, surplus mining capacity, sufficient transport infrastructure or the ability to develop the required facilities and perhaps most important, a stated policy of increasing coal exports. Australia and the United States are predicted to compete for the Pacific Rim market. South Africa and the United States are expected to vie for the Western European market. Combined, these three suppliers are fore-casted to capture over 70 percent of world steam coal trade by the year 2000. Other countries though have the potential to be competitive in selected markets.

Coal mined in western Canada has high mining and inland transport costs, but with low cost ocean freight rates, Canada is considered as a likely supplier in the Pacific Rim region. The coal industries of Western Europe are mature, but face depleted coal reserves and will be hard pressed to meet domestic demands. Only West Germany and Great Britain coal producers appear to have the potential to supply marginal amounts of steam coal to their European neighbors. Both of these countries subsidize their coal industries, suggesting that neither will promote coal exports over domestic consumption.

Poland's position as a major supplier of coal to Western European nations has been re-established after that nation's political turmoil in 1981. Poland's ability to supply Western Europe will be restricted though by its deep underground coal deposits, labor difficulties, and demand by other Eastern European countries. The competitive position of the U.S.S.R. in the European market is judged to be poor as its eastern coal deposits are of low quality. Western U.S.S.R. coal reserves though are considered to be a potential source of coal exports for Pacific Rim customers. China, with huge coal reserves, has a high potential to develop into a major exporter in the Pacific Rim market. For China to become a major exporter in the region, large amounts of foreign capital will be required to finance mine and transportation facilities. One of the world's largest coal projects is currently being developed along the north coast of Colombia. Foreign investment in Colombia's coal sector is already aiding Colombia in modernizing and expanding its coal production capabilities. Colombia's goal is to capture ten percent of the world steam coal trade by the year 2000.

Other developing countries are endowed with sufficient coal reserves located close enough to coastal areas, such that coal exporting is a possibility. The ability of these nations to finance the required infrastructure of not only the mine operation, but also rail and port facilities is uncertain. Investment by multinational companies into developing countries' coal industries appears possible if import demand reaches the optimistic forecasts. Considering the investment required and the current mining capacity surplus available in the established coal producing countries, export activity by these developing countries is not anticipated before the 1990s.

Coal Trade Model

World steam coal trade flows are projected for the years 1985, 1990 and 2000 via a linear programming model. The model was formulated to represent the international steam coal market by minimizing total delivered costs under two levels of world demand. Demand from 25 coal importing countries, represented by 52 coal importing ports, is matched with supply from 19 coal producing regions in 13 countries through the export activities of 65 ports. The model can be written formally as:

$$\text{minimize} \sum_{i=1}^{52}\sum_{j=1}^{65} C_{ij} * I_iE_j + \sum_{j=1}^{65} CL_j * L_j + \sum_{j=1}^{65} CM_j * M_j \sum_{j=1}^{65} CH_j * H_j \qquad (1)$$

subject to

$$\sum_{i=1}^{52} I_iE_j \leq EXP_j \qquad j = 1 \text{ to } 65 \qquad (2)$$

$$\sum_{j=1}^{65} I_iE_j \leq IMP_j \qquad i = 1 \text{ to } 52 \qquad (3)$$

$$\sum_{j=1}^{65} I_kE_j = DEM_k \qquad k = 1 \text{ to } 25 \qquad (4)$$

$$\sum_{i=1}^{52} I_jE_j - L_j - M_j - H_j = 0 \qquad j = 1 \text{ to } 65 \qquad (5)$$

$$L_s \leq MSUP_S \qquad s = 1 \text{ to } 19 \qquad (6)$$

$$M_s \leq HSUP_s \qquad s = 1 \text{ to } 19 \qquad (7)$$

where the notation represents:

C_{ij} - ocean transport cost per tce (ton of coal equivalent) between import port i and export port j;

I_iE_j - tce shipped between import port i and export port j;

CL_j, CM_j, CH_j - export price (or F.O.B. price) per tce for export port j over three regional coal supply levels, low (CL), mid (ML) and high (HL);

L_j, M_j, H_j - tce shipped from export port j over three regional coal supply levels;

EXP_j - annual throughput capacity for export j;

IMP_j - annual throughput capacity for import port i;

DEM_k - annual steam coal demand for country k;

$MSUP_s$ - low supply limit for coal producing region s

$HSUP_s$ - mid supply limit for coal producing region s.

The objective function, equation (1), seeks to minimize total world delivered costs for a given level of world steam coal demand. Delivered coal costs are measured in dollars per ton of coal equivalent (tce) units. One ton of coal equivalent equals one metric ton (2,205 pounds) of coal with a heating value of 12,600 British thermal units per pound. Delivered coal costs consist of ocean transport charges plus the export price of the coal (price of the coal at the port of departure). Ocean transport costs between trading ports depend on the distance between ports and the size of vessel used in transit. In the model, three possible routes and six ship sizes are available for each potential trading combination between ports. Coal can be shipped either directly or through either the Panama or Suez Canals, on vessels ranging in size from 25,000 to 200,000 deadweight tons (dwt). Route and ship size between trading ports are selected based on least cost criterion. Larger vessels provide lower transit cost, but ship size is restricted by harbor depth and canal draft limits.

Export prices for each exporting port are based on inland transport costs and regional coal supply curves. For each coal producing region, a three-step coal supply curve has been derived yielding low, mid and high supply prices. The relative coal price relationships between supply regions change as regions reach supply limits. Equations (6) and (7) limit each coal producing region's low and mid priced coal to given levels. Equation (5) is a transfer equation, equating each port's regional coal supply total with its export total.

Equations (2) and (3) are importing and exporting volume constraints. For each port, coal trade activity is limited by throughput capacity. For 1985 projections, current port throughput capacity is utilized. Many ports have plans for increasing throughput capacity as well as harbor depth in anticipation of higher world steam coal demand. For 1990 and 2000 projections, future possible expansions in throughput capacity and harbor depth are included in the model. Equation (4) forces the model to satisfy all coal demand.

Total delivered cost of one metric ton of coal equivalent from any exporter is derived in the model as:

$$TDC = [P + A + (B * D)]*HV$$

where

TDC = total delivered cost per tce;

P = export price per metric ton;

A = fixed shipping cost per metric ton;

B = variable shipping cost per metric ton;

D = roundtrip distance between trading ports;

HV = heating value adjustment factor.

For each potential trading combination, seaborne shipping costs are calculated for the three available routes between the trading ports. Ship size on each route is restricted by either canal draft limitations or by the shallower harbor draft of the two trading ports. The lowest shipping charge added to export price, adjusted for the heating value of the coal yields total delivered coal cost between the trading ports. In the model, delivered coal cost on any route depends on export price, heating value of the coal, harbor depth and ocean transport cost. Total world delivery costs, which the model minimzies, depend further on the throughput capacity of all the ports. Coal trade flows predicted by the model are determined entirely by the above factors. Accordingly, the input data corresponding to the factors are discussed below.

Ocean Transport

Seaborne transporting of coal represents an important component of international coal trading, accounting for between ten to thirty percent of delivered cost. As the international steam coal market expands, seaborne coal movements will increase more than proportionally since the centers of expanding demand will be Europe and the Pacific Rim while production will be centered in Australia, South Africa and the United States. Currently, shipments of metallurgical coal comprise just over one-half of seaborne coal. Of the estimated 199 million metric tons (mt) moved by sea in 1983, 112 mt or 56 percent involved metallurgial coal.[5/] The drop in steel production during the recent recession coupled with an increase in steam coal trade in the early 1980s, has sharply increased the role of steam coal in the shipping industry during the last few years. In 1975, steam coal accounted for only 27 percent of coal shipments versus 44 percent in 1983.

Coal in bulk is shipped in a variety of vessel sizes and types as few vessels are built specifically for ocean transfer of coal. Most coal is shipped on bulk carriers although some coal movement occurs on combination carriers. Bulk carriers are suitable for transport of such dry commodities as grain, iron ore, bauxite and phosphate as well as coal. Combination carriers, also referred to as "OBO" or ore/bulk/oil vessels, are equipped to carry crude oil along with bulk commodities. Growth in the world's stock of dry bulk vessels was extreme in the 1970s in response to expansion in grain, iron ore and coal trading. The world's total dry bulk fleet increased from 61.3 million deadweight tons in 1970 to over 153 million dwt by 1978.[6/]

The bulk shipping market is highly competitive, possessing several traits indicative of a competitive market. There are numerous ship owners, entry into and exit from the industry is relatively unrestricted, product differentiation is insignificant and the vessels are highly mobile and capable of serving worldwide. The competitive nature of the industry has led to spot prices for single voyages fluctuating widely as market conditions vary. This has led to the coal shipping market being dominated by long-term time charter constraints or direct ownership of vessels by coal buyers or sellers.

Although price trends may be hard to recognize from spot price movements, a significant shift to the use of larger vessels has been readily apparent since the mid 1960s. Longer voyages, larger coal purchases and higher fuel costs have been the prominant forces behind the shift. In 1965, fewer than five percent of all coal hauling vessels were above 50,000 dwt. Today, almost one-half of all coal shipments are on vessels above 50,000 dwt.[7/] The trend is likely to continue as the factors mentioned above will continue to shift shippers to larger vessels to lower costs. The longer the shipping distance and the larger the vessel, the greater the economics of scale and the lower the cost. Cost per ton of a 25,000 dwt collier on a journey from Australia to Europe run fifty percent more than on a 100,000 dwt collier. The shift to even larger sized vessels seems likely in the future as steam coal trade grows. The technology for 150-200 thousand dwt size vessels has already been demonstrated by iron ore trade movements. Port and canal capacities represent the one limiting factor to larger vessels.

In addition to vessel size, the amount of ballast distance during a voyage is a critical factor in determining shipping costs. Cost per ton can be reduced by almost fifty percent when a vessel returns with a cargo. The possibilities of coal-hauling vessels securing return cargo from major coal importing countries in Europe and the Pacific Rim region are limited since these regions mainly export manufactured goods. Generally, manufactured products are more efficiently shipped by other types of vessels than dry bulk colliers. Multi-leg journeys involving several ports and commodities offer more possibilities for reducing ballast distance. But as the volume of seaborne coal increases, without a relative gain in other commodities trading, opportunities for multi-leg journeys will be limited.

In this analysis seaborne transport cost estimates developed by the International Energy Agency (IEA) have been adjusted to 1982 dollars and utilized to estimate seaborne transport cost.[8/] The estimated costs are long run economic costs, representing the shipping rates which cover all costs of factor inputs including replacement of the vessel. The actual market sales are expected to converge towards the estimated costs in the long run. In developing the cost estimates, IEA figured labor costs to increase at two percent annually in real terms, and real fuel prices to increase by two and one-half percent per year after 1985. The cost functions utilized in this analysis to derive seaborne transport costs are listed in Table 10.

TABLE 10

Oceanborne Transport Cost Functions
(1982 dollars)

Vessel Size (dwt)	1985	1990	2000
25,000	C = 2.42 + 1.59 * D	C = 2.46 + 1.69 * D	C = 2.54 + 1.89 * D
50,000	C = 1.63 + 1.10 * D	C = 1.65 + 1.18 * D	C = 1.62 + 1.33 * D
75,000	C = 1.33 + 0.85 * D	C = 1.36 + .94 * D	C = 1.41 + 1.06 * D
100,000	C = 1.13 + 0.76 * D	C = 1.13 + .81 * D	C = 1.12 + 0.92 * D
150,000	C = 0.95 + 0.63 * D	C = 0.97 + 0.67 * D	C = 1.01 + 0.75 * D
200,000	C = 0.97 + 0.60 * D	C = 0.99 + 0.63 * D	C = 0.95 + 0.71 * D

C represents cost per metric ton in 1982 dollars.

D represents distance of voyage in thousand miles including one-way in ballast.

Heating Values

As discussed earlier, coal quality varies widely with regard to heat or caloric content and chemical composition. The heat content, usually stated in Btu/lb units, is of prime importance to buyers as it indicates the energy obtainable from the coal when burned. To compare delivered coal cost worldwide each coal producing region's coal cost is adjusted for differences in heat content. The common unit utilized to compare coals is cost per ton of coal equivalent. While most United States ports are likely to be shipping coal mined primarily from a specific region, several ports are geographically situated such that coal mined in two regions may be shipped from them. Because of this, several U.S. ports in the model export coal with a Btu value derived by averaging the two coal producing regions' values. Average heating values for the nineteen producing regions are listed in Table 11.

TABLE 11

Heating Values of Exporters

Producing Region	Exporting Port Number	Btu/lb
Queensland, Australia	1-4	11,660[1/]
New South Wales, Australia	5-6	12,380[1/]
Western Canada	9-11	10,880[1/]
India	12	9,000[2/]
Mozambique [Zimbabwe coal]	13	11,800[3/]
Eastern U.S.S.R.	14	12,800[1/]
Western U.S.S.R.	15	10,000[3/]
Peru/Chile	16	11,000[3/]
West Germany	17	10,250[3/]
China	18-20	11,250[1/]
Colombia	21	11,900[4/]
Poland	22-23	11,250[1/]
United Kingdom	24	10,250[1/]
South Africa	25	11,880[1/]
Northern Great Plains	26-28,35-37	9,600[1/]
Appalachia	29-31,52-65	12,000[1/]
Great Lakes Mix	32-34	10,800
Alaska	38	11,500[5/]
Rocky Mountain	42-48	11,150[1/]
Northern Great Plains/Rocky Mtn. Mix	39-41	10,375[1/]
Appalachia/Illinois Basin Mix	49-51	11,630[1/]

Sources:

1/ <u>Constraints on International Trade in Coal</u>

2/ <u>Coal--Bridge to the Future</u>

3/ <u>Future Coal Prospects, Country and Regional Assessment</u>

4/ <u>International Coal</u>, 1981-1982 edition

5/ <u>America's Role in World Coal Exports</u>

Port Capacity and Throughput

Port capacity, in terms of harbor depth or ship size capacity, and throughput, in terms of annual coal handling tonnage capability, strongly influence the model's steam coal trade projections. Port capacity restricts ship size, thereby affecting seaborne transport cost and consequently delivered coal costs. Throughput constraints limit both exporting and importing ports' coal handling abilities forcing importers to switch to more expensive coal suppliers as low cost suppliers reach their export limits. Tables 12 through 15 list the exporting and importing ports included in the model along with estimates of port capacities and throughput rates over time. Estimates are based on port data gathered from several secondary sources.[9/] Since even current worldwide coal handling capacity data is incomplete, the port data utilized in the model is subject to continuous updating. This is especially so for the 1990 and 2000 data since future port capacity and throughput estimates are based on terminal expansion plans which are themselves based on expectations of future coal trade levels. Future port capacities and throughput rates used in the model are based on expectations of high steam coal trade activity. The ship demurrage which occurred at several East Coast coal ports during the 1981 shipping season generated numerous plans across the United States for either expansion of existing coal terminals or development of new facilities.

Since most of U.S. port development plans have been cancelled or delayed with the recent slowdown in steam coal exports, the U.S. port data in the model reflects this by pushing expansions to later dates. For U.S. coal ports which handle both metallurgical and steam coal, a fixed mix of met/steam coal based on the 1981 ratio was assumed in estimating future steam coal shipping capacities.

In order to best capture coal handling capabilities, especially with regard to harbor depth around the world, countries with coal ports of differing harbor depths and U.S. ports with coal terminals of varying ship size accomodations are treated in the model as separate ports. Thus, many of the port listed in the tables represent a country or a U.S. port's aggregated coal handling capacity for a specific ship size. For example, the coal handling capacity of the port of Long Beach/Los Angeles is broken up into four ports representing the four ship sizes which can presently or in the future load coal for export. The same procedure is followed for importing ports as Japan's ports show. Japan has numerous ports of varying harbor depths which in the model are aggregated by harbor depth.

TABLE 12

Importing Port Throughput
(millions of metric tonnes)

	PORT	Throughput 1985	1990	2000
1.	Port Gallegos, Argentina	4.0	4.0	4.0
2.	Rio de Janeiro, Brazil	2.0	2.0	2.0
3.	Carupano, Venezuela (other South American)	3.0	3.0	3.0
4.	Antwerp/Zeeburgge, Belgium	20.4	30.4	30.4
5.	La Spezia, Italy	6.5	6.5	6.5
6.	Gioa Tauro, Italy	13.6	33.0	33.0
7.	Taranto, Italy	--	5.0	20.0
8.	Copenhagen, Denmark	8.0	8.0	8.0
9.	Kalundborg, Denmark	5.0	5.0	5.0
10.	Aabenra, Denmark	9.5	9.5	9.5
11.	Oulu, Finland	4.3	4.3	4.3
12.	Pori, Finland	4.5	4.5	4.5
13.	Marseille, France (Mediterranean ports)	10.0	10.0	10.0
14.	Bordeaux, France (Bay Of Biscay ports)	6.5	6.5	6.5
15.	Bordeaux, France	5.5	5.5	5.5
16.	Bordeaux, France	5.0	5.0	5.0
17.	Rouen, France (English Channel ports)	6.5	8.5	8.5
18.	La Harve, France (English Channel ports)	24.0	33.0	42.0
19.	Hamburg, West Germany	6.7	6.7	6.7
20.	Hamburg, West Germany	6.8	6.8	6.8
21.	Wilhelmshaven, West Germany	1.0	1.0	1.0
22.	Piraeus, Greece	2.0	4.0	5.0
23.	Money Point, Ireland	4.5	4.5	7.0
24.	Amsterdam, Netherlands	7.0	7.0	7.0
25.	Rotterdam, Netherlands	24.0	28.0	45.0
26.	Rana, Norway	1.0	1.0	3.0
27.	Sines, Portugal	2.0	2.0	5.0
28.	Carboneras, Spain	7.5	7.5	7.5
29.	Algeciras, Spain	15.0	15.0	15.0
30.	Oxelosund, Sweden	14.0	14.0	14.0
31.	Gothenburg, Sweden	5.0	5.0	5.0
32.	Alexandria, Egypt	1.0	1.0	1.0
33.	Ashod, Israel	5.0	10.0	12.0
34.	Eregli, Turkey	5.0	15.0	15.0
35.	Keelung, Taiwan	1.1	2.7	2.7
36.	Taichung, Taiwan	.8	2.7	2.7
37.	Kaoshiung, Taiwan	8.2	13.9	21.6
38.	Taichung, Taiwan	--	2.8	10.6
39.	Mospo, South Korea	--	6.5	6.5
40.	Incheon, South Korea	4.2	4.2	19.5
41.	Samcheonpo, South Korea	4.7	4.7	20.0
42.	Hong Kong	2.5	2.5	2.5
43.	Hong Kong	2.5	4.5	5.5

Table 12 (cont.)

44.	Poro Point, Philippines		4.0	4.0	4.0
45.	Poro Point, Philippines		4.0	4.0	4.0
46.	Tsuruga, Japan		0.5	0.5	0.5
47.	Muroran, Japan		3.7	4.6	4.6
48.	Tomakomai, Japan		14.3	25.2	25.2
49.	Yokkaichi, Japan		3.2	5.0	5.0
50.	Kashima, Japan		0.5	14.3	35.8
51.	Fukuyama, Japan		7.2	8.2	30.0
52.	Port Keelang, Malaysia		2.0	4.0	9.0
		TOTAL	309.0	426.5	573.4

SOURCES: Existing and Potential U.S. Coal Export Loading Terminals, Maritime Administration, U.S. Department of Transportation, May 1983.

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Constraints on International Trade in Coal, Ray Long, International Energy Agency, 1982.

Constraints on International Trade in Coal, (ii) Current and Future Port Capacities, Ray Long, International Energy Agency, November 1981.

Coal Exports and Port Development, Office of Technology Assessment, April 1981.

America's Role in World Coal Export Market, Congressional Report, 1981.

TABLE 13

Exporting Port Throughput
(millions of metric tonnes)

	PORT	Throughput 1985	1990	2000
1.	Queensland, Australia	1.0	1.0	1.0
2.	Queensland, Australia	4.0	6.5	12.0
3.	Queensland, Australia	6.5	10.0	18.5
4.	Queensland, Australia	9.0	30.0	56.5
5.	New South Wales, Australia	1.0	1.0	1.0
6.	New South Wales, Australia	1.5	2.5	5.0
7.	New South Wales, Australia	17.0	12.5	23.0
8.	New South Wales, Australia	--	28.5	53.0
9.	Prince Rupert, Canada	4.0	8.0	15.0
10.	Vancouver, Canada	1.0	1.0	1.0
11.	Vancouver, Canada	6.0	6.0	6.0
12.	Haldia, India	--	.5	1.0
13.	Maputo, Zambabwe (Mozembique)	2.0	4.5	4.5
14.	Ilichevsk, U.S.S.R. (East)	1.0	1.0	1.0
15.	Vostochny, U.S.S.R. (West)	1.0	2.0	6.5
16.	Huasco, Peru/Chile	1.0	1.0	.0
17.	Hamburg, West Germany	4.5	2.5	2.5
18.	Lianyungang, China	2.0	2.5	8.0
19.	Qinhuangdao, China	1.5	5.5	16.5
20.	Shijiusuo, China	--	1.0	2.5
21.	Portete Bay, Colombia	1.0	13.5	22.5
22.	Swinoujscie, Poland	11.0	14.0	20.0
23.	Gdansk, Poland	4.5	6.0	9.0
24.	Immingham, United Kingdom	7.0	7.0	7.0
25.	Richards Bay, South Africa	42.0	63.0	96.5
26.	Superior WI - Direct	7.0	13.5	13.5
27.	Superior, WI - Transshipping	7.0	13.5	13.5
28.	Superior, WI - Transloading	7.0	13.5	13.5
29.	Toledo, OH - Direct	18.5	18.5	18.5
30.	Toledo, OH - Transshipping	18.5	18.5	18.5
31.	Toledo, OH - Transloading	18.5	18.5	18.5
32.	Great Lakes mix - Direct	14.0	14.0	14.0
33.	Great Lakes mix - Transloading	14.0	14.0	14.0
34.	Great Lakes mix - Transshipping	14.0	14.0	14.0
35.	Puget Sound Ports, WA	5.4	8.2	8.2
36.	Puget Sound Ports, WA	--	1.0	1.0
37.	Puget Sound Ports, WA	--	2.7	2.7
38.	Seward, AK	.9	1.8	1.8
39.	Portland, OR	--	10.9	10.9
40.	Astoria, OR	--	11.3	11.3
41.	Kalama, WA	--	4.5	4.5
42.	Sacramento/Stockton, CA	1.8	6.3	6.3

Table 13 (cont.)

43.	Long Beach/Los Angeles, CA	4.5	4.5	4.5
44.	Long Beach/Los Angeles, CA	2.7	5.8	5.8
45.	Long Beach/Los Angeles, CA	13.6	13.6	13.6
46.	Long Beach/Los Angeles, CA	--	13.6	13.6
47.	Galveston, TX	--	9.1	9.1
48.	Port Arthur, TX	3.6	3.6	3.6
49.	Baton Rouge, LA	1.8	1.8	1.8
50.	New Orleans, LA	29.0	73.0	73.0
51.	Mobile, AL	8.6	8.6	8.6
52.	Moorehead, NC	2.7	5.4	5.4
53.	Moorehead, NC	--	13.6	13.6
54.	Charleston, SC	2.2	5.4	5.4
55.	Savannah, GA	2.7	11.7	25.3
56.	Hampton Roads, VA	1.5	12.5	12.5
57.	Hampton Roads, VA	8.5	2.0	2.0
58.	Baltimore, MD	13.1	15.0	15.0
59.	Philadelphia, PA	6.6	6.6	6.6
60.	Philadelphia, PA	5.0	10.0	10.0
61.	New York, NY	2.1	2.1	2.1
62.	New York, NY	--	8.3	8.3
63.	New York, NY	--	7.0	7.0
64.	Kingston, NY (other East Coast ports)	1.0	9.0	9.0
65.	Albany, NY (other East Coast ports)	.5	5.0	5.0
	TOTAL	272.8	556.9	730.0

SOURCES: see Table 12.

TABLE 14

Importing Port Capacity
(thousand deadweight tons)

	Port	Ship Size Capacity
1.	Port Gallegos, Argentina	100
2.	Rio de Janeiro, Brazil	75
3.	Carupano, Venezuela (other South American)	75
4.	Antwerp/Zeeburgge, Belgium	150
5.	La Spezia, Italy	50
6.	Gioa Tauro, Italy	150
7.	Taranto, Italy	200
8.	Copenhagen, Denmark	50
9.	Kalundborg, Denmark	75
10.	Aabenra, Denmark	150
11.	Oulu, Finland	75
12.	Pori, Finland	100
13.	Marseille, France (Mediterranean ports)	200
14.	Bordeaux, France (Bay of Biscay ports)	50
15.	Bordeaux, France	75
16.	Bordeaux, France	150
17.	Rouen, France (English Channel ports)	50
18.	La Harve, France (English Channel ports)	200
19.	Hamburg, West Germany	50
20.	Hamburg, West Germany	75
21.	Wilhelmshaven, West Germany	100
22.	Piraeus, Greece	50
23.	Money Point, Ireland	160
24.	Amsterdam, Netherlands	150
25.	Rotterdam, Netherlands	200
26.	Rana, Norway	50
27.	Sines, Portugal	150
28.	Carboneras, Spain	75
29.	Algeciras, Spain	150
30.	Oxelosund, Sweden	100
31.	Gothenburg, Sweden	150
32.	Alexandria, Egypt	50
33.	Ashod, Israel	150
34.	Eregli, Turkey	150
35.	Keelung, Taiwan	50
36.	Taichung, Taiwan	75
37.	Kaoshiung, Taiwan	150
38.	Taichung, Taiwan	200
39.	Mospo, South Korea	75
40.	Incheon, South Korea	100
41.	Samcheonpo, South Korea	150

Table 14 (cont.)

42.	Hong Kong	75
43.	Hong Kong	100
44.	Poro Point, Philippines	100
45.	Poro Point, Philippines	150
46.	Tsuruga, Japan	25
47.	Muroran, Japan	75
48.	Tomakomai, Japan	100
49.	Yokkaichi, Japan	150
50.	Kashima, Japan	150
51.	Fukuyama, Japan	200
52.	Port Keelang, Malaysia	75

SOURCES: see Table 12.

TABLE 15

Export Port Capacity
(thousand deadweight tons)

	Port	Ship Size Capacity 1985	Ship Size Capacity 1990-2000
1.	Queensland, Australia	25	25
2.	Queensland, Australia	75	75
3.	Queensland, Australia	150	150
4.	Queensland, Australia	200	200
5.	New South Wales, Australia	50	50
6.	New South Wales, Australia	100	100
7.	New South Wales, Australia	150	150
8.	New South Wales, Australia	200	200
9.	Prince Rupert, Canada	200	200
10.	Vancouver, Canada	100	100
11.	Vancouver, Canada	200	200
12.	Haldia, India	100	100
13.	Maputo, Zambabwe (Mozembique)	100	100
14.	Ilichevsk, U.S.S.R. (East)	50	50
15.	Vostochny, U.S.S.R. (West)	150	150
16.	Huasco, Peru/Chile	75	75
17.	Hamburg, West Germany	75	75
18.	Lianyungang, China	25	25
19.	Qinhuangdao, China	75	75
20.	Shijiusuo, China	100	100
21.	Portete Bay, Colombia	150	150
22.	Swinonjscie, Poland	50	50
23.	Gdansk, Poland	100	100
24.	Immingham, United Kingdom	50	50
25.	Richards Bay, South Africa	200	200
26.	Superior, WI - Direct	25	25
27.	Superior, WI - Transshipping	100	100
28.	Superior, WI - Transloading	150	150
29.	Toledo, OH - Direct	25	25
30.	Toledo, OH - Transshipping	100	100
31.	Toledo, OH - Transloading	150	150
32.	Great Lakes mix - Direct	25	25
33.	Great Lakes mix - Transloading	100	100
34.	Great Lakes mix - Transshipping	150	150
35.	Puget Sound Ports, WA	60	60
36.	Puget Sound Ports, WA	100	100
37.	Puget Sound Ports, WA	150	150
38.	Seward, AK	60	60
39.	Portland, OR	60	60
40.	Astoria, OR	100	100
41.	Kalama, WA	60	60

Table 15 (cont.)

42.	Sacramento/Stockton, CA	30	40
43.	Long Beach/Los Angeles, CA	70	70
44.	Long Beach/Los Angeles, CA	100	100
45.	Long Beach/Los Angeles, CA	150	150
46.	Long Beach/Los Angeles, CA	200	200
47.	Galveston, TX	100	100
48.	Port Arthur, TX	60	60
49.	Baton Rouge, LA	60	100
50.	New Orleans, LA	60	100
51.	Mobile, AL	60	100
52.	Moorehead, NC	70	90
53.	Moorehead, NC	100	100
54.	Charleston, SC	40	50
55.	Savannah, GA	50	70
56.	Hampton Roads, VA	40	100
57.	Hampton Roads, VA	80	150
58.	Baltimore, MD	60	100
59.	Philadelphia, PA	40	85
60.	Philadelphia, PA	60	60
61.	New York, NY	33	36
62.	New York, NY	150	150
63.	New York, NY	260	260
64.	Kingston, NY (other E. Coast Ports)	25	25
65.	Albany, NY (other E. Coast Ports)	30	30

SOURCES: see Table 12.

Export Prices

Export price as utilized in the model serve as a proxy for the total cost of mining, transporting and loading of the coal onto ocean vessels at the exporting port. The underlying assumption of the model, that the world coal steam market is highly competitive, suggests that coal prices as determined in the open market will tend towards the long run production and transportation costs. Coal prices reflect the demand and supply forces of the market. On the supply side, excess exporting capacity exists worldwide indicating that suppliers will be competing by pricing close to their costs to attract buyers. Coal demand is determined to a large degree by the price of substitute fuels. With the current state of the petroleum market, that of dropping price and excess supplies, additional market pressures exist to hold down coal prices.

For each exporting port, export prices at three levels of regional steam coal production are included in the model. Coal mining costs are a function of both the cost of inputs, such as capital, equipment and labor, and the geological features of the coal deposit, such as seam thickness and amount of overburden. As coal mining increases in a country or region, costs of inputs are likely to rise while quality of coal deposits decline leading to higher coal production cost. The regional supply curves exhibit increasing mining cost with increasing coal output. Listed in Table 16 are the mid and high production points on each coal producing region's supply curve. For an exporting port, low mine costs are used in calculating total delivered costs until total regional exporting activity exceeds the mid point

TABLE 16

Coal Supply Curve Points
(million metric tonnes)

Producing Region	Mid Point	High Point
Queensland, Australia	32.0	65.0
New South Wales, Australia	51.0	61.0
Western Canada	22.0	41.0
India	0.0	0.0
Zambabwe	2.0	2.0
Eastern U.S.S.R.	1.0	1.0
Western U.S.S.R.	1.0	1.0
Peru/Chile	1.0	1.0
West Germany	4.5	4.5
China	34.0	56.0
Colombia	32.0	53.0
Poland	17.0	34.0
United Kingdom	7.0	7.0
South Africa	85.0	127.0
Northern Great Plains	17.0	34.0
Appalachia	95.0	218.0
Alaska	1.8	1.8
Rocky Mountain	20.0	40.0
Illinois Basin	15.0	37.0

SOURCE: Constraints on International Trade in Coal, International Energy Agency, 1982.

of the regional supply curve. Mining costs, or the price of coal at the mine, increase further when regional output expands beyond the high point of the supply curve. By having three-step supply curves in the model, delivered coal cost estimates more accurately reflect the price dynamics of the steam coal market as it expands. Supply curve estimates are based on research of mining costs done by the International Energy Agency's Coal Research Division.

The export price estimates for 1985 scenarios are displayed in Table 17. Export price per short ton along with export price per tce for each export are shown. The 1990 and 2000 export prices utilized in the model retain the same relative price relationships among the exporting ports. U.S. export prices, excluding Great Lakes ports prices, are estimated from average 1982 mine prices published by the Energy Information Administration (EIA) and transportation rates published by the National Coal Association.[10/] Export prices for Great Lakes ports were estimated based on average mine prices published by the EIA and transportation costs obtained from personal communications with Great Lakes shipping industry contacts.[11/] The U.S. export price estimates compared favorably with other secondary sources of U.S. coal mine and transport cost estimates. Export prices for foreign ports were derived from data obtained from several secondary sources.[12/]

Basic Analysis and Results

Future U.S. steam coal exports as projected by the model are moderate under the low coal demand scenario. Overseas steam coal shipments stagnate during the next ten years before increasing to slightly above early 1980s totals by the year 2000. As Table 18 shows, East and West Coast ports share

TABLE 17

1985 Relative Export Prices
(1982 dollars)

		Export Price		
		Low Supply	Mid Supply	High Supply
1.	Queensland, Australia	42.70 (50.87)*	52.80 (62.90)	72.05 (85.84)
2.	Queensland, Australia	42.70 (50.87)	52.80 (62.90)	72.05 (85.84)
3.	Queensland, Australia	42.70 (50.87)	52.80 (62.90)	72.05 (85.84)
4.	Queensland, Australia	42.70 (50.87)	52.80 (62.90)	72.05 (85.84)
5.	New South Wales, Australia	42.19 (47.34)	54.84 (61.54)	74.97 (84.12)
6.	New South Wales, Australia	42.19 (47.34)	54.84 (61.54)	74.97 (84.12)
7.	New South Wales, Australia	42.19 (47.34)	54.84 (61.54)	74.97 (84.12)
8.	New South Wales, Australia	42.19 (47.34)	54.84 (61.54)	74.97 (84.12)
9.	Prince Rupert, Canada	38.53 (49.19)	49.14 (62.74)	63.33 (80.86)
10.	Vancouver, Canada	37.53 (47.92)	48.14 (61.46)	62.33 (79.58)
11.	Vancouver, Canada	37.53 (47.92)	48.14 (61.46)	62.33 (79.58)
12.	Haldia, India	38.00 (58.78)	38.00 (58.78)	38.00 (58.78)
13.	Maputo, Zambabwe (Mozambique)	38.00 (58.78)	38.00 (58.78)	38.00 (58.78)
14.	Ilichevsk, U.S.S.R. (East)	35.69 (38.73)	35.69 (38.73)	35.69 (38.73)
15.	Vostochny, U.S.S.R. (West)	35.00 (48.62)	35.00 (48.62)	35.00 (48.62)
16.	Huasco, Peru/Chile	38.08 (48.09)	38.08 (48.09)	38.08 (48.09)
17.	Hamburg, West Germany	74.48 (100.94)	74.48 (100.94)	74.48 (100.94)
18.	Liayungang, China	36.19 (44.69)	45.91 (56.69)	55.54 (68.58)
19.	Qinhuangdao, China	36.19 (44.69)	45.91 (56.69)	55.54 (68.58)
20.	Shijiusuo, China	36.19 (44.69)	45.91 (56.91)	55.54 (68.58)
21.	Portete Bay, Colombia	41.05 (47.92)	45.66 (53.30)	55.83 (65.17)
22.	Swinoujscie, Poland	43.93 (54.24)	58.96 (72.80)	77.56 (95.77)
23.	Gdansk, Poland	43.93 (54.24)	58.96 (72.80)	77.56 (95.77)
24.	Immingham, United Kingdom	71.41 (96.78)	71.41 (96.78)	71.41 (96.78)
25.	Richards Bay, South Africa	38.06 (44.50)	51.14 (59.80)	67.66 (79.12)
26.	Superior, WI - Direct	44.74 (64.74)	49.04 (70.96)	55.49 (80.30)
27.	Superior, WI - Transshipping	42.82 (61.96)	47.12 (68.18)	53.57 (77.52)
28.	Superior, WI - Transloading	43.21 (62.53)	47.51 (68.75)	53.96 (78.08)
29.	Toledo, OH - Direct	55.24 (63.95)	90.19 (104.41)	124.27 (143.86)
30.	Toledo, OH - Transshipping	53.33 (61.74)	88.28 (102.20)	122.36 (141.65)
31.	Toledo, OH - Transloading	53.99 (62.50)	88.94 (102.96)	123.02 (142.41)
32.	Great Lakes mix - Direct	49.99 (64.30)	57.80 (74.35)	86.06 (89.45)
33.	Great Lakes mix - Transshipping	48.08 (61.84)	55.89 (71.89)	67.63 (86.99)
34.	Great Lakes mix - Transloading	48.61 (62.52)	56.42 (72.57)	68.16 (87.67)
35.	Puget Sound ports, WA	31.41 (45.45)	35.71 (51.67)	42.16 (61.01)
36.	Puget Sound ports, WA	31.41 (45.45)	35.71 (51.67)	42.16 (61.01)
37.	Puget Sound ports, WA	31.41 (45.45)	35.71 (51.67)	42.16 (61.01)
38.	Seward, AK	35.00 (42.28)	35.00 (42.28)	35.00 (42.28)
39.	Portland, OR	35.27 (47.22)	45.19 (60.51)	61.16 (81.89)
40.	Astoria, OR	35.27 (47.22)	45.19 (60.51)	61.16 (81.89)

Table 17 (cont.)

41.	Kalama, WA	35.27 (47.22)	45.19 (60.51)	61.16 (81.89)
42.	Sacramento/Stockton, CA	42.05 (52.39)	57.12 (71.16)	81.39 (101.40)
43.	Long Beach/Los Angeles, CA	40.05 (49.90)	55.12 (68.67)	65.91 (98.81)
44.	Long Beach/Los Angeles, CA	40.05 (49.90)	55.12 (68.67)	65.29 (98.81)
45.	Long Beach/Los Angeles, CA	40.05 (49.90)	55.12 (68.67)	65.29 (98.81)
46.	Long Beach/Los Angeles, CA	40.05 (49.90)	55.12 (68.67)	65.29 (98.81)
47.	Galveston, TX	46.95 (58.49)	62.02 (77.27)	86.29 (107.51)
48.	Port Arthur, TX	46.95 (58.49)	62.02 (77.27)	86.29 (107.51)
49.	Baton Rouge, LA	45.85 (54.77)	63.56 (75.92)	93.04 (111.13)
50.	New Orleans, LA	45.85 (54.77)	63.56 (75.92)	93.04 (111.13)
51.	Mobile, AL	46.21 (55.20)	63.92 (76.35)	93.40 (111.56)
52.	Moorehead, NC	46.79 (54.17)	81.74 (94.62)	115.82 (134.08)
53.	Moorehead, NC	46.79 (54.17)	81.74 (94.62)	115.82 (134.08)
54.	Charleston, SC	49.08 (56.82)	84.03 (97.28)	118.11 (136.73)
55.	Savannah, GA	50.67 (58.66)	85.62 (99.12)	119.70 (138.57)
56.	Hampton Roads, VA	46.67 (54.05)	81.61 (94.51)	115.70 (133.96)
57.	Hampton Roads, VA	46.67 (54.05)	81.62 (94.51)	115.70 (133.96)
58.	Baltimore, MD	46.30 (53.60)	81.25 (94.06)	115.33 (133.51)
59.	Philadelphia, PA	47.51 (55.00)	82.46 (95.46)	116.54 (134.91)
60.	Philadelphia, PA	47.51 (55.00)	82.46 (95.46)	116.54 (134.91)
61.	New York, NY	49.68 (57.01)	84.63 (97.97)	118.71 (137.42)
62.	New York, NY	49.68 (57.01)	84.63 (97.97)	118.71 (137.42)
63.	New York, NY	49.68 (57.01)	84.63 (97.97)	118.71 (137.42)
64.	Kingston, NY	49.68 (57.01)	84.63 (97.97)	118.71 (137.42)
65.	Albany, NY	49.68 (57.01)	84.63 (97.97)	118.71 (137.42)

* Export price per short ton (export price per tce)

most of the U.S. steam coal exporting activity under low demand. Hampton Roads and Baltimore terminals ship coal to European countries while Puget Sound ports, the Alaskan port and Astoria capture part of the Pacific Rim trade. In the model, low cost suppliers such as South Africa are assigned the same expanding export capacities under the two demand levels.

TABLE 18

Export Projections
(million metric tons)

	1985		1990		2000	
	Low	High	Low	High	Low	High
Great Lakes Ports	--	--	--	--	--	13.5*
East Coast Ports	9.0	37.4	2.0	70.6	21.5	80.0
Gulf Coast Ports	0.7	1.7	--	--	--	30.0
West Coast Ports	0.9	13.5	4.5	32.1	15.8	47.0
U.S. TOTAL	10.6	52.6	6.5	102.7	37.3	170.5
Australia	1.9	26.3	14.4	43.5	51.0	122.3
South Africa	42.0	42.0	60.7	63.0	85.0	96.5
Canada	4.3	11.0	13.6	15.0	21.0	22.0
China	3.5	3.5	9.0	9.0	27.0	27.0
Colombia	1.0	1.0	12.5	13.5	22.5	22.5
Poland	17.0	17.0	17.0	17.0	17.0	29.0
Others	5.0	5.0	7.5	7.5	13.0	14.0
TOTAL	85.3	158.4	141.2	271.2	273.8	503.8

* 13.5 mt through Superior.

Consequently, the low cost suppliers under the low demand case have sufficient export capacity to satisfy world demand. Predicted growth in steam coal exporting by China, Canada and Colombia even under low world demand emphasizes the increasing competitiveness of the international steam coal market.

World steam coal demand increases by more than eighty percent above the low demand level under the high demand scenario. The four-fold increase in U.S. exports by the year 2000 attest to the U.S. role as a marginal supplier. As a marginal supplier, U.S. coal exporting rate depends on world demand exceeding the supply available from lower cost exporters. This is the case under the high demand scenario. Throughput capacities limit South Africa, China, Poland and Colombia to their predicted export levels in the year 2000. U.S. coal exports fill the remaining demand. Market shares projected by the model under both demand levels are listed in Table 19. Under the high demand scenario, U.S. exports capture one-third of world steam coal exports. Australia overtakes South Africa in 2000 as the number two steam coal exporter by obtaining over fifty percent of the Pacific Rim market. As expected, U.S. East Coast ports ship to European countries, supplying almost one-third of the European demand. New Orleans captures ten percent of the European market while Superior ships 13.5 million metric tonnes (mt) to Europe, roughly five percent of European demand. In aggregate, U.S. supplies Europe with almost one-half of its imported steam coal by the year 2000 under the high demand scenario. In the Pacific Rim market, U.S. West Coast ports ship twenty-two percent of total steam coal demand, second to Australian coal exports.

Great Lakes ports are predicted to be coal exporters in the year 2000 only if demand is high. The port of Superior, via the transloading method, ships 9.5 mt to Aabenra, Denmark and 4.0 mt to Gothenburg, Sweden. Toledo's export price increases greatly in 2000 in the high demand scenario. This is a result of Appalachian minemouth coal costs inflating as East Coast ports' coal shipments

TABLE 19

Export Market Share Projections
(percentage of demand)

	1985		1990		2000	
	Low	High	Low	High	Low	High
			WORLD DEMAND			
United States	12.5	33.2	4.6	37.9	13.7	33.9
Australia	2.2	16.6	10.2	16.0	18.6	24.2
South Africa	49.2	26.5	43.0	23.2	31.0	19.1
Canada	5.0	6.9	9.6	5.5	7.7	4.3
China	4.1	2.2	6.4	3.3	9.9	5.4
Colombia	1.2	0.6	8.9	5.0	8.2	4.5
Poland	19.9	10.7	12.0	6.3	6.2	5.8
Others	5.9	3.3	5.3	2.8	4.7	2.8
			EUROPEAN DEMAND			
United States	13.6	37.3	2.2	46.2	15.5	46.8
South Africa	57.6	35.9	66.0	32.3	57.7	29.8
Colombia	1.5	1.0	13.1	8.3	14.2	8.5
Poland	25.8	16.9	18.7	11.1	12.3	11.0
Others	1.5	8.9	--	2.1	0.3	3.9
			PACIFIC RIM DEMAND			
United States	7.7	28.6	10.3	32.5	13.3	22.1
Australia	16.4	38.5	32.8	41.3	42.8	51.9
Canada	37.1	23.4	30.9	15.2	17.6	10.3
China	30.2	7.4	20.5	9.1	22.6	12.7
Others	8.6	2.1	5.5	1.9	3.7	3.0

reach the mid-point of the region's supply curve. Blending of Appalachian and Great Plains coal at Toledo, referred to as the Great Lakes mix in this assessment, is also affected by the rise in Appalchian minemouth price as East Coast coal shipments expand to the mid-point supply range. Both Toledo and the Great Lakes mix have export prices below that of Superior coal, but higher than that of East Coast ports shipping low priced Appalachian coal. Higher inland transport costs push Toledo's export price above those of the East Coast ports of Hampton Roads, Baltimore, Philadelphia and Moorehead City. Lower ocean transport costs for Toledo coal to most European ports fail to alleviate the export price differential favoring East Coast ports. Consequently, the least-cost solution from the model projects all Appalachian coal being exported out of East Coast ports and New Orleans.

Tables 20-22 illustrate the market position of Superior, Toledo and the Great Lakes mix under both demand levels and over time. Listed in the tables are the cost differences between the Great Lakes ports delivered costs and the delivered costs at the likely importing ports that Great Lakes ports would supply. For each of the Great Lakes terminals, the transloading option of transporting coal abroad is the most efficient. The transshipping option has the lowest export price, but by shipping in 150,000 dwt vessels under the transloading mode, ocean transport charges are reduced by over a dollar making the transloading mode the least cost option of exporting coal from the Great Lakes. Landed coal costs under the transshipping option exceed transloading landed costs by ten to fifty cents at the Great Lakes ports' most likely customers. Delivered costs under the direct shipping mode are far

TABLE 20

Market Position of Superior Coal
Transloading Option
(1982 dollars per tonne of coal equivalent)

	Import Port	Least-Cost Cost	Superior Cost	Cost Difference	Export Port
Low Scenario					
1985	Money Point, Ireland	61.47	69.08	7.61	Hampton Roads
	Antwerp, Belgium	61.83	69.63	7.80	Hampton Roads
	Amsterdam, Netherlands	61.50	69.63	8.13	Hampton Roads
	Wilhelmshaven, W. Germany	62.18	71.01	8.83	Hampton Roads
1990	Oxelosund, Sweden	62.70	76.53	13.83	Hampton Roads
	Pori, Finland	63.23	77.47	14.24	Hampton Roads
	Hamburg, W. Germany	60.52	77.29	16.77	Portete Bay
	Gothenburg, Sweden	57.23	74.36	17.13	Richards Bay
2000	Money Point, Ireland	72.30	81.33	9.03	Baltimore
	Hamburg, W. Germany	75.07	85.29	10.22	Baltimore
	Oxelosund, Sweden	74.06	84.40	10.24	Hampton Roads
	Wilhelmshaven, W. Germany	73.15	83.58	10.43	Baltimore
High Scenario					
1985	Le Havre, France	62.40	69.08	6.68	Baltimore
	Money Point, Ireland	62.40	69.08	6.68	Baltimore
	Antwerp, Belgium	62.81	69.63	6.82	Baltimore
	Wilhelmshaven, W. Germany	63.89	71.01	7.12	Hampton Roads
1990	Money Point, Ireland	66.66	73.78	7.12	Philadelphia
	Amsterdam, Netherlands	67.04	74.36	7.32	Philadelphia
	Gothenburg, Sweden	66.71	74.36	7.65	Moorehead City
	Le Havre, France	65.96	73.78	7.82	Moorehead City
2000	Shipped 9.5 mt to Aabenraa, Denmark at $82.41 per tce and 4.0 mt to Gothenburg, Sweden at $81.98 per tce.				

TABLE 21

Market Position of Toledo Coal
Transloading Option
(1982 dollars per tonne of coal equivalent)

	Import Port	Least-Cost Cost	Toledo Cost	Cost Difference	Export Port
Low Scenario					
1985	Money Point, Ireland	61.47	67.78	6.31	Hampton Roads
	Antwerp, Belgium	61.83	68.22	6.39	Hampton Roads
	Amsterdam, Netherlands	61.50	68.23	6.73	Hampton Roads
	Wilhelmshaven, W. Germany	63.43	70.42	6.99	Baltimore
1990	Oxelosund, Sweden	62.70	74.53	11.83	Hampton Roads
	Pori, Finland	63.23	75.38	12.15	Hampton Roads
	Hamburg, W. Germany	60.52	75.24	14.72	Portete Bay
	Pori, Finland	60.27	75.38	15.11	Portete Bay
2000	Money Point, Ireland	72.30	79.83	7.52	Baltimore
	Hamburg, W. Germany	75.07	82.99	7.92	Baltimore
	Oxelosund, Sweden	74.06	82.26	8.20	Hampton Roads
	Pori, Finland	74.79	83.11	8.32	Hampton Roads
High Scenario					
1985	Hamburg, W. Germany	66.70	72.27	5.57	Philadelphia
	Le Havre, France	62.40	67.78	5.38	Hampton Roads
	Money Point, Ireland	62.40	67.78	5.38	Hampton Roads
	Antwerp, Belgium	62.81	68.22	5.41	Hampton Roads
1990	Moncy Point, Ireland	66.46	72.23	5.77	Philadelphia
	Amsterdam, Netherlands	67.04	72.90	5.86	Philadelphia
	Gothenburg, Sweden	66.71	72.90	6.19	Moorehead City
	Kalundborg, Denmark	69.25	75.46	6.21	Philadelphia
2000	Toledo's delivered costs far exceed least-cost suppliers as a result of Appalachian minemouth price increasing by over fifty percent.				

TABLE 22

Market Position of Great Lakes Mix
Transloading Option
(1982 dollars per tonne of coal equivalent)

	Import Port	Least-Cost Cost	Great Lakes Mix Cost	Cost Difference	Export Port
Low Scenario					
1985	Money Point, Ireland	61.47	68.39	6.92	Hampton Roads
	Antwerp, Belgium	61.85	68.88	7.05	Hampton Roads
	Amsterdam, Netherlands	61.50	68.88	7.38	Hampton Roads
	Hamburg, W. Germany	63.43	71.31	7.88	Baltimore
1990	Oxelosund, Sweden	62.70	72.36	9.66	Hampton Roads
	Pori, Finland	63.33	73.20	9.87	Hampton Roads
	Hamburg, W. Germany	60.52	73.04	12.52	Portete Bay
	Pori, Finland	60.27	73.20	12.93	Portete Bay
2000	Money Point, Ireland	72.30	80.53	8.23	Baltimore
	Hamburg, W. Germany	75.07	84.05	8.98	Baltimore
	Oxelosund, Sweden	74.11	83.29	9.18	Hampton Roads
	Wilhelmshaven, W. Germany	73.15	82.53	9.38	Baltimore
High Scenario					
1985	Le Havre, France	62.40	68.34	5.99	Baltimore
	Antwerp, Belgium	62.81	68.88	6.07	Baltimore
	Wilhelmshaven, W. Germany	63.64	70.11	6.47	Hampton Roads
	Hamburg, W. Germany	64.62	71.31	6.69	Philadelphia
1990	Money Point, Ireland	66.66	69.92	3.26	Philadelphia
	Amsterdam, Netherlands	67.04	70.44	3.40	Philadelphia
	Gothenburg, Sweden	66.71	70.44	3.73	Moorehead City
	Hamburg, W. Germany	69.03	72.95	3.92	Philadelphia
2000	Great Lakes Mix delivered costs far exceed least-cost suppliers as a result of Appalachian minemouth price increasing by fifty percent.				

above the other two methods, exceeding transloading costs by over ten dollars. The model includes importing ports of all sizes, but importing ports' ship size capacities are skewed toward ports with deep harbors capable of handling 100,000 dwt vessels or larger. The relative high ocean transport cost under the direct shipping option in 25,000 dwt vessels rules it out as a competitive alternative.

The cost minimization solutions of the model indicate that Superior coal exports must compete with exports from either Hampton Roads or Baltimore. Up until the year 2000 under the high demand scenario, landed cost for coal shipped from Superior via the transloading option exceed the cost of active exporting ports by more than six dollars. For Superior to capture coal customers, its delivered cost to European ports would have to decline by six to ten dollars, a decrease of over 10 percent of estimated cost. Coal demand under the high scenario in the year 2000 equals roughly seventy percent of total world export capacity as inputed in the model. World steam coal demand will have to be extremely strong or exporting capacities for other coal producing countries will have to fall below current expectations for Superior to become active in the international market before 2000. Superior's most promising markets as identified by the model appear to be Ireland, Belgium, West Germany, Finland, France, Sweden and the Netherlands.

Toledo and the Great Lakes mix coals cost less to deliver to European importers than Superior shipped coal, but still have landed coal costs three dollars or more above the least-cost coal as identified in the model. As with Superior coal, Toledo coal and the Great Lakes mix coal must compete with East Coast ports in the European market. Competition with East Coast ports extends to competing for coal supplies as well as coal markets for Toledo. Since Toledo and half of the Great Lakes blend coal is mined in Appalachia, Lake Erie terminals such as Toledo compete with East Coast ports to be one of the exporting port for Appalachia steam coal which is shipped overseas. Toledo has a slight cost advantage over Superior coal exports as does the Great Lakes mix, but both of these Great Lakes coal exporting options are undercut by the East Coast ports.

Table 23 compares delivered costs for coal shipped from the Great Lakes ports with the leading European suppliers predicted by the model. The delivered costs listed are for steam coal exported to Antwerp, Belgium. Great Plains coal after adjusting for its low heating value is the least expensive coal at the mine. But high inland transport costs for Northern Great Plains (NGP) coal push its export price above most of the other suppliers. Due to a low heating value, 1.44 short tons of NGP coal must be shipped in order to supply a user with the equivalent energy of a ton of coal equivalent, i.e., 12,600 Btus. As a result, transport cost for a ton of coal equivalent of NGP coal are forty percent higher than a standard short ton of coal would be. Appalachian coal being shipped through Toledo requires only 1.16 short tons to reach a ton of coal equivalent due to the higher heating value of Appalachian coal.

Shipping costs to Europe for NGP coal accounts for almost seventy-five percent of total delivered cost. Over half of delivered costs are inland transport, while ocean transport cost accounts for twenty percent of total landed cost. Reduction in either railroad rates or Great Lakes shipping charges are necessary for the Great Lakes ports to improve their

TABLE 23

1985 Antwerp Delivered Cost Comparison
(1982 dollars per ton equivalent)

Export Port	Minemouth Cost	Inland Transport Cost	Export Cost	Ocean Transport Cost	Total Delivered Cost
Superior-Direct Option	18.68	46.05	64.73	18.79	83.52
Superior-Transshipping Option	18.68	43.28	61.79	9.17	71.13
Superior-Transloading Option	18.68	43.85	62.53	7.10	69.63
Toledo-Direct Option	39.40	24.55	63.95	15.10	79.05
Toledo-Transshipping Option	39.40	22.34	61.74	7.32	69.06
Toledo-Transloading Option	39.40	23.10	62.50	5.72	68.22
Great Lakes Mix-Direct Option	30.20	34.10	64.30	16.70	81.00
Great Lakes Mix-Transshipping Option	30.20	31.64	61.84	8.16	70.00
Great Lakes Mix-Transloading Option	30.20	32.32	62.52	6.36	68.88
Hampton Roads	39.40	14.65	54.05	7.78	61.83
Baltimore	39.40	14.20	53.60	9.21	62.81
New Orleans	36.43	18.34	54.77	11.92	66.69
Portete Bay, Colombia	42.08	5.84	47.92	8.11	56.03
Richards Bay, South Africa	36.66	7.83	44.49	12.79	57.29
Gdansk, Poland	48.07	6.17	54.24	3.15	57.39

position in the international steam coal market.

Supplemental Analysis and Results

The preceding section presented the basic results of the model by reviewing export projections and analyzing the competitive position of the Great Lakes ports in terms of relative delivered coal costs. While analysis of the basic results provide valuable insights into the international steam coal market and possible future trade flow developments, awareness of the model's limitations is desirable. The model's projections are derived from data which is based on forecasts of port capacity around the world, relative coal and transport cost estimates, and projections of future world steam coal demand. Given the required data, the model simply allocates coal exports under the criterion of minimizing total world delivered steam coal costs. In theory, the trade flows projected by the model should mirror those arrived at in the market. Discrepancies between the model's results and actual future coal trade flows will arise from two broad sources: inaccurate data and unexpected developments which affect the market directly or indirectly.

Imperfections of the model originating from the above two types of incomplete information can be reduced though through sensitivity analysis. By varying input data and postulating possible future developments which might affect the coal market, the robustness of or confidence in the basic results and analysis can be judged. The initial effort at sensitivity analysis involved using both a low and high coal import demand scenario. As discussed earlier, the data utilized in the model is secondary data based on forecast and estimates from other research work. The substantial difference between Great Lakes ports' delivered coal costs and the model's active coal exporters' delivered coal costs suggest that alteration of the coal and transport cost data would have to be major before Great Lakes ports benefited. With this in mind, sensitivity analysis based on modifying the cost data appears futile. The relative costs between coal exporters is accepted as accurate. Instead, sensitivity analysis based on possible developments which are not directly market caused have been conducted. The stability of South Africa's exports, increased emissions controls on coal burning, U.S. railroad deregulation, U.S. port development and the related topic of waterway user fees are issues for which additional analysis was done.

The current political and social unrest of South Africa raises questions about the ability of its coal sector to expand to the degree envisioned in the model. The impact on the international steam coal market of a possible disruption of South Africa's coal industry is analyzed through the model by decreasing that country's exporting capacity first to 80 percent of its current export capacity, and then to the extreme case of a complete collapse of coal exporting by South Africa, i.e., zero export activity. Table 24 lists aggregated coal export projections under a South African export constraint of 35 mt.

United States' exports gain the most when South Africa exports are restricted. U.S. shippers capture almost all of the trade lost by South Africa under both low and high demand in 1990 and under low demand in 2000. Australia benefits from raising coal prices in the U.S. under the high demand scenario by the year 2000, breaking into the European and Middle East markets in place of South Africa. U.S. coal prices increase as East Coast coal exports exceed the mid-point of the Appalachian coal supply curve.

TABLE 24

Export Projections - Limited South African Exports
(million metric tonnes)

	1990		2000	
	Low	High	Low	High
Great Lakes Ports	--	--	--	38.0*
East Coast Ports	26.3	80.4	70.5	80.0
Gulf Coast Ports	--	10.8	--	30.0
West Coast Ports	4.5	38.8	16.8	47.0
U.S. Total	30.8	130.0	87.3	195.0
Australia	14.8	44.2	51.0	159.3
South Africa	35.0	35.0	35.0	35.0
Canada	13.6	15.0	21.0	22.0
China	9.0	9.0	27.0	27.0
Colombia	13.5	13.5	22.5	22.5
Poland	17.0	17.0	17.0	29.0
Others	7.5	7.5	13.0	14.0
Total	141.2	271.2	273.8	503.8

* 13.5 mt through Superior and 24.5 mt of Great Lakes mix coal.

The Great Lakes mix becomes competitive in the year 2000 under the high demand scenario, shipping blended coal to Denmark, France and Sweden.

U.S. steam coal export increase further under the extreme case of no South African exports as displayed in Table 25. East Coast ports continue to be the leading export region, but all coasts gain. Export projections show 1.9 mt of coal being shipped from Toledo to Denmark in 1985 under high demand. This result occurs as a result of the current export capacities of the lower cost East Coast ports being reached. By 1990, increased export capacity on the East Coast allows East Coast shippers to supplant Toledo coal. Toledo's shipping activity under this scenario corresponds to the early 1980s coal shipping events. As the demurrage mounted at East Coast ports, several Lake Erie ports expanded their overseas metallurgical coal movements. If South Africa's coal exporting activity is disrupted in the near future, the competitive position of Great Lakes ports would improve substantially, especially in the short run since excess capacity exists. Steam coal demand would have to be considerably higher than at present though since excess capacity is also available at the lower cost East Coast ports. A reduction of the anticipated growth of South African steam coal capacity has no immediate effect on Superior's export potential. Instead, East and Gulf Coast ports increase export activity in lieu of South African exports.

NGP coal's low sulphur content has been suggested as another factor which could improve the competitive position of NGP coal not only domestically but internationally as well. The Great Lakes mix, a blend of low sulphur NGP

TABLE 25

Export Projections - No South African Exports
(million metric tons)

	1985		1990		2000	
	Low	High	Low	High	Low	High
Great Lakes Ports	--	1.9[1]	--	.4[2]	--	40.5[3]
East Coast Ports	33.3	39.2	51.3	79.8	80.2	80.0
Gulf Coast Ports	1.7	30.0	--	37.1	16.3	30.0
West Coast Ports	.9	16.0	4.5	31.5	21.6	69.8
U.S. Total	35.9	87.1	55.8	148.8	118.1	220.3
Australia	18.5	33.8	24.8	59.4	54.2	169.0
Canada	4.4	11.0	13.6	15.0	22.0	22.0
China	3.5	3.5	9.0	9.0	27.0	27.0
Colombia	1.0	1.0	13.5	13.5	22.5	22.5
Poland	17.0	17.0	17.0	17.0	17.0	29.0
Others	5.0	5.0	7.5	8.5	13.0	14.0
Total	85.3	158.4	141.2	271.2	273.8	503.8

[1] 1.9 mt through Toledo.

[2] .4 mt of Great Lakes mix.

[3] 13.5 mt through Superior and 27.5 mt of Great Lakes mix coal.

coal and high sulphur Appalachian coal, was included in the model to test this notion. While the blended coal is the most competitive coal of the Great Lakes ports, it remains considerably below low cost suppliers under the cost data utilized in deriving the initial model projections. By adding additional cost to high sulphur coals to account for emissions control costs, thereby improving NGP relative cost position, the low sulphur attribute of NGP coal is again tested for its market attractiveness.

National policies on sulphur emissions control vary widely around the world. Some nations require certain grades of coal while others require specific equipment to control emissions. In general, importing countries prefer to burn coal with 1.5 percent or less sulphur by weight. Until steam coal demand approaches the high demand scenario, there appears to be an ample supply of low sulphur coal available for international trade from exporters with delivered coal costs below Superior's low sulphur NGP coal. If coal demand accelerates to the level forecast in the high demand scenario, low sulphur NGP coal may become attractive to buyers as other producers of low sulphur coal reach production constraints leading to rising prices. Additionally, high coal consumption levels may result in more stringent emissions control policies stimulating demand for low sulphur coal. To analyze the trade consequences of such a development, Appalachia, Illinois, South Africa and Poland coals were assigned additional coal costs representing cleaning and desulphurization treatment costs. The coal reserves of the above coal producing regions have been identified as moderate to high sulphur coals. The additional cost or sulphur penalty added to the export price of these regions is based on reducing sulphur content by weight to .8 percent.[13/] The sulphur penalty alters the relative coal costs, reflecting the additional cost of sulphur emissions control.

Table 26 displays the coal trade flows projected with the sulphur penalty added in under low and high demand in the year 2000. U.S. total steam coal exports remain almost uneffective, but regional export distribution is significantly altered. Under the low demand case, East Coast shipping is completely curtailed as the low sulphur coal of Australia breaks into the European market. West Coast shippers increase Pacific Rim trading, replacing Australian coal being shipped to Europe. East Coast exports improve under high demand despite Australia's entrance into the European market mainly because demand is so strong. Great Lakes ports benefit from higher cost for high sulphur coals. Under the high demand scenario 7.3 mt of Great Lakes mix coal are projected to be exported to Denmark. The Great Lakes ports increased shipping activity comes at the expense of Poland and U.S. Gulf Coast ports. The low sulphur quality of NGP coal appears to be advantageous only when coal demand is strong.

The attractiveness of low sulphur NGP coal to foreign buyers will, in part, be determined by the foreign nations' policies and strategies towards coal burning emissions controls. Emissions control policies are formed politically, influenced by market forces, but not formulated solely on market behavior considerations. Recent deregulation of U.S. railroads is under another indirect factor which is influencing both the domestic and international coal markets.

Similar to emissions control policy, railroad deregulation was shaped politically only partially based on market forces. The Railroad Revitalization

TABLE 26

Export Projections - Sulphur Penalty
(million metric tons)

	2000	
	Low	High
Great Lakes Ports	--	20.8*
East Coast Ports	--	85.4
Gulf Coast Ports	--	11.9
West Coast Ports	33.1	47.0
U.S. Total	33.1	165.1
Australia	54.2	139.7
South Africa	85.0	96.5
Canada	22.0	22.0
China	27.0	27.0
Colombia	22.5	22.5
Poland	17.0	17.0
Others	13.0	14.0
Total	273.8	503.8

* 13.5 mt through Superior and 7.3 of Great Lakes mix coal.

and Regulatory Act of 1976, the Staggers Rail Act of 1980 and Interstate Commerce Commission actions since then have converted the railroad industry from a collection of regulated monopolies to an increasingly competitive industry characterized by competition through flexible pricing practices. Since rail is the dominant mode of coal transport in the U.S., the direction of coal hauling rates, especially variations between rate increases inter-regionally, will affect the U.S. steam coal exporting pattern.

The recent rail legislation was aimed at improving the profitability of the railroads by reducing regulation and encouraging pricing flexibility. Prior to the recent rail deregulation acts, railroads were required to limit rate increases and were forced to operate unprofitable lines. Deregulation eased rate adjustment limits and reduced barriers to rail line abandonment. As railroad companies respond to the new competitive state of the industry, analysts expect rates to raise as railroads seek to attain adequate revenues. Forecasts of future rail rate increases are beyond the scope of this analysis. But to investigate the impact of possible rail rate changes which favor NGP coal, export projections under relative higher Eastern railroad costs were derived with the model. For East Coast export ports, rail rates are increased by fifty percent for 1990 and hundred percent for 2000. For all other ports served by rail, rail rates increase by twenty-five percent in 1990 and fifty percent in 2000. Inland transport costs are held constant for the ports served primarily by barge. Relative inland transport rates are in effect doubled for East Coast ports, an extremely favorable scenario for NGP coal.

Table 27 displays the export projections under the rail rate developments postulated above. Shifts in relative inland transport costs between regional coal shippers resulting from asymetric increases in rail rates across the country have little impact on the 1990 export projections. Inland transport costs which include rail and lake shipping charges continue to preclude Great Lakes ports from actively competing in international steam coal trade. The disportionate increase in rail rates for Eastern or Appalachian coal effects U.S. regional exporting shares by the year 2000. East Coast ports relinquish exports to Gulf ports under low demand and to Toledo under high demand. Toledo's inland transport charges decrease relative to East Coast ports since the distance from coal fields to Toledo is shorter than most East Coast ports' distances from coal fields. Toledo ships coal to Denmark and Sweden under the high demand scenario given the rail rate adjustments. U.S. total exports decrease slightly under the modified rail rate scenario primarily due to West Coast exports being replaced by Australian coal in the Pacific Rim market. Superior coal exports appear uneffected by the rail rate adjustments, suggesting that marginal relative increases in rail rates for Eastern coal will not greatly improve Superior's export potential.

The current fall off in international steam coal trading, caused by dropping oil prices, suggest that the high demand scenario advanced in the model may be overly optimistic. The low demand scenario presently appears more probable. Since much of the port capacity data included in the model is based on expectations of high future coal trading levels, a scenario scaling down the planned port expansions is appropriate. The competitive position of Great Lakes ports could improve under minimal U.S. port expansion

TABLE 27

Export Projections - Rail Rates Divergence
(million metric tons)

	1990		2000	
	Low	High	Low	High
Great Lakes Ports	--	--	--	25.0*
East Coast Ports	--	71.0	21.5	64.9
Gulf Coast Ports	--	--	--	30.0
West Coast Ports	1.8	31.7	1.8	25.5
U.S. Total	1.8	102.7	23.3	145.4
Australia	16.7	43.5	64.0	147.4
South Africa	61.7	63.0	85.0	96.5
Canada	14.0	15.0	22.0	22.0
China	9.0	9.0	27.0	27.0
Colombia	13.5	13.5	22.5	22.5
Poland	17.0	17.0	17.0	29.0
Others	7.5	7.5	13.0	14.0
Total	141.2	271.2	273.8	503.8

* 13.3 mt through Superior and 11.7 through Toledo.

as Great Lakes ports already have the port throughput and harbor depths utilized in the model as opposed to most other U.S. ports capacity data which are based on planned expansions. To examine the situation of stagnate coal demand and cancellation of planned U.S. port expansion, the model's port capacity data are revised such that all U.S. ports capacities remain at their 1985 levels for all years.

Table 28 lists the resulting export projections under low demand and no U.S. port expansion. U.S. total exports unexpectedly increase slightly under this scenario. In 1990, West Coast ports lose most of their exports as a result of smaller harbor depths. On the East Coast, Hampton Roads expands exports supplanting Colombia as the least cost supplier to Finland and West Germany. With no port expansion, Hampton Roads capacity for 80,000 dwt or smaller ships remains at 8.5 mt as opposed to 12.5 mt for 70,000 dwt vessels and 2.0 mt for 100,000 dwt vessels under port expansion. The West Coast increases exports in the year 2000 under the no port expansion case as Long Beach/Los Angeles coal terminals gain from the change in coal trade pattern caused by the absence of port capacity at Astoria, Oregon. Baltimore gains at the expense of Hampton Roads in this scenario, as Hampton Roads export capacity is cut by six mt for vessels above 70,000 dwt. Great Lakes ports are not projected by the model to be coal exporters if no U.S. port expansion occurs and demand remains low. But the competitive position of Great Lakes coal ports improves when compared to the initial projections with U.S. port expansion under both low and high demand.

Table 29 displays the market position of the three Great Lakes ports included in the model under the situation of low demand and no new U.S.

TABLE 28

Export Projections - No U.S. Port Expansion
(million metric tonnes)

	1990	2000
Great Lakes Ports	--	--
East Coast Ports	8.5	23.7
Gulf Coast Ports	--	--
West Coast Ports	.9	22.6
U.S. Total	9.4	46.3
Australia	17.6	42.0
South Africa	60.7	85.0
Canada	14.0	21.0
China	9.0	27.0
Colombia	6.0	22.5
Poland	17.0	17.0
Others	7.5	13.0
Total	141.2	273.8

TABLE 29

Market Position of Great Lakes Ports
No U.S. Port Development
(1982 dollars per ton of coal equivalent)

	Import Port	Least-Cost Cost	Great Lakes Cost	Cost Difference	Export Port
1990					
Superior	Hamburg, W. Germany	68.93	77.29	8.36	Hampton Roads
	Oxelosund, Sweden	68.11	76.53	8.42	Hampton Roads
	Pori, Finland	68.63	77.47	8.84	Hampton Roads
	Hamburg, W. Germany	60.52	77.29	16.77	Portete Bay
Toledo	Hamburg, W. Germany	68.93	75.24	6.31	Hampton Roads
	Oxelosund, Sweden	68.11	74.63	6.52	Hampton Roads
	Pori, Finland	68.63	74.98	6.35	Hampton Roads
	Hamburg, W. Germany	60.52	75.24	14.72	Portete Bay
Great Lakes Mix	Hamburg, W. Germany	68.93	73.04	4.11	Hampton Roads
	Oxelosund, Sweden	68.11	72.36	4.25	Hampton Roads
	Pori, Finland	68.83	73.36	4.53	Hampton Roads
	Hamburg, W. Germany	60.52	73.04	12.52	Portete Bay
2000					
Superior	Antwerp, Belgium	75.10	81.98	6.88	Baltimore
	Money Point, Ireland	74.11	81.33	7.22	Baltimore
	Oulu, Finland	77.56	86.83	9.27	Baltimore
	Hamburg, W. Germany	75.85	5.29	9.44	Baltimore
Toledo	Antwerp, Belgium	75.10	80.35	5.25	Baltimore
	Money Point, Ireland	74.11	79.82	5.71	Baltimore
	Oulu, Finland	77.56	84.14	6.58	Baltimore
	Hamburg, W. Germany	75.35	82.99	7.64	Baltimore
Great Lakes Mix	Antwerp, Belgium	75.10	81.11	6.01	Baltimore
	Money Point, Ireland	74.11	80.53	6.42	Baltimore
	Oulu, Finland	77.56	85.42	7.86	Baltimore
	Hamburg, W. Germany	75.35	84.05	8.70	Baltimore

port development. The costs listed are for coal moved via the transloading mode, the least costly method. Comparison of Table 29 figures with those of Tables 20-22 show that the Great Lakes ports' market positions, while still rather poor, improve under this scenario. Differences between the predicted suppliers' costs and those of the Great Lakes ports at the same importing ports for which Great Lakes ports are nearest to supplying are reduced by at least twenty-five percent and in some cases by more than forty percent. Lower East Coast port capacity combined with higher ocean transport cost due to shallower harbors at East Coast ports substantially improve the Great Lakes competitive position.

The surprising rise in U.S. coal exports with no port expansion reinforces two points. First, the model's results are sensitive to input data on port capacity. And since port capacity data is primarily planned expansion figures, analysis of the model's projections must be made with the uncertainty of port expansion plans considered. Updating of port expansion developments is essential in order to produce reliable projections. Secondly, the drive by U.S. ports to deepen harbors, based on the rationale that future coal movements will only be competitive on 100,000 dwt vessels or larger, may not be economically sound. This is certainly the case if steam coal demand continues to be weak. Current U.S. port capacity is sufficient to retain the nation's market shares. Expansion of port capacity would be costly and would not guarantee expanded steam coal exports.

The argument of expanding coal exports through port expansion is part of a related issue that of user fees or charges for shippers who use the nation's waterways and deep harbors. User fee proposals that are currently being debated on in Congress are aimed at raising revenue to replace general tax money that is presently used to finance dredging and other maintenance costs. As of now, if a user fee bill is passed, costs to coal shippers will be minimal on a per ton basis. Great Lakes ports' coal exporting potential may be improved if Seaway tolls are discontinued as part of the user fee bill. But given the Great Lakes ports' solid cost disadvantages as outlined in this assessment, user fees with or without Seaway tolls elimination will not alone transform the Great Lakes ports into international coal shippers.

Summary

Since coal is a widely available competitive source of energy, future world coal consumption and trade totals are expected to grow as normal world economic growth occurs. Increased energy requirements in energy deficient regions of the world, Western Europe and the Pacific Rim continues being most prominent, will in part be met by steam coal exports from coal abundant nations. While the magnitude of coal trade expansion remains uncertain, being heavily dependent on oil availability and price, future steam coal trade growth will most likely surpass the low demand level of this report, but fall far short of the high demand reported.

Assessment of the potential of Great Lakes coal terminals to compete in the anticipated growing international steam coal trade is based on results obtained through a linear programming model which minimizes total world delivered steam coal costs. The model was constructed to simulate world steam coal trading activity under the assumption of a competitive steam coal market.

Data for the model which includes coal costs estimates, inland and ocean transport cost estimates, port depth and throughput projections and trade forecasts strives to accurately reflect the international market. Data limitations exist though since much of the data will be revised as additional information surfaces as time passes and unanticipated developments occur. Awareness of the model's data base is essential when analyzing the results.

Under the low demand scenario, South Africa and Australia dominate the steam coal market, controlling over one-half of it. Another fourth of the market is captured by countries which currently are just beginning to develop coal export capabilities. Canada, China and Colombia are the leading emerging exporters. U.S. steam coal exporters appear to be the marginal suppliers in the market. U.S. coal ports start exporting only after lower cost suppliers reach their export capacities. Superior's market potential under the low demand is mediocre as delivered coal costs for Superior shipped coal exceeds active exporters' costs by more than seven dollars, being approximately ten percent above the low cost suppliers. Due to the low heating value of Northern Great Plains coal shipped through Superior, transportation costs are inflated since more coal has to be moved per unit of energy. Inland transport costs account for fifty percent of delivered cost for Superior coal shipped to European ports while ocean transport costs account for another twenty percent of delivered cost.

Superior's position as marginal supplier among U.S. coal ports is indicated under the high demand scenario. Superior exports coal to Denmark and Sweden in 2000 only after the lower cost East Coast coal terminals reach export limits. Under the high demand, coal trade is eighty percent higher than under low demand in the year 2000. Steam coal demand will have to greatly increase before Superior becomes a factor in the world steam coal market.

Lake Erie coal ports, represented by Toledo in the model, are slightly more competitive than Superior, yet still appear to have high cost disadvantages. Lake Erie ports compete with East Coast ports not only for export markets, but also for coal supplies from the coal fields of Appalachia. The blending of NGP and Appalachian coals improves the market position of Great Lakes coal ports further, but not enough to insure export activity under either demand level. All Great Lakes ports directly compete with U.S. East Coast ports for the Northern European market.

Developments that might improve Superior's market potential such as higher rail rates for Appalachian coal movements or additional treatment costs for high sulphur coals, are not individually enough to turn Superior into an international coal exporter. Even the simultaneous occurrence of several favorable developments will not aid Superior's competitive position unless steam coal demand accelerates.

FOOTNOTES

1/ 1973 total from Coal Markets in the Future, National Coal Association, March 1984. 1984 total from The Coal Situation, Chase Manhattan Bank, Vol. 5, No. 2, March 1985.

2/ Existing and Potential U.S. Coal Export Loading Terminals, Maritime Administration, U.S. Department of Transportation, May 1983.

3/ Btu = British thermal unit, a measure of energy content.

4/ Geological resources are defined as a measure of the tonnage of coal in situ. Reserves measure the quantity of resources that can be technologically and economically recovered given current technology and economic conditions.

5/ The Coal Situation, Vol. 5, No. 3, June 1985.

6/ "Economics of Oceanborne Coal Transportation," by Ron Hettena.

7/ The Long-Run Economics of the Ocean Transport of Coal, by Hugh Mellanby Lee.

8/ Steam Coal--Prospect to 2000, International Energy Agency.

9/ See Table 12.

10/ Average mine prices were obtained from Coal Production--1982, Energy Information Administration, September 1983. Transportation rates were derived from data presented in Coal Traffic--1982, National Coal Association, 1984.

11/ The mine price data used in estimating U.S. export prices are based primarily on 1982 contract price data. Since 1982, excess coal production capacity has developed across the country leading to increased spot market sales. Spot market prices have decreased significantly since 1982 but the relative price relationships between regional coals remains similar to the price relationships utilized in the study. The decrease in coal prices have been nationwide, with no region gaining new relative price advantages.

12/ Foreign export prices were derived primarily from data continued in Constraints on International Trade in Coal, IEA, 1982. Additional price data was obtained from Coal--Bridge to the Future, 1980.

13/ Desulphurisation costs vary depending on the method employed and the percentage of sulphur removed. The sulphur penalties added to high sulphur coals' prices in this report are based on desulphurisation costs reported in Constraints on International Trade in Coal, IEA, 1982. Coal costs for South Africa, Poland and Eastern U.S. coal are increased by $7 per ton while Illinois coal costs increase by $14 per ton to reflect desulphurisation costs.

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