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Comparative Transportation Costs of Supplying Low-Sulfur Fuels to Midwestern and Eastern Domestic Energy Markets

UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 8614

Comparative Transportation Costs of Supplying Low-Sulfur Fuels to Midwestern and Eastern Domestic Energy Markets

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UNITED STATES DEPARTMENT OF THE INTERIOR
Rogers C. B. Morton, Secretary

BUREAU OF MINES
John D. Morgan, Jr., Acting Director

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COMPARATIVE TRANSPORTATION COSTS OF SUPPLYING LOW-SULFUR FUELS TO MIDWESTERN AND EASTERN DOMESTIC ENERGY MARKETS

by

P. H. Mutschler,[1] R. J. Evans,[2] and G. M. Larwood[3]

ABSTRACT

The Bureau of Mines studied the costs of transporting fossil fuels, coal, and residual fuel oil from areas of production to consumer regions. Transportation data were stratified by type of carrier, size of shipment, and distance to determine what general effects these variables have upon transportation costs.

Economies of haul for coal exist for longer versus shorter distances, and for larger versus smaller trainload sizes. Tanker and barge transportation of residual fuel oil does not show economies of haul for longer distances. It is shown that tanker size and seasonal variation are primary factors influencing the cost of shipping. Railroad transportation data show that coal from western coalfields could be competitive with foreign residual fuel oil in selected midwestern fossil fuel markets. However, the western coal would not be competitive in the New England and the eastern seaboard energy markets.

INTRODUCTION

Transportation costs are an important factor in the delivered cost of fossil fuels. Transportation has generally comprised from one-third to one-half the delivered cost of coal (6).[4] The consideration of transportation costs has new pertinence in view of the burgeoning concern over the environment. New, stricter air quality standards will tend to place constraints upon the use of high-sulfur fossil fuel in the East and Midwest, and new sources of low-sulfur fuels will be needed. Western coal is generally lower in sulfur content than eastern coal and constitutes a possible source. Alternatively, low-sulfur fuel oil could be imported from North Africa. Both sources, however, require transportation over longer distances. Longer distances imply higher costs for transportation. It is possible that a fuel that is low in sulfur may not be produced because it is too far from its potential market to be competitive with other fuels when considering transportation costs.

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[1]Industry economist.
[2]Mechanical engineer.
[3]Metallurgist.
[4]Underlined numbers in parenthesis refer to items in the list of references preceding the appendixes.

Transportation technology is changing. Unit trains for coal movements have improved efficiency and lowered tariff rates (3). Increases in tanker size have increased efficiency in oil shipments (2). However, given the technology of coal and oil production, new environmental considerations may significantly increase transportation costs and these costs may become a much greater determinant of the cost of energy.

This study examines projected transport routes for low-sulfur fuels to midwestern and eastern energy markets and determines their relative transport costs. The cost of coal transportation by railroad is considered. The oil transportation section considers residual fuel oil transportation by water. Transportation costs are developed for tanker and/or inland destination by barge. In the last section, the costs of transporting coal and oil are compared for selected consuming cities.

ACKNOWLEDGMENT

The authors acknowledge the contribution of Richard J. Leary, Metallurgist, Eastern Field Operation Center, to the development of the cost functions and the econometric analysis.

RAIL TRANSPORTATION COSTS OF COAL

The major factors affecting the cost of rail transportation are--

1. Type of train used:

    a. Unit. (See Appendix C.--Definitions.)

    b. Conventional.

2. Size of the shipment (minimum trainload tonnage).

3. Distance.

Each of these factors has been analyzed in the text to determine approximate cost of rail shipments. Some other factors that also affect the cost of transportation but were not directly considered in the analysis are--

1. Annual trainload tonnage. (See Appendix C.--Definitions.)

2. Ownership of equipment.

3. Supply of railroad cars.

4. Backhaul economies.

For coal, a shipper petitions the Interstate Commerce Commission (ICC) for rate changes when it is felt the change in cost of service justifies such an action or when a new route is established. The ICC grants or denies the petition on the basis of cost data presented by the railroad company. It is from this basic established rate that the railroad company charges the coal buyer for the distance and quantity shipped. Generally, rates for coal are stable, at least over the short run (1 year).

Analysis of Rates

This section provides an analysis of rail transport rates for bituminous coal, classified by origin, distance, and minimum trainload tonnage. The coal-producing regions are illustrated in figure 1 and the coal-producing districts in figure 2. (Coal-producing districts are defined in appendix A.)

Transportation rates were compiled and analyzed to determine if economies of haul exist for coal over longer distances. Data were obtained from the ICC, from tariff tables published by railroad associations, and from a telephone survey of railroad and electric utility companies. Appendix tables A-1, A-2, and A-3 present all the coal data and a description of the coding.

The bulk of the experience for rail transport costs lies in the smaller distances (less than 600 miles). This occurred because most coal mined in the past several decades traveled only short distances to their point of consumption. Both steel mills and powerplants located in an area where coal was available.

Within the last 5 years, however, coal has been shipped longer distances (greater than 600 miles), mainly to comply with the new environmental legislation. Although most of the rates that will be analyzed are for shorter distances, there are a sufficient number of observations for the longer distances to give an indication of what may be expected in terms of transport costs when coal is shipped from the West into the Midwest and East.

Methodology

Cost analysis of transportation systems can be dichotomized into fixed and variable components. Fixed costs do not change with the volume of activity; that is, terminal charges, capital cost of carriers, insurance, etc. Variable costs, however, change directly with the volume of activity; in this case, distance.

A complete explanation of the linear and quadratic curves is included in this study for the reader who may not be familiar with methods of analysis. The methodology should serve to illustrate how the equations were developed and how they may be used.

The simplest way to analyze total shipping cost is with a linear model represented by the equation $Y = A_0 + A_1X$, where Y represents the cost to ship a ton of coal or oil, X represents the distance (in miles) that the fossil fuel is shipped, A_0 represents the fixed cost component (terminal charges), and A_1 is the coefficient which represents the variable or running cost per

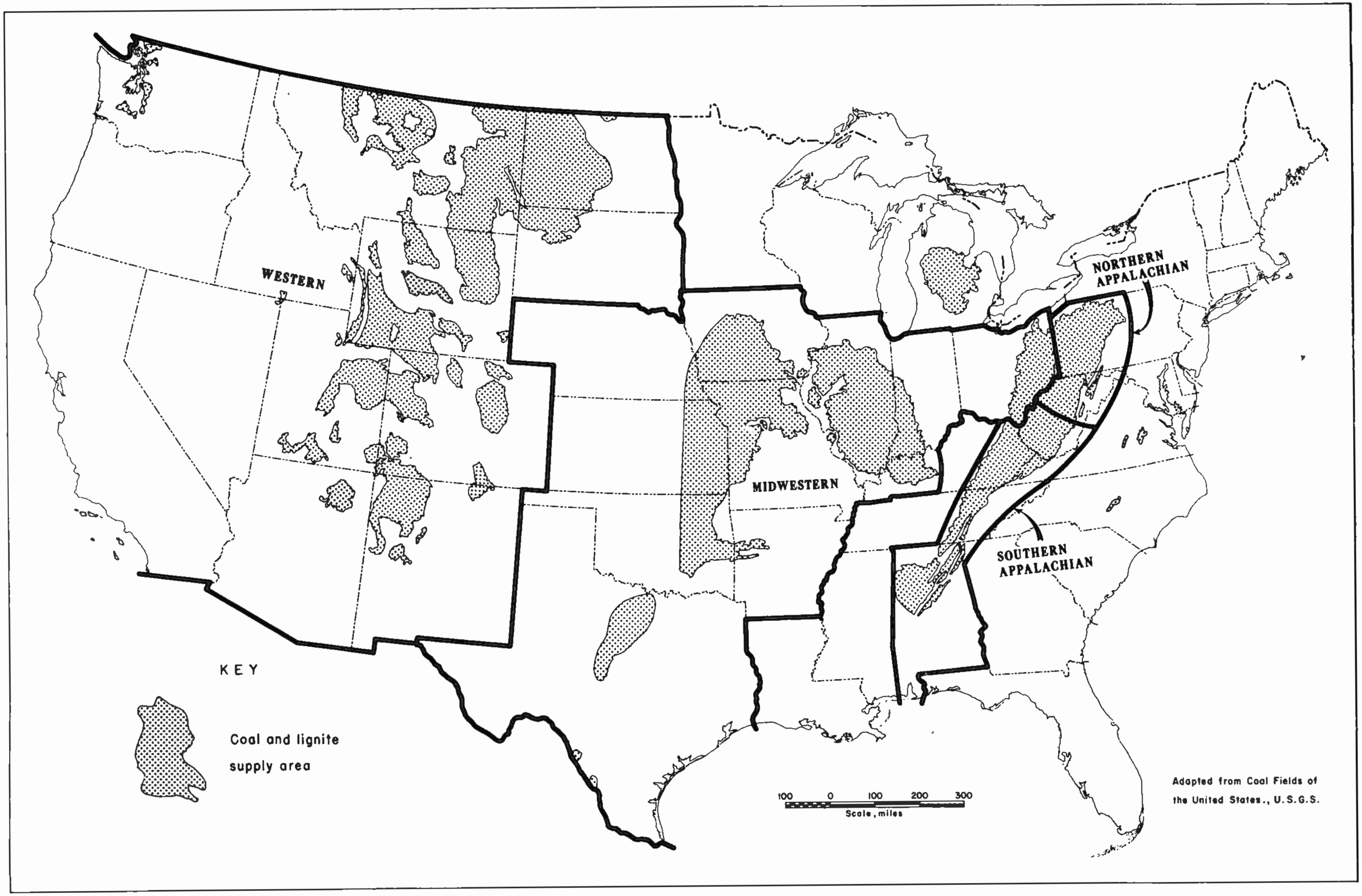

FIGURE 1. - Coal-producing regions of the United States.

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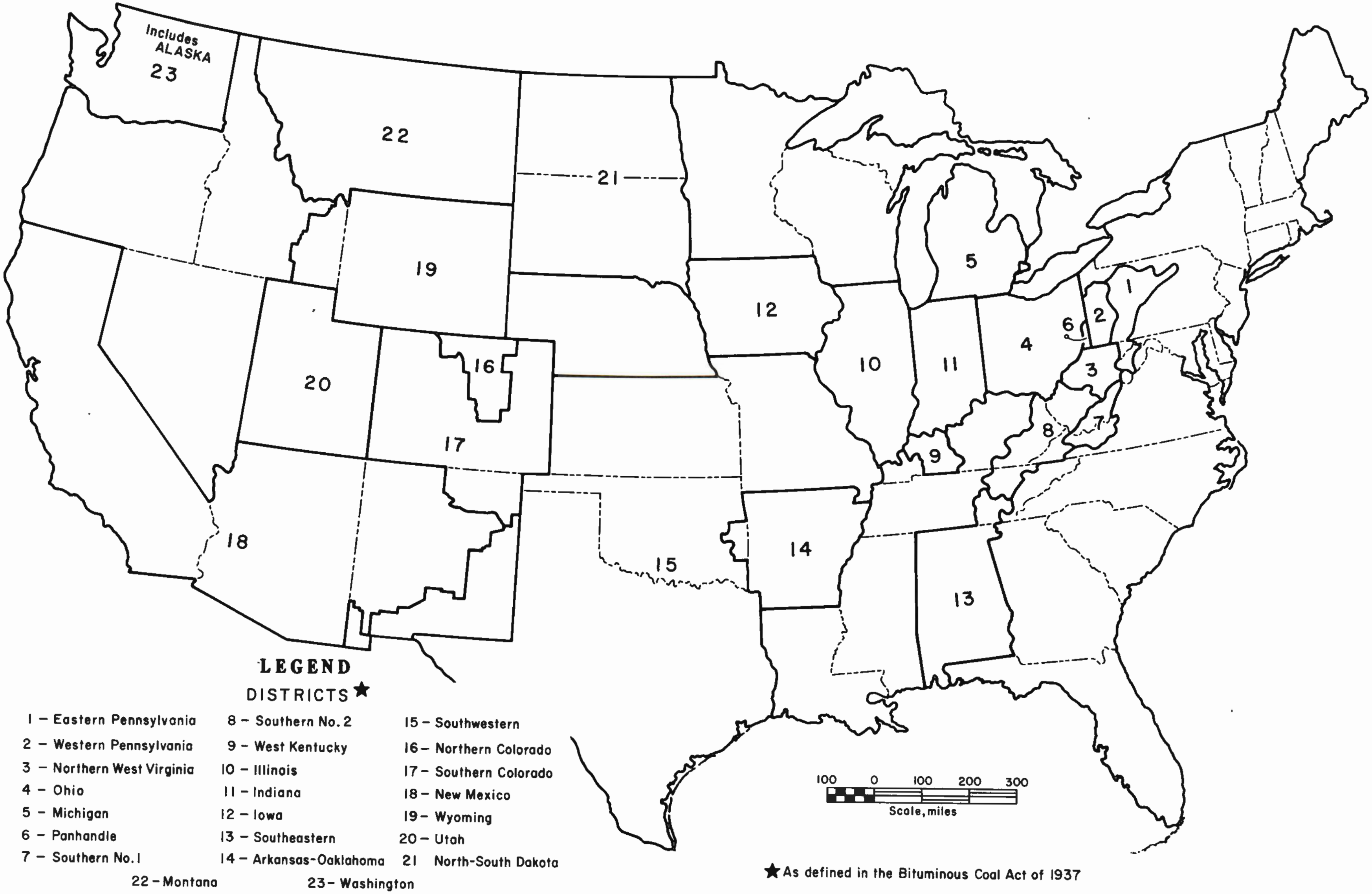

FIGURE 2. - Coal-producing districts of the United States.

mile for either coal or oil. This linear model, owing to its functional nature, cannot measure economies of haul (see appendix C).[5]

Therefore, a parabolic model was used to test for economies of haul if such a condition existed. This is the simplest model that will show economies of haul for large-scale transportation operations and long distances.

The general form of the parabolic model is:

$$Y = A_0' + A_1'X + A_2'X^2,$$

where Y represents the total cost to ship a ton of coal or oil,

X represents the distance (in miles) that the fossil fuel is shipped,

A_0' represents the fixed or terminal charges,

A_1' and A_2' are the coefficients of the variable cost function,

and A_2' reflects the economies of haul if they exist.

Both the linear and parabolic models were examined to see how well each explained the total variance in transportation costs. This is measured by the variance ratio associated with the respective models. A standard statistical test, the F-test, is used to determine whether the ratio observed might have occurred by chance. If that is too unlikely, the parabolic model is asserted to be a significantly better description of the cost function than the linear model.[6]

Table 1 lists the coefficients of the terms in the linear and the parabolic estimating equations with the correlation coefficient, (R), standard error of regression coefficients, and F-test. The coefficients for coal districts 1, 2, 4, and 8 were systematically similar, had the greatest number of observations, and showed the greatest stability. Table 1 also lists the calculated value of F from the comparison between linear and parabolic cost functions for each coal district and Minimum Trainload Tonnage (MTLT). All values of F for the coal districts and the minimum trainload tonnages were significant at the 1-percent level except for trainload tonnages above 8,000 tons, and coal districts 5, 7, 10 and 13.

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[5] Since any linear model has a constant marginal cost throughout (1st derivative), no economies of haul could be expressed functionally.
[6] This application of the F-test has been described by Karl Fox (4).

TABLE 1. - Coefficients of cost functions for rail transportation of coal with R, F-test, and standard error of the regression coefficients

Coal district	Number of observ-ations	Linear model[1] $[Y = A_0 + A_1X]$			Parabolic model[1] $[Y = A_0' + A_1'X + A_2'X^2]$				
		A_0	A_1	R	A_0'	A_1'	A_2'	R	F
1	149	216.91 (16.65)	+0.583 (.049)	0.69	101.34 (28.30)	+1.285 (.151)	-0.00091 (.00018)	0.74	22.79
2	131	189.86 (14.22)	+.589 (.032)	.84	111.67 (24.86)	+1.031 (.121)	-.00053 (.00014)	.86	14.83
3	82	421.84 (57.31)	+.173 (.099)	.19	819.48 (139.52)	-1.473 (.054)	+.00153 (.00050)	.37	9.48
4	138	191.45 (23.53)	+.486 (.078)	.46	119.64 (36.35)	+1.132 (.264)	-.00119 (.00046)	.50	8.15
5	17	1005.13 (316.92)	+4.31 (.923)	.77	(2)	-	-	-	-
7	38	100.45 (55.64)	+.810 (.127)	.72	225.08 (98.22)	-.003 (.547)	+.00109 (.00071)	.74	[3]2.37
8	99	153.91 (23.07)	+.583 (.056)	.72	82.64 (34.72)	+1.030 (.175)	-.00057 (.00021)	.74	7.98
10	47	106.15 (19.40)	+.518 (.069)	.74	113.63 (28.38)	+.443 (.021)	+.00012 (.00032)	.74	[3].282
11	30	78.07 (24.22)	+.861 (.141)	.75	17.82 (28.00)	+2.334 (.471)	-.00377 (.00116)	.83	10.74
13	15	56.56 (17.25)	+.568 (.074)	.90	-2.18 (34.10)	+1.227 (.346)	-.00116 (.00060)	.92	(4)
22	13	56.97 (28.78)	+.439 (.044)	.94	118.27 (30.98)	+.063 (.135)	+.00033 (.00011)	.97	3.35
Composite.	759	170.68 (8.32)	+.590 (.021)	.71	91.68 (12.19)	+1.105 (.063)	-.00065 (.00007)	.74	73.65
Minimum trainload tonnage:									
<5,000	106	130.48 (15.66)	+.734 (.052)	.80	57.63 (17.42)	+1.599 (.141)	-.00129 (.00020)	.86	42.42
≥5,000 <8,000	451	229.89 (12.12)	+.522 (.028)	.66	103.93 (21.48)	+1.251 (.108)	-.00087 (.00012)	.70	52.81
≥8,000	202	175.11 (10.47)	+.360 (.030)	64	167.81 (17.89)	+.400 (.084)	-.00004 (.00008)	.64	[3]1.24

[1]The standard errors are given in parenthesis below the coefficients.

[2]Second degree curve cannot be calculated because data clustered at two shipping distances.

[3]Not significant at the 1-percent level; therefore, linear model is more suitable estimator of costs.

[4]F not significantly different from 0.

Average Practice

The parabolic cost function parameters for each coal district for large sample sizes (table 1) tend toward similarity. As such, it is assumed that they are reasonable estimates of average cost. The average of these parameters for coal districts 1, 2, 4, and 8 (with $N \geq 99$) provides the cost function for rail transportation of coal up to about 700 miles.[7] The average practice cost equation then becomes

$$Y = 103.5 + 1.124X - 0.00081X^2,$$

where Y represents cost, cents/ton,

and X represents distance, miles.

This is illustrated in figure 3.

Best Practice

The parabolic model was also used to analyze data for minimum trainload tonnages (table 1). Figure 4 shows the cost functions for the three ranges of minimum trainload tonnage. The F-test, comparing the parabolic with the linear model, shows that for the <5,000 and 5,000-to-8,000 minimum trainload

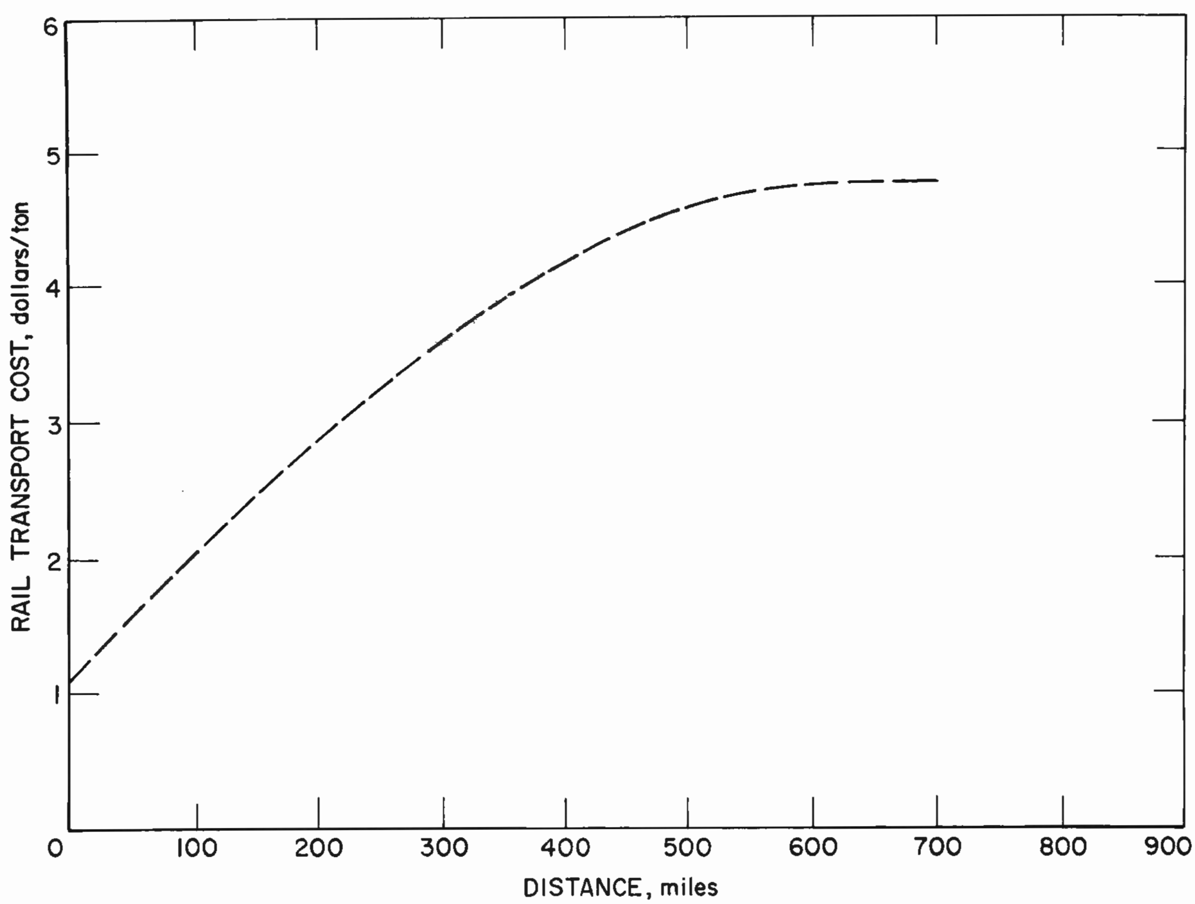

FIGURE 3. - Average practice coal transportation cost function.

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[7]This is the practical limit of the model's range.

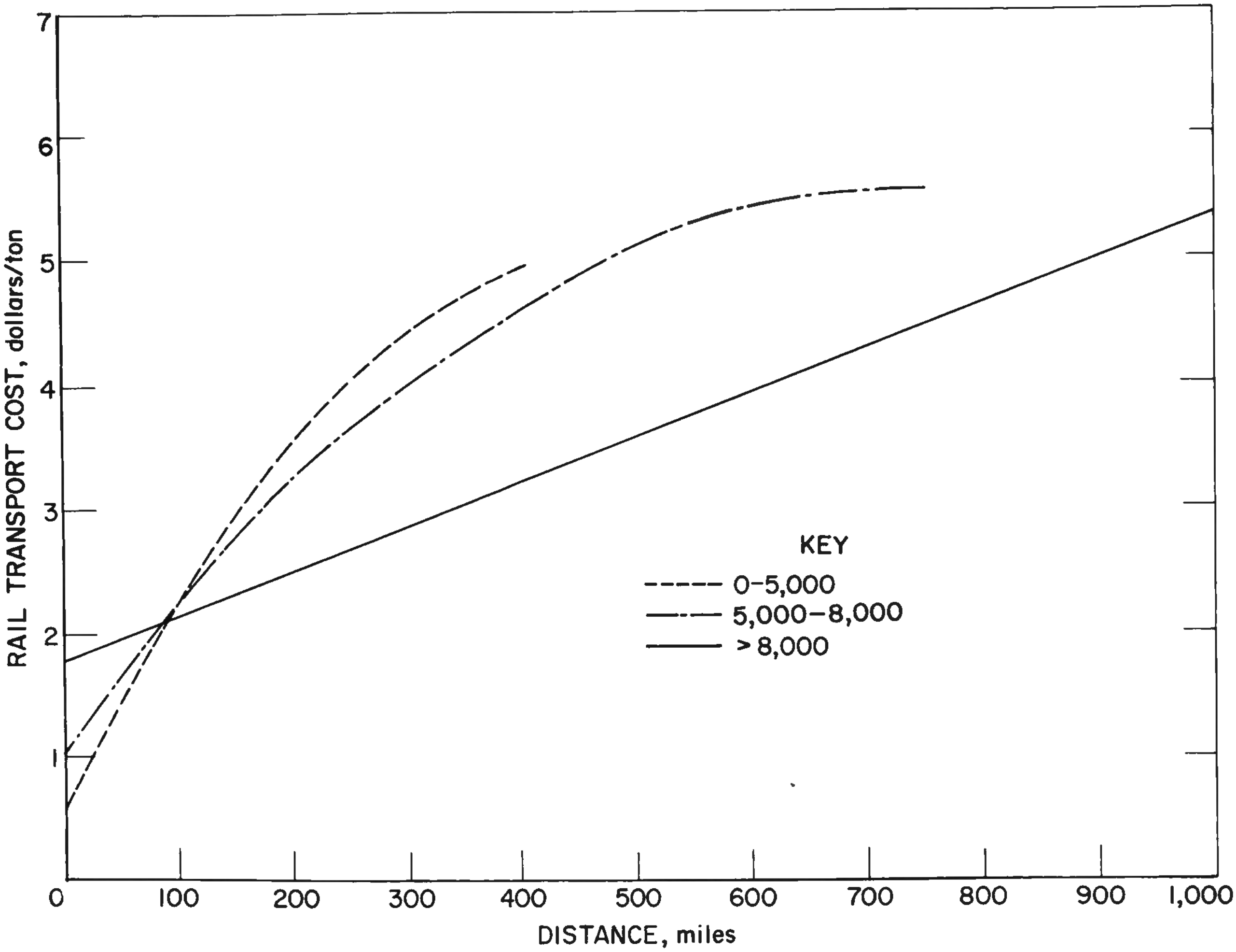

FIGURE 4. - Coal transportation cost functions for three ranges of minimum trainload tonnage.

tonnages ranges, the third term for the parabolic model is significant. Therefore, there are economies of haul (negative value for A_2'). This is not true for the >8,000-ton range. Here the A_2' parameter is not significant at the 1-percent level, and the parabolic model does not express the cost function any better. Therefore, the linear model best describes this set of data. The inference is that economies of haul (for longer distances) do not exist for minimum trainload tonnages greater than 8,000 tons.

Figure 5 displays, for the >8,000-ton train size, the data points and linear regression line. The lower limits of the envelope represent the lowest cost function for the limits of our experience. For the purpose of this analysis, this lower envelope is taken as the best practice. The method used to estimate the best practice equation was by drawing a judgment line through the most efficient points (least cost) for selected distances. Therefore, in essence, the best practice equation is a judgment line, or average of the best or most efficient data points. (See appendix C.) The equation representing

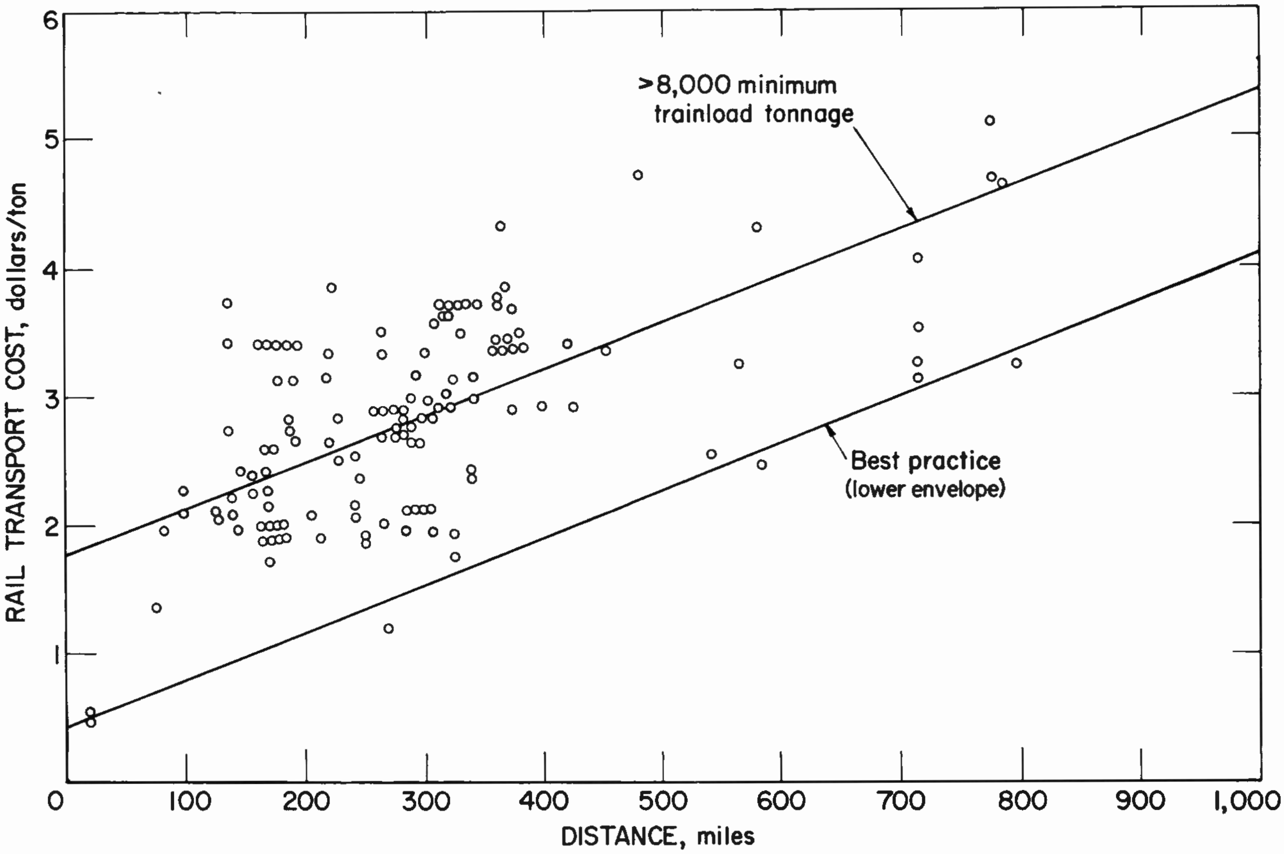

FIGURE 5. - Best practice coal transportation costs for trainload sizes of greater than 8,000 tons.

the best practice is given by:

$$Y = 33 + 0.38X,$$

where Y represents cost, cents/ton,

and X represents distance, miles.

Figure 6 shows two cost functions, one the average practice cost function (from fig. 3) and the other, the most efficient or best practice cost function (from fig. 5) for hauling coal by unit trains of greater than 8,000 tons. When comparing the two cost functions, a wide divergence in cost between average practice for the universe and best practice for unit trains over 8,000 tons in both terminal and running cost can be seen. Figure 7 presents the average and best practice rate per ton-mile equation. The average practice curve is presented mainly for interpolative purposes for those who wish to determine the average cost of shipping coal on a cents-per-ton-mile basis for the relevant range of 0 to 700 miles. For those who wish to extrapolate and estimate costs for greater than 700 miles, or to estimate costs for shorter distances by large unit trains, usage of the lower or best practice curve is suggested.

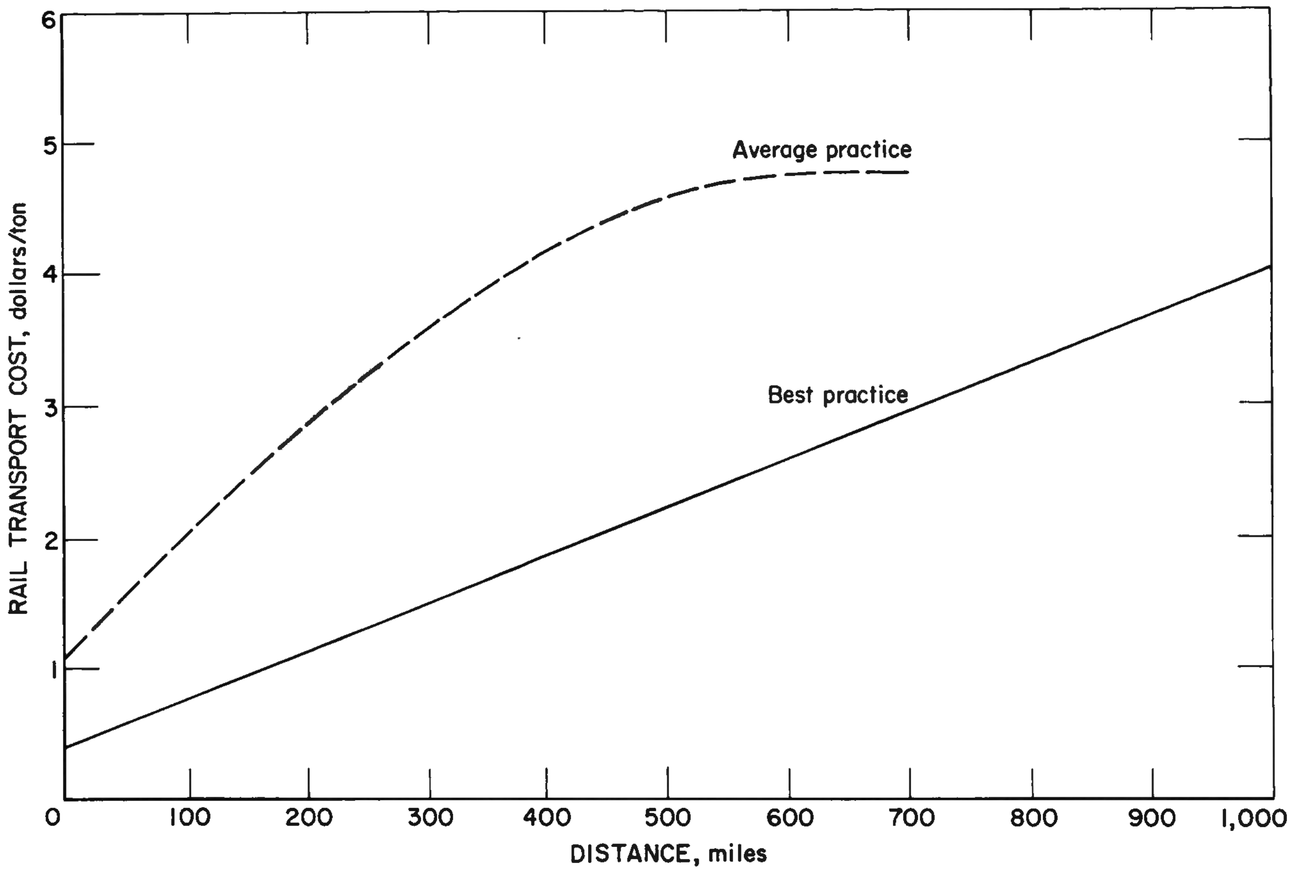

FIGURE 6. - Average and best practice coal transportation cost functions.

Analysis of Data

The importance of transportation costs for western coal being shipped to Eastern and Midwestern markets is in part illustrated by table 2. Table 2 shows the comparative costs of Western coal versus the least cost high-sulfur coal for a specific area; for example, how does the delivered cost of Western coal (fig. 1) in Chicago compare with that of high-sulfur coal produced in Illinois and shipped to Chicago.

Table 2 was constructed for illustrative purposes and it is realized that the likelihood of shipping Western coal into certain areas would be remote; for example, from Wyoming to Boston. The table establishes a methodology so the reader can compare high- and low-sulfur coals from areas of his own choosing.

TABLE 2. - Comparative costs of supplying high- and low-sulfur coal from selected producing districts to selected consuming regions, 1970[1]

	Producer district	Consumer region								
		South Atlantic (Richmond, Va.)			Middle Atlantic (New York, N.Y.)			New England (Boston, Mass.)		
		Cost of coal per million Btu[2]		Cost difference	Cost of coal per million Btu[2]		Cost difference	Cost of coal per million Btu[2]		Cost difference
		Low sulfur	High sulfur		Low sulfur	High sulfur		Low sulfur	High sulfur	
16 and 17	Northern and Southern Colorado (Denver).....	$0.597	$0.298	$0.299	$0.615	$0.324	$0.291	$0.635	$0.353	$0.282
18	Arizona and New Mexico (Albuquerque, N. Mex.)	.450	.298	.152	.479	.324	.155	.501	.353	.148
19	Wyoming (Cheyenne).....	.493	.298	.195	.504	.324	.180	.523	.353	.170
20	Utah (Salt Lake City)..	.657	.298	.359	.667	.324	.343	.683	.353	.330
21	North and South Dakota (Fargo, N. Dak.)......	.584	.298	.286	.597	.324	.273	.627	.353	.274
22	Montana (Billings).....	.502	.298	.204	.510	.324	.186	.530	.353	.177
23	Washington (Seattle)...	.968	.298	.670	.977	.324	.653	.998	.353	.645

	Producer district	Consumer Region								
		East North Central (Chicago, Ill.)			West North Central (St. Louis, Mo.)			East South Central (Vicksburg, Miss.)		
		Cost of coal per million Btu[2]		Cost difference	Cost of coal per million Btu[2]		Cost difference	Cost of coal per million Btu[2]		Cost difference
		Low sulfur	High sulfur		Low sulfur	High sulfur		Low sulfur	High sulfur	
16 and 17	Northern and Southern Colorado (Denver).....	$0.453	$0.312	$0.141	$0.433	$0.312	$0.121	$0.508	$0.283	$0.225
18	Arizona and New Mexico (Albuquerque, N. Mex.)	.337	.312	.025	.313	.312	.001	.304	.283	.021
19	Wyoming (Cheyenne).....	.345	.312	.033	.332	.312	.020	.415	.283	.132
20	Utah (Salt Lake City)..	.530	.312	.218	.519	.312	.207	.583	.283	.300
21	North and South Dakota (Fargo, N. Dak.)......	.344	.312	.032	.394	.312	.082	.537	.283	.254
22	Montana (Billings).....	.342	.312	.038	.438	.312	.126	.429	.283	.146
23	Washington (Seattle)...	.805	.312	.493	.819	.312	.507	.901	.283	.618

[1]For methodology see appendix B. Cities in parentheses represent point of origin or destination for calculation of distance.

[2]Low-sulfur coal is from producer district given. High-sulfur coal given is least-cost-available high-sulfur coal (transportation cost + f.o.b. mine price) for each consumer region.

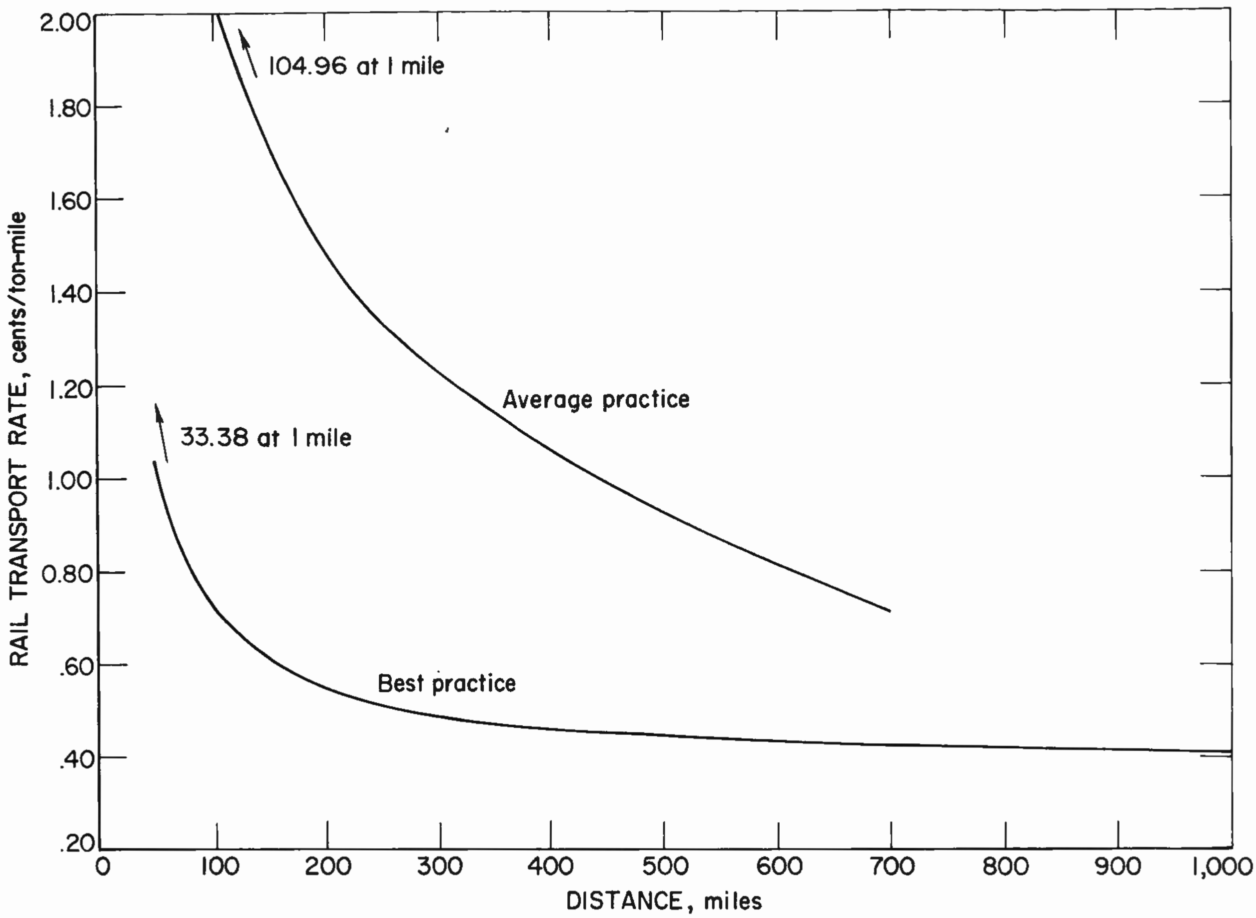

FIGURE 7. - Average and best practice rate per ton-mile for coal transportation.

In all instances in the East and Midwest, high-sulfur coal from the West is less expensive than low-sulfur coal. However, low-sulfur Western coal must be shipped to conform with environmental regulations. Therefore, the differences in costs between the two coals reveal the following:

1. The magnitude of the increased costs of energy in the East if western coal is used instead of eastern coal.

2. The amount of money which may be spent for an alternative pollution abatement system (for example, stack gas cleaning) while maintaining the competitive edge for locally produced coal.

3. How critically important transportation costs are in the two conditions stated above.

If western coal were used instead of eastern or midwestern coal; the increased costs of energy would be due to higher transportation charges, offset in part by cheaper mining costs in the West than in the East or Midwest.

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Table 2 also shows that an alternative pollution abatement system would be more feasible in the East than in the Midwest. This is due to the increased costs of transporting Western coals greater distances. Cost differences in the eastern U.S. range from 14.8 to 67.0 cents per million Btu for the same areas chosen. The range of cost differences for the Midwest was approximately 0.10 to 61.0 cents per million Btu.

RESIDUAL FUEL OIL TRANSPORTATION COSTS

In 1971, the United States depended on imports for over 500 million barrels (table 3) of its residual fuel oil[8] requirements. Most fuel oil is imported using foreign flag tankers because of the high construction and labor costs of U.S. flag tankers. However, by law, coastal movements of residual fuel oil must be made by U. S. flag tankers (14).

TABLE 3. - Origin of U.S. residual fuel oil imports (13)

Country	1970		1971	
	Quantity, thousand barrels	Percent	Quantity, thousand barrels	Percent
Venezuela	211,230	37.9	212,518	36.8
Virgin Islands	52,453	9.4	77,198	13.4
Netherland Antilles	135,010	24.2	116,412	20.1
Trinidad	61,553	11.0	48,492	8.4
Bahamas	10,848	2.0	47,843	8.3
Total Caribbean	471,094	84.5	502,463	87.0
Canada	7,683	1.4	12,505	2.2
Netherlands	14,020	2.5	6,674	1.2
Italy	27,637	4.9	25,653	4.4
Total	520,434	93.3	547,437	94.8
Other Countries	37,411	6.7	30,263	5.2
Grand Total	557,845	100.0	577,558	100.00

The United States is divided into five geographical Petroleum Administration Districts (PAD, see appendix D.) which have no import restrictions and are licensed to import residual fuel oil to meet their marketing requirements. The east coast accounted for more than 99 percent of the total imports from 1968 to 1971. During this same period, the Central Atlantic, New England, and Lower Atlantic States received approximately 57, 24, and 18 percent, respectively, of all the residual fuel oil imports (fig. 8).

Approximately 94 percent of the fuel oil imported during 1970 and 1971 came from the Caribbean, the Netherlands, Italy, and Canada (table 3). The

[8]The residual fuel oil used by electric utilities is the residue left from atmospheric and vacuum distillation of crude oil at petroleum refineries. Residual fuel oil includes ASTM grades No. 5 and No. 6, heavy diesel, Navy special, and bunker C oils.

FIGURE 8. - Geographic market areas for imported residual fuel oil (13).

majority of the residual fuel oil came from the Caribbean--over 80 percent of the total during 1970 and 1971 (table 3).

The domestic ports that received a majority of the imported residual fuel oil are shown in table 4. Boston, Baltimore, New York, Perth Amboy, Philadelphia, and Norfolk received approximately 60 percent of all residual fuel oil imported during 1970 and 1971 (table 4). New York City, which received the largest amount, accounted for approximately 27 percent of the total. Interior cities, such as Vicksburg, St. Louis, and Chicago, receive their fuel oil via Mississippi River barges from the port of New Orleans.

TABLE 4. - Destination of imported residual fuel oil (13)

City	1970		1971	
	Quantity, thousand barrels	Percent	Quantity, thousand barrels	Percent
Baltimore....................	25,268	4.9	24,381	4.6
Boston.......................	43,840	8.5	33,672	6.3
New York.....................	140,915	27.3	141,527	26.4
Norfolk......................	22,984	4.5	27,664	5.2
Perth Amboy..................	29,509	5.7	27,822	5.2
Philadelphia.................	56,841	11.0	52,640	9.8
Subtotal................	319,357	61.9	307,706	57.4
Other cities.................	196,347	38.1	228,069	42.6
Grand total[1]...........	515,704	100.0	535,775	100.0

[1]The grand total does not include oils withdrawn from bond for bunkering vessels engaged in foreign trade or imports by the military for offshore use.

One method of measuring the transportation cost to these ports would be to evaluate the spot rate (see appendix C) over the long run. The variations of the spot rate at its lowest level approximates the cost of operation of a tanker over the long run. This will be discussed at greater length later.

Analysis of Rates

Tankers

The ownership and operation of the world tanker fleet is divided into three distinct categories (12):

1. Oil company owned and operated tankers, which account for approximately 40 percent of the world's deadweight ton (dwt) capacity.

2. Independently owned tankers that are hired out to oil companies for periods that cover most of the tankers life; these account for approximately 45 percent of the world's dwt capacity.

3. Independently owned tankers that are operated in the spot market for single voyages or time-chartered to oil companies for less than a year; these account for approximately 15 percent of the world's dwt capacity.

Oil companies, after making an evaluation of their shipping requirements over the long term, supplement their ownership with vessels chartered on a long-term basis (generally 1 to 3 years) from independent shipowners, up to a maximum of 90 percent of their expected requirements (12). Approximately one-third of all the oil companies' shipping requirements are carried out by company-owned tankers. The remaining requirements are chartered at a spot rate or single-voyage basis, which allows freedom for maneuvering during fluctuating demand. Although the spot rate only accounts for approximately 10 to 20 percent of the fuel oil being transported, it is an important barometer for determing rates for long-term charters. Spot rates generally shape price expectations about the future (17). Therefore, spot rates were used to determine the cost of tanker operation (7).

The transactions in the tanker market are divided into two basic categories: spot or single voyage, and long term. The spot rate (transportation costs of oil) is a function of the following variables:

1. Expectations of price changes in the future.

2. Demand for tankers.

3. Supply of tankers.

4. Tanker size.

5. Distance.

Although the spot rate system works very well under normal conditions, it has its drawbacks. The demand for tankers falls upon a comparatively small amount of marginal tonnage (spot market). Over the short term, the supply of tankers in the spot market is inelastic. This in turn causes marked changes in spot tanker freight rates. Figure 9 illustrates the price and consumption for spot rates of residual fuel oil in New York City. For example, in the latter part of 1969 and early months of 1970, consumption of residual fuel oil in New York City increased. Shipping requirements tended to outstrip tanker availability, causing spot prices of residual fuel oil to rise. During this period, not only was there an increase in demand for low-sulfur fuel oil, but the break in the Trans Arabian Pipeline (Tapline) forced tanker traffic around Cape of Good Hope, virtually drying up all available tonnage (spot market), causing tanker spot rates, and hence the price of residual oil, to soar. The rise in price from January 1970 to January 1971 was approximately 60 percent.

During periods in which tankers are in strong demand, those tankers engaging in spot market transactions can fall to approximately 10 percent of the total tanker fleet because charterers are eager to secure as much long-term charter tonnage as possible to protect against expected future increases in tanker rates.

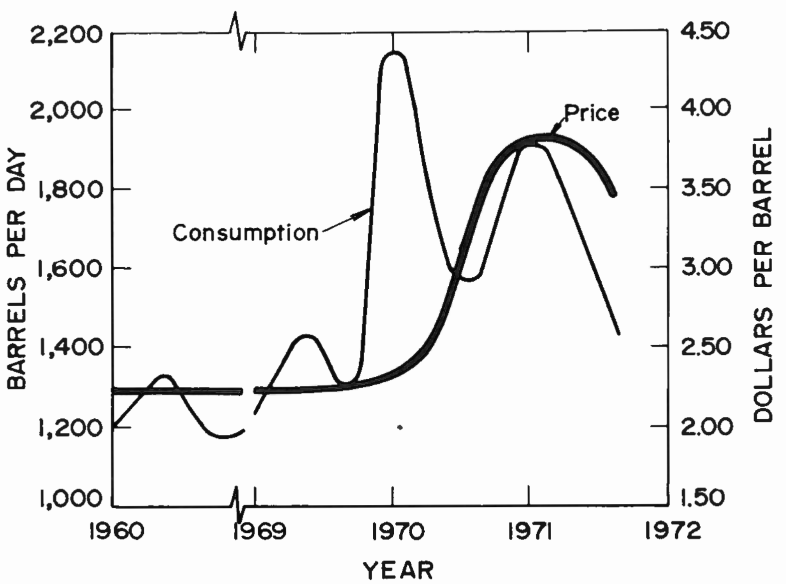

FIGURE 9. - Residual fuel oil price versus consumption for spot rates in New York City.

Rates in the spot market are generally higher than long-term rates because of the risks involved, which is mainly the unemployment of vessels. Also, the rates must be sufficient to attract the marginal speculator in the spot market to stay in operation.

During a recession, when spot rates decline and approach the operating cost of a tanker, the rate of scrapping and conversions of tankers into grain-carriers tends to increase. Also, during this period, oil companies placed their surplus tanker requirements into the spot market, further weakening spot rates. However, when an upturn in rates occurs after a recession period, the oil companies pull their transportation requirements out of the spot market, further weakening the tanker supply, which creates a further increase in rates.

Oil rates are negotiated in both the national and international market between the receiver and shipper. The majority of tankers are chartered in London and New York. The negotiated price is transacted through brokers who act as intermediaries between the shipper, who advises the brokers of his current and expected availability of tonnage, and the receiver, who advises the brokers of his requirements.

The system of quoting rates for oil tankers is divided into two major categories--Worldscale and American Tanker Rate Schedule (ATRS). Worldscale is a schedule of flat rates prepared and published by the Association of Ship Brokers and Agents, Inc. (U.S.A.), New York, and the International Freight Scale Association, London. The rates are jointly set and revised January 1 of each year. The ATRS scale, which is compilied by the Tanker Committee of the Association of Ship Brokers and Agents, New York, is a schedule of flat rates used mainly for calculating shipping rates between various loading and discharging ports that lie within the United States. The Worldscale is used for calculating shipping rates between various loading and discharging ports around the world and from foreign to U.S. ports. Oil tanker rates are volatile in the short run and vary daily.

Both the Worldscale and ATRS are given in terms of a percentage of a flat rate (see appendix C) that is intended solely as a standard of reference, by means of which rates for all voyages and market levels can be compared and readily judged. It does not in any way represent an average or normal level of tanker rates. The Worldscale is used as a positive percentage index with the flat rate expressed as Worldscale 100. With the ATRS scale, it has been the practice to express market levels in terms of the flat rate plus or minus a percentage; that is, ATRS flat rate plus or minus 15 percent. Therefore, using the above example, Worldscale 85 would be analogous to ATRS minus 15 percent, while ATRS plus 15 percent would be analogous to Worldscale 115.

Barge

Of the 57,700 million barrels of residual fuel oil consumed in the U.S. in 1971, less than 1.2 percent (6,932 million barrels) was transported by barge. Like tanker costs, the cost of barging residual fuel oil is generally unknown. However, a way of estimating costs would be to examine price over the long term. Barge rates are not regulated and are subject to private negotiation.

Analysis of Data

Tankers

Figure 10 illustrates the volatility of the spot rate over a 36-month period from 1969 through 1971. Significant changes in the Worldscale rate

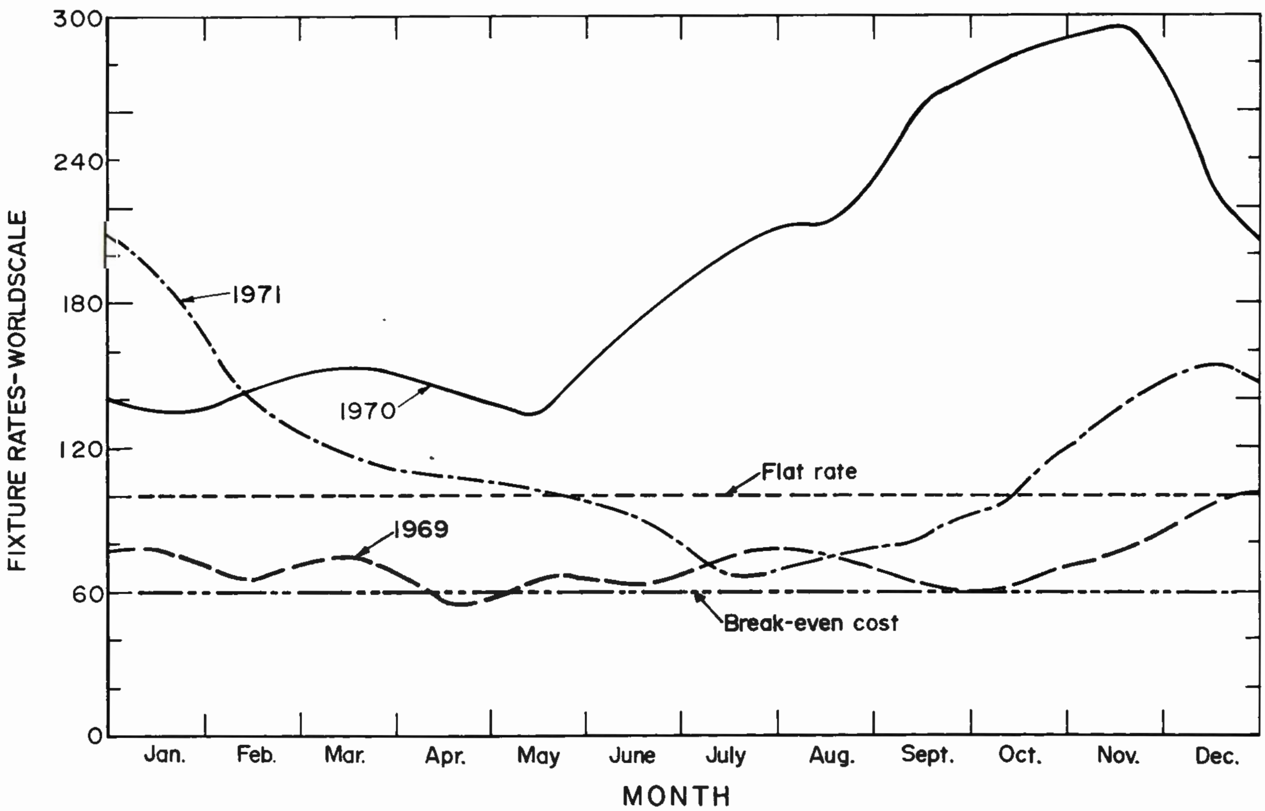

FIGURE 10. - Seasonal variation of spot rates (7).

occur from month to month, indicating the instability of the spot rate in the short term. It is apparent that there is seasonal variation occurring during the fall and winter months, caused by changes in supply and demand. Spot rates fluctuate markedly around the flat rate (Worldscale 100). The erratic spot rates in 1970, which reached Worldscale 290, can be attributed in part to the break in the Trans Arabian Pipeline. This placed a heavy demand upon world tanker supply and allowed expectations of future prices to soar. During periods of low demand the minimum spot rate was around Worldscale 60, which suggests the approximate break-even cost.

To confirm the above assumption that spot rates over the 3-year period approached the break-even cost (see appendix C), a break-even transportation cost curve is presented in figure 11. The break-even cost is shown to be indirectly proportional to the size of tanker. However, the break-even cost (fig. 11) excludes normal profit and applies only to independent tanker owners and to crews other than U.S. Theoretically, any tanker that operates at a rate below break-even cost would be operating at a loss. To determine the break-even cost for the spot rates shown in figure 10, the mean tanker size for the 3-year period (1969-71) was found to be approximately 27,000 dwt. The appropriate break-even cost for 27,000-dwt tanker was found on figure 11 to be Worldscale 60. This supports the above assumption that rates over the long run approach break-even cost.

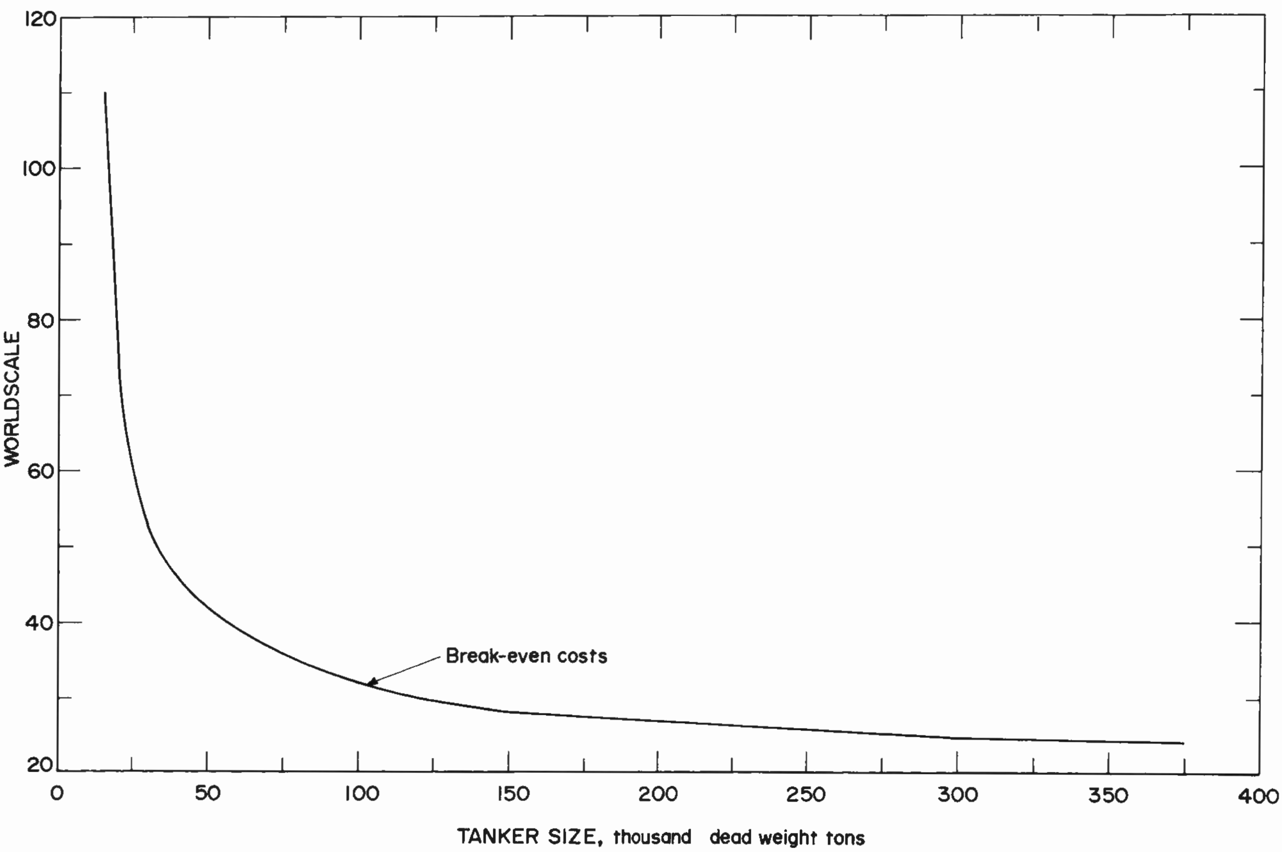

FIGURE 11. - Tanker transportation break-even costs (9).

Shallow channels, estuaries, and/or shoals prevent the larger tankers from entering ports on the east and gulf coasts of the United States. The deepest channels of existing ports restrict vessels to a maximum of 80,000 dwt, drawing 45 feet of water, fully loaded (2). This represents break-even cost of Worldscale 35. The average size tanker that docked in New York in 1971 was about 47,000 dwt (2), and represented a break-even cost of Worldscale 43.

Residual fuel oil transportation rates were analyzed utilizing the same statistical analysis as coal. Unlike the coal analysis, where actual transportation rates were analyzed, tanker transportation rates are analyzed using flat rates (Worldscale 100) rather than spot rates. Spot rates were not used for the analysis because they are very volatile (fig. 10).

The linear model for tanker transportation flat rates, as a function of distance, is shown in figure 12 for the cities of Boston, New Orleans, New York, and Norfolk. Although there are differences in the facilities at each loading and discharge port, the transportation functions are quite similar. With the exception of Boston, using a 95-percent confidence interval, the F-test proved to be insignificant for the parabolic equations, suggesting the

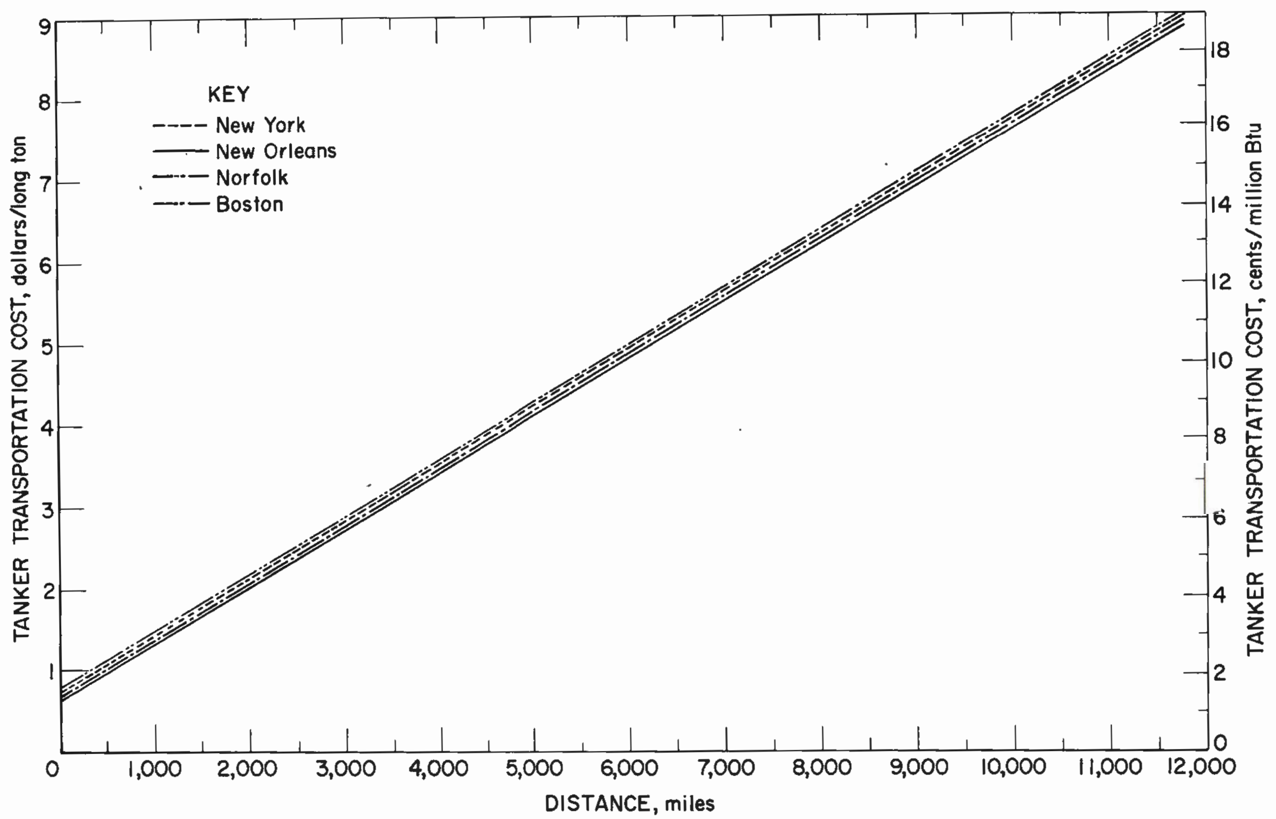

FIGURE 12. - Tanker transportation flat rate cost function for selected port cities, 1971 (1).

linear model to be statistically appropriate (table 5). In the case of Boston, where the F-test proved to be significant, the parabolic model was discounted because the high standard error of the A'_2 term in the parabolic equation suggested this coefficient may not be significantly different than zero. Therefore, in all cases, the linear model best represents an estimation of the transportation price function for the cities analyzed. Additionally, extremely high "R" values were obtained in all cases suggesting that these flat rates came from a prearranged schedule that was determined for a standard vessel under fixed conditions. The slight dispersion of points around the least squares line was possibly due to the differences in port charges and irregularities, such as transit of the Panama Canal.

Therefore, figure 12 can be used to estimate the price of tanker transportation by determining the flat rate corresponding to the distance of the voyage and in turn multiplying that rate by the negotiated fixture (see appendix C). To facilitate price estimates, figure 13 is presented to show the composite for the cities shown on figure 12. Included on figure 13 are the break-even costs for the 80,000-dwt and 27,000-dwt tankers which represent, respectively, the largest size tanker, fully loaded, that is able to dock on the east and gulf coasts and the average size tanker used for the spot rate.

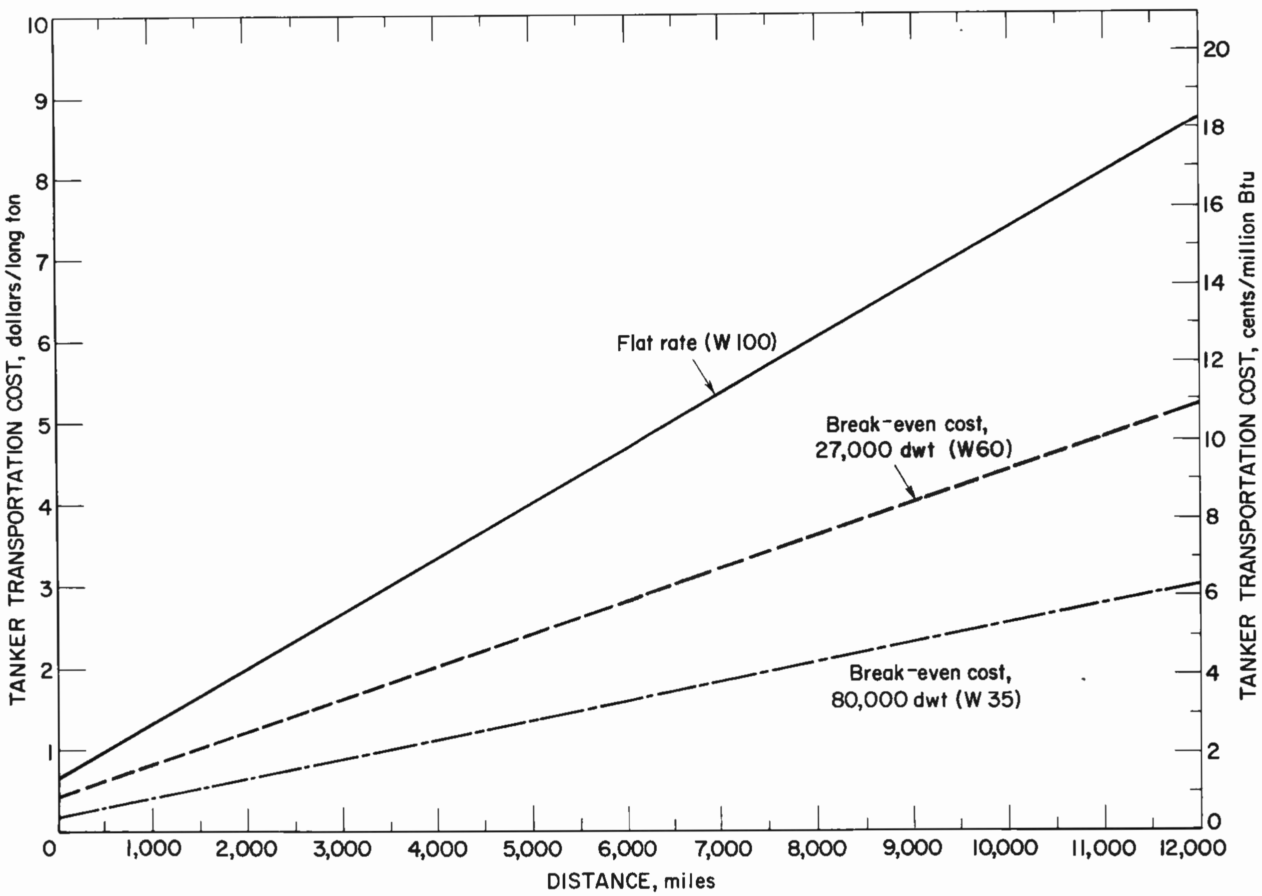

FIGURE 13. - Flat rate and break-even tanker cost for New York, Boston, Norfolk, and New Orleans, 1971 (1).

TABLE 5. - Tanker and barge transportation equations with regression coefficients, standard errors, correlation coefficients, and F-test values[1]

(Standard error of coefficient is listed in parenthesis)

Analysis	Number of observation	Linear $Y = A_0 + A_1X$			Parabolic $Y = A_0' + A_1'X + A_2'X^2$				F
		A_0	A_1	R	A_0'	A_1'	A_2'	R	
Tanker:									
Boston..........	16	0.694	0.000736	0.989	0.474	0.000853	-0.0000000097	0.990	17.41
		(0.115)	(0.000029)		(0.249)	(0.000122)	[2] (0.0000000097)		
New Orleans.....	13	0.608	0.000743	0.999	0.445	0.000825	-0.0000000068	0.999	[2] -12.13
		(0.053)	(0.000011)		(0.069)	(0.000029)	(0.0000000023)		
New York........	44	0.672	0.000749	0.991	0.918	0.000628	0.0000000100	0.991	[2] 2.19
		(0.074)	(0.000016)		(0.136)	(0.000059)	(0.0000000047)		
Norfolk.........	17	0.773	0.000760	0.983	0.216	0.001060	-0.0000000235	0.988	[2] -28.98
		(0.172)	(0.000036)		(0.302)	(0.000142)	(0.0000000109)		
Average......	[3] 90	0.683	0.000749	0.989	0.636	0.000774	-0.0000000021	0.989	9.08
		(0.054)	(0.000012)		(0.103)	(0.000046)	[2] (0.0000000036)		
Best practice...	-	0.239	0.000262	-	-	-	-	-	-
Barge:									
Average......	20	0.761	0.00244	0.987	0.785	0.00197	0.00000034	0.988	[2] 3.34
		(0.040)	(0.00009)		(0.047)	(0.00048)	[2] (0.00000034)		
Best practice...	-	0.668	0.00214	-	-	-	-	-	-

[1] Tanker rates expressed in dollars per long ton; barge rates expressed in dollar per short ton.
[2] Not significant at the 5-percent level.
[3] Total.

The best practice cost was obtained for the gulf and east coast by using the break-even cost (fig. 11) for an 80,000-dwt tanker. The break-even cost curve shown in figure 11 does not include a normal profit. Therefore, a conservative estimate of the normal profit would be approximately 12 percent above the break-even cost.[9]

The average and best practice for tanker transportation rates on a basis of cost per long ton-mile is shown in figure 14. Each curve was constructed by transforming the corresponding curves shown in figure 13. The best practice curve shown in figure 14 includes the normal profit. The transformation consisted of dividing the linear equation by the distance to obtain the cost per long ton-mile, and adding 12 per cent to that cost.

Barge

Unfortunately, there is generally a lack of published information on barge rates. However, data obtained by interviews with barge shippers and

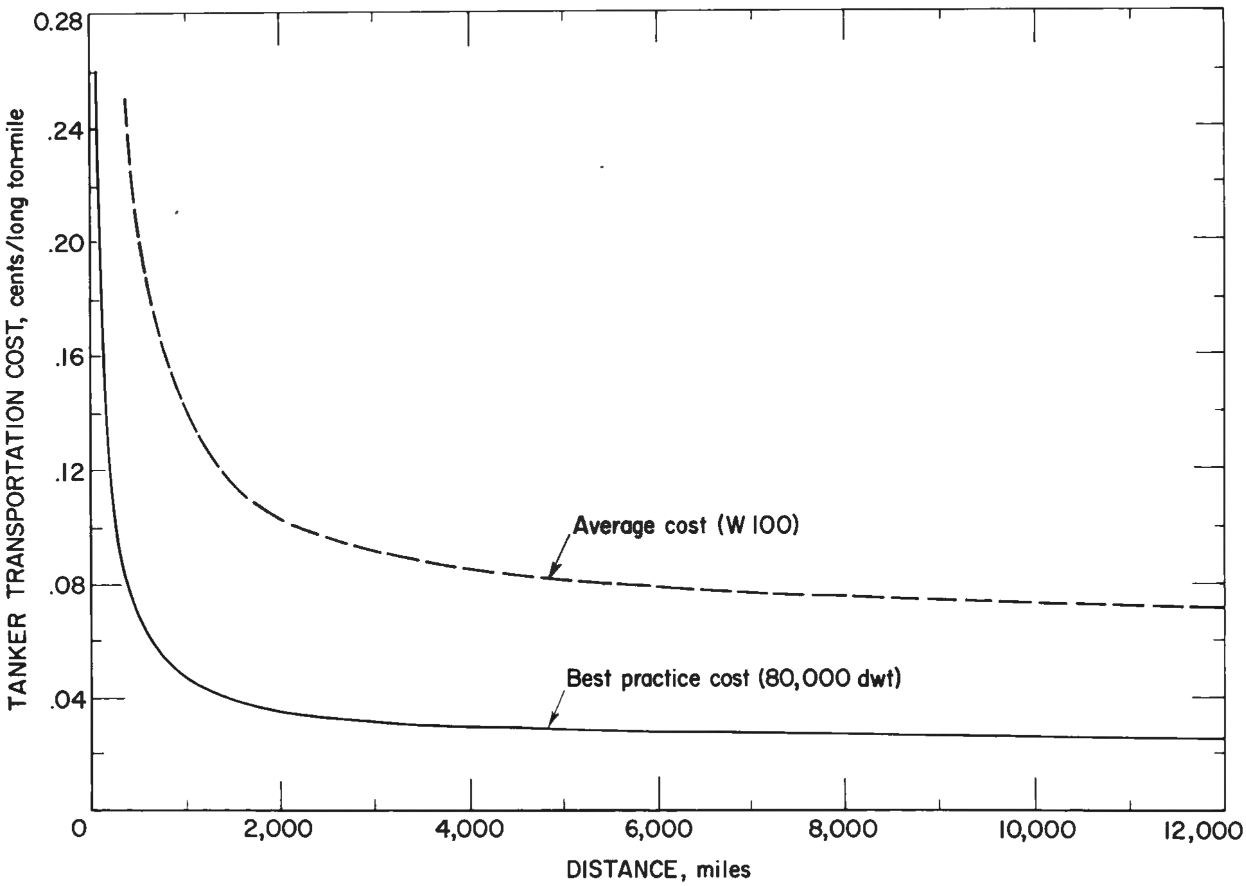

FIGURE 14. - Average and best practice tanker transportation cost functions, 1971.

[9]The authority for using 12 percent as the normal profit was based on information obtained from several shipping companies.

carriers were used to estimate a line of best fit shown in figure 15. Unlike tanker spot rates, there is little fluctuation of barge spot rates; generally plus or minus 10 percent.

The parameters for the linear and parabolic regression equations along with the calculated F-value are shown in table 5. The F-test indicated that the third term is not significant at the 5-percent level of significance and therefore the linear model is used.

The best practice rate for barges (which includes the normal profit) was also estimated by interviews with shippers and carriers and is shown in figure 15.

The average and best practice price on a basis of cost per long ton-mile is shown in figure 16. These curves were constructed by transforming the curves shown in figure 15. (See earlier discussion on spot rates, p. 23, for method transformation.)

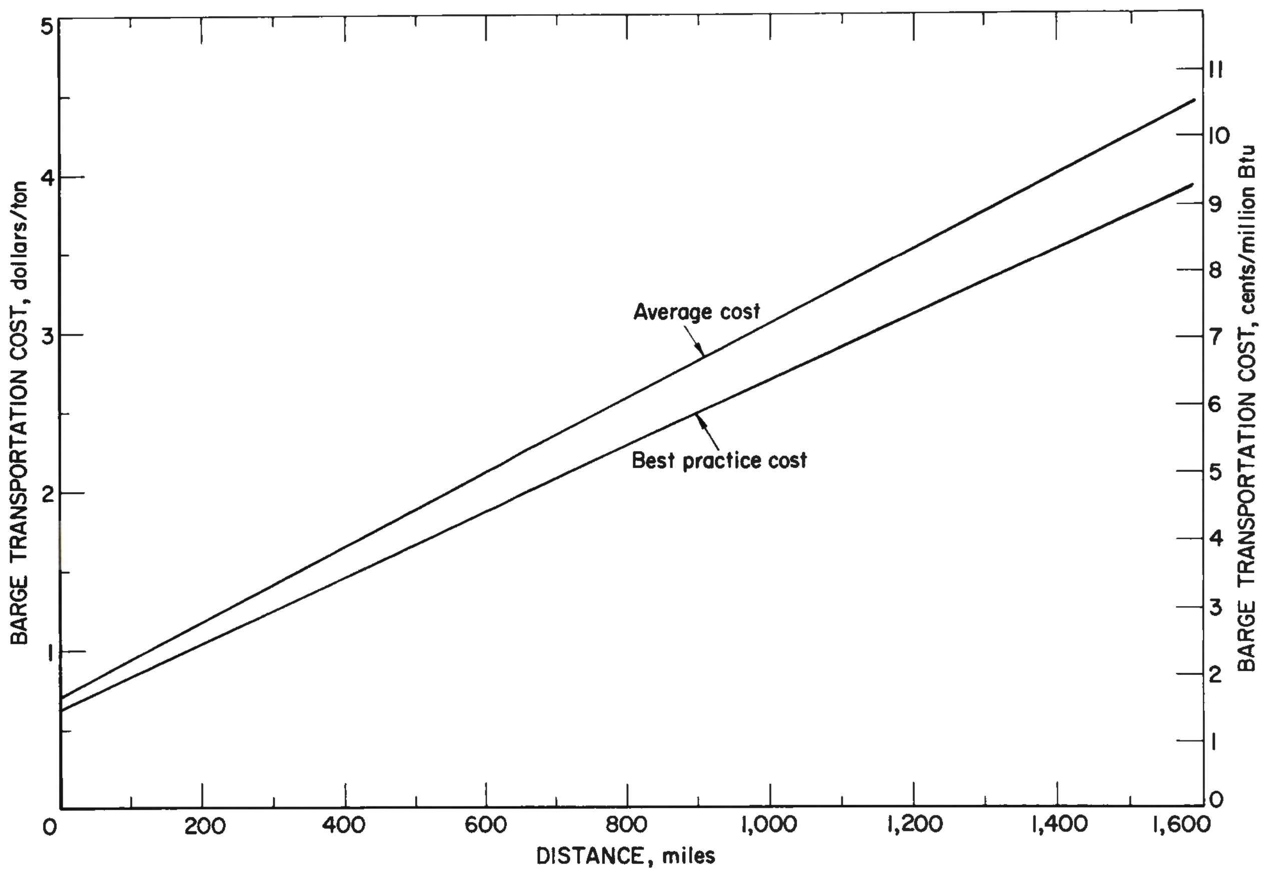

FIGURE 15. - Barge transportation costs, average and best practice.

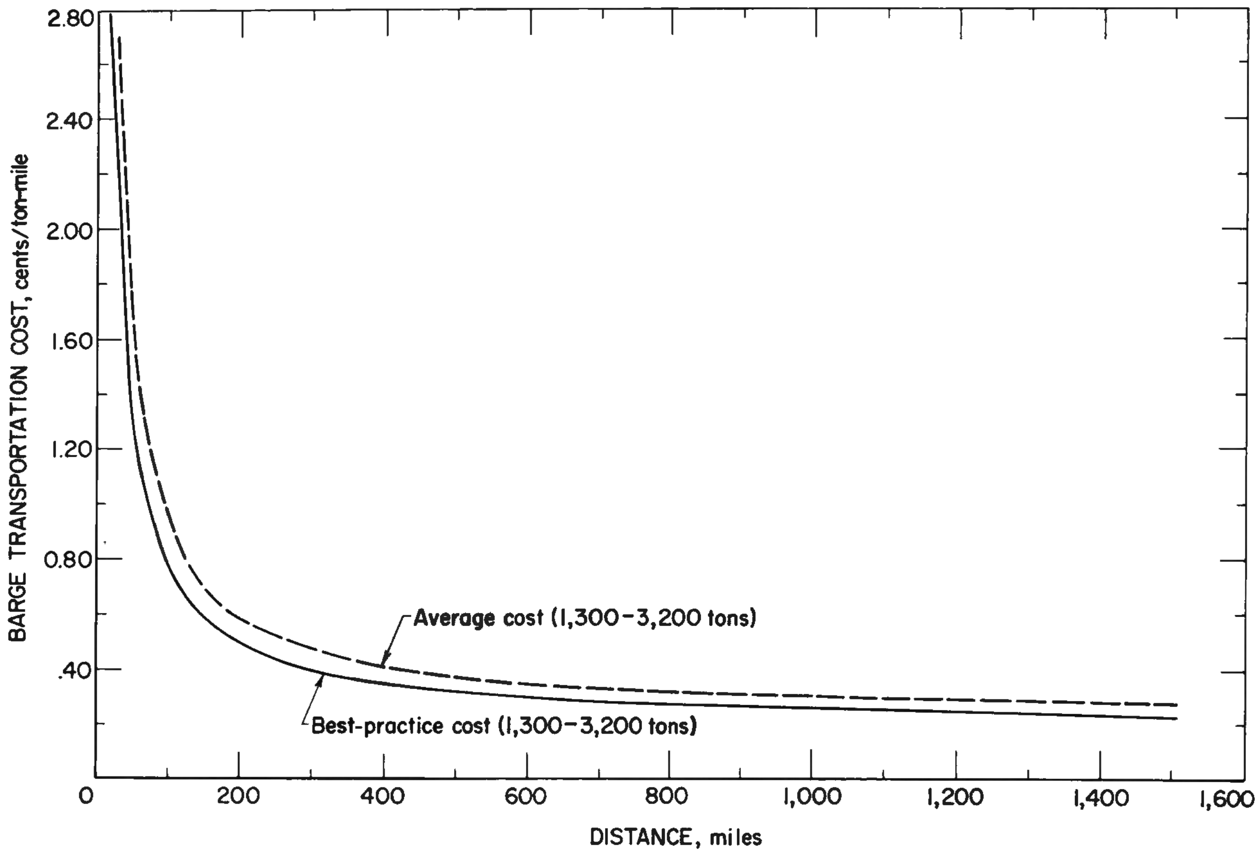

FIGURE 16. - Barge average and best practice cost functions.

Summary

In both the tanker and barge transportation models, it was found that economies of haul do not exist. Therefore, in every case, the linear model was used.

Transportation by barge has proved to be more expensive than by tanker. For example, the best practice cost for a distance of 1,200 miles by barge was 0.23 cents per ton-mile, while the best practice cost by tanker for the same distance was 0.04 cents per long ton-mile. In this example, it costs approximately six times as much to ship by barge than by tanker. This can be attributed to high construction and operating costs, slower speed, and smaller containers, all of which are characteristic of barge transportation.

The estimated best-practice equations for tanker and barge transportation rates for residual fuel oil are as follows:

Tanker, dollars/long ton.....$Y = 0.239 + 0.000262X$

Barge, dollars/ton..........$Y = 0.668 + 0.00214X$

COMPARATIVE TRANSPORTATION COSTS OF COAL AND OIL

The best practice equation (fig. 6) was used to construct tables 6 and 7. Table 6 compares the cost of supplying coal (production plus transportation cost) from western producing areas and oil from eastern ports to eastern markets. Table 7 compares the cost of supplying coal from western producing areas and oil from Gulf Coast to midwestern markets. The method of obtaining the cost of coal from a specific western area and oil from eastern ports is explained in detail in appendix B.

Table 6 shows that western coal cannot compete with foreign residual fuel oil in the Richmond, New York, or Boston fuel markets. For example, the cost for residual fuel oil was 28.7 cents per million Btu in the Richmond market, while the lowest potential cost for western coal was estimated to be 45 cents per million Btu, from the New Mexico coal-producing area. Overall coal costs ranged from 1.2 to 3.3 times higher than the cost of residual fuel oil. It should be noted that these costs do not include the cost of desulfurization, which may increase the total price somewhat.

Table 7 shows that western coal may be a viable economic substitute for foreign residual fuel oil in the Chicago, St. Louis, and Vicksburg fuel markets. In all three market areas, coal from several western locations was potentially cheaper than oil. For example, the potential cost of coal in the St. Louis area was as low as 31 cents per million Btu, while the average cost of residual fuel oil was 63 cents per million Btu. Overall coal costs for all areas ranged from 30 to 90 cents per million Btu, while oil costs ranged from 29 to 63 cents per million Btu. The only coal-producing area in the West that potentially could not compete with residual fuel oil in midwestern or eastern markets is the State of Washington. The total cost of transportation makes coal from Washington prohibitively expensive. However, the other coal-producing areas may be able to make some inroads into the energy market in the Midwest.

Table 8 illustrates the importance of transportation costs again when comparing the costs of western coal with foreign residual fuel oil in the market. In tables 6 and 7, in all instances where the cost of coal was higher than the cost of oil, the transportation costs of coal versus oil were also higher (table 8). Alternatively, where the cost of coal was less than that of oil, the transportation costs for coal were lower. This again leads to the overriding conclusion that many of the major decisions in environmental control and energy costs will be based on estimates of transportation costs and its impact upon cost of the commodity in the marketplace.

TABLE 6. - Comparative costs of supplying coal from Western producing districts and oil from East Coast to Eastern Markets, 1970[1]

Coal producer district		South Atlantic (Richmond, Va.) Cost per million Btu Coal	South Atlantic Cost per million Btu Oil	South Atlantic Coal-oil cost ratio	Middle Atlantic (New York, N.Y.) Cost per million Btu Coal	Middle Atlantic Cost per million Btu Oil	Middle Atlantic Coal-oil cost ratio	New Endland (Boston, Mass.) Cost per million Btu Coal	New Endland Cost per million Btu Oil	New Endland Coal-oil cost ratio
16 and 17	Northern and Southern Colorado (Denver)........	$0.597	$0.287	2.080	$0.615	$0.376	1.636	$0.635	$0.336	1.890
18	Arizona and New Mexico (Albuquerque, N. Mex.)...	.450	.287	1.568	.479	.376	1.274	.501	.336	1.491
19	Wyoming (Cheyenne)........	.493	.287	1.718	.504	.376	1.340	.523	.336	1.557
20	Utah (Salt Lake City).....	.657	.287	2.289	.667	.376	1.774	.683	.336	2.033
21	North and South Dakota (Fargo, N. Dak.).........	.584	.287	2.035	.597	.376	1.588	.627	.336	1.866
22	Montana (Billings)........	.502	.287	1.749	.510	.376	1.356	.530	.336	1.577
23	Washington (Seattle)......	.968	.287	3.373	.977	.376	2.598	.998	.336	2.970

[1]Cities in parentheses represent point of origin or destination for calculation of distance.

TABLE 7. - Comparative costs of supplying coal from Western producing districts and oil from Gulf Coast to Midwestern markets, 1970[1]

Coal producer district		East North Central (Chicago, Ill.) Cost per million Btu Coal	East North Central Cost per million Btu Oil	East North Central Coal-oil cost ratio	West North Central St. Louis, Mo. Cost per million Btu Coal	West North Central Cost per million Btu Oil	West North Central Coal-oil cost ratio	East South Central (Vicksburg, Miss.) Cost per million Btu Coal	East South Central Cost per million Btu Oil	East South Central Coal-oil cost ratio
16 and 17	Northern and Southern Colorado (Denver)........	$0.453	$0.480	0.944	$0.433	$0.631	0.686	$0.508	$0.484	1.050
18	Arizona and New Mexico (Albuquerque, N. Mex.)...	.337	.480	.702	.313	.631	.496	.304	.484	.628
19	Wyoming (Cheyenne)	.345	.480	.719	.332	.631	.526	.415	.484	.857
20	Utah (Salt Lake City).....	.530	.480	1.104	.519	.631	.823	.583	.484	1.205
21	North and South Dakota (Fargo, N. Dak.).........	.344	.480	.717	.394	.631	.624	.537	.484	1.110
22	Montana (Billings)........	.342	.480	.713	.438	.631	.694	.429	.484	.886
23	Washington (Seattle)......	.805	.480	1.677	.819	.631	1.298	.901	.484	1.862

[1]For methodology see appendix B. All data for oil was obtained from Steam Electric Plant Factors, 1970 (8). Cities in parentheses represent point of origin cr destination for calculation of distance.

TABLE 8. - Comparative transportation costs for coal[1] and residual fuel oil[2] consumed in selected cities in 1971, cents per million Btu

New York		Boston		Richmond		Vicksburg		St. Louis		Chicago	
Coal	Oil	Coal	Oil	Coal	Oil	Coal	Oil	Coal	Oil	Coal[3]	Oil
3.7	1.7	4.0	1.7	3.4	3.2	2.0	4.8	1.9	8.8	1.9	10.4

[1]Origin of coal is New Mexico, unless otherwise noted.
[2]Origin of residual fuel is Puerta La Cruz, Venezuela.
[3]Origin of coal is Wyoming.

CONCLUSIONS

A significant portion of fossil fuel cost is the transportation cost. In most instances, transportation costs for coal from the West constitute over 50 percent of the total cost of the product.

The major determinant of a fossil fuel's potential market area is transportation cost. The dominant low-sulfur fossil fuel in the eastern market is foreign residual fuel oil. Western coal would dominate the midwestern fuel market if precombustion air pollution regulations were implemented nationwide.

Average practice transportation cost for coal shipped distances less than 700 miles is given by $Y = 103.5 + 1.124X - 0.00081X^2$, where Y represents cost, cents/ton, and X represents distance, miles. Economies of haul exist for coal when shipped for distances up to 700 miles. For distances greater than 700 miles or for large unit trains, the transport cost is $Y = 33 + 0.38X$.

A model was developed to compare high-sulfur eastern and midwestern coal with low-sulfur coal from the West competing for eastern and midwestern fuel markets. In all cases, in the East and Midwest, high-sulfur coal is less expensive than low-sulfur coal from the West. The difference in costs between the two coals indicates (1) the amount of money which may be spent for an alternative pollution abatement system; (2) the magnitude of the increased costs of energy in the East if western coal is used instead of eastern coal to conform with environmental regulations; and (3) how critically important transportation costs are.

Best practice transport rate for residual fuel oil by tanker is given by $Y = 23.9 + 0.0262X$, where Y represents cost in cents/long ton. Best practice barge is given by $Y = 66.8 + 0.214X$, where Y represents cost in cents/ton.

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APPENDIX A.--TRANSPORTATION COST DATA

TABLE A-1. - State codes (consumption points)

Code	State	Code	State
010......	Alabama	300......	Montana
040......	Arizona	330......	New Hampshire
060......	California	340......	New Jersey
080......	Colorado	360......	New York
090......	Connecticut	370......	North Carolina
100......	Delaware	380......	North Dakota
110......	District of Columbia	390......	Ohio
130......	Georgia	420......	Pennsylvania, East
170......	Illinois	426......	Pennsylvania, West
180......	Indiana	440......	Rhode Island
190......	Iowa	450......	South Carolina
200......	Kansas	460......	South Dakota
211......	Kentucky, East	470......	Tennessee
240......	Maryland	490......	Utah
250......	Massachusetts	500......	Vermont
260......	Michigan	510......	Virginia
270......	Minnesota	540......	West Virginia
290......	Missouri	550......	Wisconsin

TABLE A-2. - Bituminous coal and lignite producing districts

DISTRICT 1.—EASTERN PENNSYLVANIA

Pennsylvania

Armstrong County (part).—All mines east of Allegheny River, and those mines served by the Pittsburgh & Shawmut Railroad located on the west bank of the river.

Fayette County (part).—All mines located on and east of the line of Indian Creek Valley branch of the Baltimore & Ohio Railroad.

Indiana County (part).—All mines not served by the Saltsburg branch of the Pennsylvania Railroad.

Westmoreland County (part).—All mines served by the Pennsylvania Railroad from Torrance, east.

All mines in the following counties:

Bedford	Centre	Forest	McKean
Blair	Clarion	Fulton	Mifflin
Bradford	Clearfield	Huntingdon	Potter
Cambria	Clinton	Jefferson	Somerset
Cameron	Elk	Lycoming	Tioga

Maryland.—All mines in the State.

West Virginia.—All mines in the following counties:

Grant	Mineral	Tucker

DISTRICT 2.—WESTERN PENNSYLVANIA

Pennsylvania

Armstrong County (part).—All mines west of the Allegheny River except those mines served by the Pittsburgh & Shawmut Railroad.

Fayette County (part).—All mines except those on and east of the line of Indian Creek Valley branch of the Baltimore & Ohio Railroad.

Indiana County (part).—All mines served by the Saltsburg branch of the Pennsylvania Railroad.

Westmoreland County (part).—All mines except those served by the Pennsylvania Railroad from Torrance, east.

All mines in the following counties:

Allegheny	Butler	Lawrence	Venango
Beaver	Greene	Mercer	Washington

DISTRICT 3.—NORTHERN WEST VIRGINIA

West Virginia

Nicholas County (part).—All mines served by or north of the Baltimore & Ohio Railroad.

All mines in the following counties:

Barbour	Jackson	Randolph	Webster
Braxton	Lewis	Ritchie	Wetzel
Calhoun	Marion	Roane	Wirt
Doddridge	Monongalia	Taylor	Wood
Gilmer	Pleasants	Tyler	
Harrison	Preston	Upshur	

DISTRICT 4.—OHIO.—All mines in the State.

DISTRICT 5.—MICHIGAN.—All mines in the State.

DISTRICT 6.—PANHANDLE

West Virginia.—All mines in the following counties:

Brooke	Hancock	Marshall	Ohio

DISTRICT 7.—SOUTHERN NO. 1

West Virginia

Fayette County (part).—All mines east of Gauley River and all mines served by the Gauley River branch of the Chesapeake & Ohio Railroad and mines served by the Virginian Railway.

McDowell County (part).—All mines in that portion of the county served by the Dry Fork branch of the Norfolk & Western Railroad and east thereof.

Raleigh County (part).—All mines except those on the Coal River branch of the Chesapeake & Ohio Railroad and north thereof.

Wyoming County (part).—All mines in that portion served by the Gilbert branch of the Virginian Railway lying east of the mouth of Skin Fork of Guyandot River and in that portion served by the main line and the Glen Rogers branch of the Virginian Railway.

All mines in the following counties:

Greenbrier	Mercer	Monroe	Pocahontas	Summers

Virginia

Buchanan County (part).—All mines in that portion of the county served by the Richlands-Jewell Ridge branch of the Norfolk & Western Railroad and in that portion on the headwaters of Dismal Creek east of Lynn Camp Creek (a tributary of Dismal Creek).

Tazewell County (part).—All mines in those portions of the county served by the Dry Fork branch to Cedar Bluff and from Bluestone Junction to Boissevain branch of the Norfolk & Western Railroad and Richlands-Jewell Ridge branch of the Norfolk & Western Railroad.

All mines in the following counties:

Montgomery	Pulaski	Wythe	Giles	Craig

DISTRICT 8.—SOUTHERN NO. 2

West Virginia

Fayette County (part).—All mines west of the Gauley River except mines served by the Gauley River branch of the Chesapeake & Ohio Railroad.

McDowell County (part).—All mines west of and not served by the Dry Fork branch of the Norfolk & Western Railroad.

Nicholas County (part).—All mines in that part of the county south of and not served by the Baltimore & Ohio Railroad.

Raleigh County (part).—All mines on the Coal River branch of the Chesapeake & Ohio Railroad and north thereof.

Wyoming County (part).—All mines in that portion served by the Gilbert branch of the Virginian Railway and lying west of the mouth of Skin Fork of Guyandot River.

All mines in the following counties:

Boone	Kanawha	Mason	Wayne
Cabell	Lincoln	Mingo	
Clay	Logan	Putnam	

Virginia

Buchanan County (part).—All mines in the county, except in that portion on the headwaters of Dismal Creek, east of Lynn Camp Creek (a tributary of Dismal Creek) and in that portion served by the Richlands-Jewell Ridge branch of the Norfolk & Western Railroad.

Tazewell County (part).—All mines in the county except in those portions served by the Dry Fork branch of the Norfolk & Western Railroad and branch from Bluestone Junction to Boissevain of Norfolk & Western Railroad and Richlands-Jewell Ridge branch of the Norfolk & Western Railroad.

All mines in the following counties:

Dickinson	Russell	Wise
Lee	Scott	

Kentucky.—All mines in the following counties in eastern Kentucky:

Bell	Greenup	Lawrence	Morgan
Boyd	Harlan	Lee	Owsley
Breathitt	Jackson	Leslie	Perry
Carter	Johnson	Letcher	Pike
Clay	Knott	McCreary	Rockcastle
Elliott	Knox	Magoffin	Wayne
Floyd	Laurel	Martin	Whitley

Tennessee.—All mines in the following counties:

Anderson	Cumberland	Overton	Scott
Campbell	Fentress	Putnam,	
Claiborne	Morgan	Roane	

North Carolina.—All mines in the State.

DISTRICT 9.—WEST KENTUCKY

Kentucky.—All mines in the following counties in western Kentucky:

Butler	Hancock	McLean	Todd
Christian	Henderson	Muhlenberg	Union
Crittenden	Hopkins	Ohio	Warren
Daviess	Logan	Simpson	Webster

DISTRICT 10.—ILLINOIS.—All mines in the State.

DISTRICT 11.—INDIANA.—All mines in the State.

DISTRICT 12.—IOWA.—All mines in the State.

DISTRICT 13.—SOUTHEASTERN

Alabama.—All mines in the State.

Georgia.—All mines in the following counties:

Dade	Walker

Tennessee.—All mines in the following counties:

Bledsoe	Marion	Sequatchie	White
Grundy	McMinn	Van Buren	
Hamilton	Rhea	Warren	

DISTRICT 14.—ARKANSAS-OKLAHOMA

Arkansas.—All mines in the State.

Oklahoma.—All mines in the following counties:

Haskell	Le Flore	Sequoyah

DISTRICT 15.—SOUTHWESTERN

Kansas.—All mines in the State.

Missouri.—All mines in the State.

Oklahoma.—All mines in the following counties:

Coal	Latimer	Okmulgee	Rogers	Wagoner
Craig	Muskogee	Pittsburg	Tulsa	

DISTRICT 16.—NORTHERN COLORADO

All mines in the following counties in the State:

Adams	Douglas	Jackson	Larimer
Arapahoe	Elbert	Jefferson	Weld
Boulder	El Paso		

DISTRICT 17.—SOUTHERN COLORADO

Colorado.—All mines except those included in District 16.

New Mexico.—All mines except those included in District 18.

DISTRICT 18.—NEW MEXICO

New Mexico.—All mines in the following counties:

Grant	McKinley	Sandoval	San Miguel	Socorro
Lincoln	Rio Arriba	San Juan	Santa Fe	

Arizona.—All mines in the State.

California.—All mines in the State.

DISTRICT 19.—WYOMING

Wyoming.—All mines in the State.

Idaho.—All mines in the State.

DISTRICT 20.—UTAH.—All mines in the State.

DISTRICT 21.—NORTH DAKOTA-SOUTH DAKOTA.—All mines in North Dakota and South Dakota.

DISTRICT 22.—MONTANA.—All mines in the State.

DISTRICT 23.—WASHINGTON

Washington.—All mines in the State.

Oregon.—All mines in the State.

Alaska.—All mines in the State.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/

Consumption point 2/	Origin point 3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment 4/	Average Btu per pound	Cost, cents per ton-mile
010	13	128	4	500	1	13,386	1.20
010	13	128	4	500	1	13,386	1.08
010	13	128	4	500 5/	1	13,386	.88
010	13	128	4	---	1	13,386	.70
010	13	135	5	1,400	1	13,386	.92
010	13	135	6	1,700	1	13,386	.88
010	13	135	7	2,000	1	13,386	.84
010	13	68	2	475	1	13,386	1.56
010	13	68	3	760	1	13,386	1.34
010	13	68	3	855	1	13,386	1.31
010	13	68	3	950	1	13,386	1.27
040	18	109	- 5/	310	2	11,749	2.31
060	18	1,100	6	500	1	11,749	.72
060	18	1,100	-	700	1	11,749	.62
060	18	1,100	-	---	1	11,749	.52
060	19	1,373	6	700	1	10,860	.40
060	19	1,349	6	---	1	10,860	.43
080	17	110	-	75	1	NA	1.82
080	17	214	-	1,250	1	NA	.93
080	19	241	10	---	1	10,860	1.34
080	17	22	-	---	1	NA	4.50
080	19	241	-	---	1	10,860	1.10
080	17	16	-	---	1	NA	3.43
090	1	351	7	---	1	13,612	1.13
090	2	502	7	---	1	13,336	.87
090	3	613	7	---	1	13,496	.74
090	1	471	7	---	1	13,612	1.18
090	2	645	7	---	1	13,336	.91
090	3	756	7	---	1	13,496	.83
090	1	351	7	---	1	13,612	1.16
090	1	430	7	---	1	13,612	1.14
090	2	604	7	---	1	13,336	.86
090	3	715	7	---	1	13,496	.75
090	1	501	7	---	1	13,612	.81
090	2	608	7	---	1	13,336	.73
090	1	471	7	---	1	13,612	.86
090	2	645	-	---	1	13,336	.68
100	1	277	7	---	1	13,612	1.58
100	2	413	7	---	1	13,336	1.14
100	3	525	7	---	1	13,496	.93
100	1	352	7	---	1	13,612	1.31
100	2	473	7	---	1	13,336	1.04
100	1	322	7	---	1	13,612	1.43
100	2	457	7	---	1	13,336	1.07
110	7	350	5	---	1	14,040	1.91
110	7	265	-	500	1	14,040	2.09
110	3	187	7	---	1	13,496	2.06
110	3	479	7	---	1	13,496	.97
110	8	316	7	---	1	13,663	1.70
110	1	295	7	---	1	13,612	1.48
110	2	368	7	---	1	13,336	1.27

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point 2/	Origin point 3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment 4/	Average Btu per pound	Cost, cents per ton-mile
130	8	350	-	150	1	13,663	1.13
130	8	400	3	475	1	13,663	.97
130	8	450	7	1,400	2	13,663	.60
130	8	475	3	525	1	13,663	.93
130	9	450	-	450	1	12,285	.86
130	9	370	7	1,300	2	12,285	.50
130	13	500	5	1,000	2	13,386	.63
130	13	500	10	1,400	2	13,386	.63
130	8	500	7	1,400	2	13,663	.63
130	8	280	5	---	1	13,663	1.18
130	9	432	7	---	1	12,285	1.01
130	8	385	5	1,500	1	13,663	.93
130	8	442	5	500	2	13,663	.48
130	8	442	10	1,400	2	13,663	.46
130	8	367	7	1,400	1	13,663	.56
130	8	665	3	525	1	13,663	.67
130	8	458	-	225	1	13,663	1.00
130	13	312	10	---	1	13,386	.75
130	13	275	7	---	1	13,386	1.24
130	8	604	7	---	1	13,663	1.08
170	10	42	-	1,260	1	11,400	2.64
170	10	44	-	1,260	1	11,400	2.36
170	10	60	-	300	1	11,400	1.71
170	10	300	10	1,000	1	11,400	.40
170	22	1,200	10	1,000	1	10,280	.58
170	10	238	5	1,000	1	11,400	.69
170	10	75	4	1,300	1	11,400	1.87
170	10	310	5	---	1	11,400	1.43
170	10	236	9	900	1	11,400	.82
170	10	341	10	1,600	2	11,400	.68
170	10	150	10	---	2	11,400	1.91
170	10	264	5	---	1	11,400	1.23
170	10	85	5	1,000	1	11,400	.86
170	10	61	5	1,000	1	11,400	1.72
170	10	61	5	1,300	1	11,400	1.66
170	10	308	7	3,300	1	11,400	.55
170	10	84	10	---	1	11,400	1.66
180	11	21	-	271	2	11,490	4.28
180	11	11	-	---	1	11,490	7.45
180	11	135	-	---	1	11,490	2.57
180	11	30	7	2,335	1	11,490	2.10
180	11	15	-	---	2	11,490	2.00
180	11	250	-	---	2	11,490	2.16
180	11	150	4	700	1	11,490	2.60
180	11	60	1	250	1	11,490	2.20
180	11	64	5	700	1	11,490	1.88
180	11	25	4	1,800	1	11,490	.54
180	11	360	6	400	1	11,490	.65
180	11	360	9	1,000	1	11,490	.56
180	11	70	5	700	1	11,490	2.67
180	11	22	10	2,500	1	11,490	1.82
180	11	22	10	2,000	1	11,490	2.14
180	11	22	6	1,000	1	11,490	2.68
180	11	100	5	700	1	11,490	1.78
180	11	170	-	---	1	11,490	2.08

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point 2/	Origin point 3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment 4/	Average Btu per pound	Cost, cents per ton-mile
180	10	215	10	1,500	1	11,400	1.31
180	10	215	10	1,500	1	11,400	1.37
180	10	215	10	1,500	1	11,400	1.15
180	11	24	-	---	1	11,490	3.67
180	11	38	1	---	1	11,490	4.05
180	11	38	3	500	1	11,490	2.74
180	11	38	3	748	1	11,490	2.40
180	11	38	6	1,300	1	11,490	2.32
180	11	38	7	1,500	1	11,490	2.26
180	11	38	7	2,000	1	11,490	2.13
180	11	38	7	2,250	1	11,490	2.08
190	10	35	-	---	1	11,400	7.60
190	10	35	-	100	1	11,400	6.57
190	10	35	-	---	1	11,400	7.30
190	12	272	-	---	1	NA	1.32
190	12	380	-	---	1	NA	1.51
190	12	150	-	---	1	NA	2.20
190	12	323	-	---	1	NA	1.65
190	10	83	2	400	1	11,400	1.30
190	10	83	2	500	1	11,400	1.28
190	10	83	2	600	1	11,400	1.25
190	10	59	3	300	1	11,400	2.78
200	14	218	6	---	1	12,293	.58
200	14	218	6	---	1	12,293	.85
211	8	110	-	100	1	13,663	1.38
211	8	70	-	---	1	13,663	2.07
211	10	80	8	2,000	1	11,400	.96
211	10	84	-	400	1	11,400	1.09
211	9	88	-	750	1	12,285	1.32
211	8	49	5	---	1	13,663	1.96
240	2	334	7	---	1	13,336	1.36
240	3	445	7	---	1	13,496	1.06
240	1	259	7	---	1	13,612	1.56
240	2	352	7	---	1	13,336	1.24
240	3	462	7	---	1	13,496	.99
240	1	253	7	---	1	13,612	1.73
240	2	346	7	---	1	13,336	1.36
240	3	457	7	---	1	13,496	1.07
240	1	366	7	---	1	13,612	1.26
240	2	461	7	---	1	13,336	1.06
240	1	240	7	---	1	13,612	1.69
240	2	323	7	---	1	13,336	1.35
240	3	434	7	---	1	13,496	1.05
240	1	323	7	---	1	13,612	1.02
240	2	416	7	---	1	13,336	1.16
240	2	333	7	---	1	13,336	1.27
240	3	444	7	---	1	13,496	.99
240	2	418	7	---	1	13,336	1.12
240	3	529	7	---	1	13,496	.92
240	1	326	7	---	1	13,612	1.37
240	2	419	7	---	1	13,336	1.15
240	3	225	7	---	1	13,496	1.99

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point2/	Origin point3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment4/	Average Btu per pound	Cost, cents per ton-mile
240	3	235	7	---	1	13,496	1.91
240	3	300	7	450	1	13,496	4.69
240	3	288	7	---	1	13,496	1.60
240	1	323	7	---	1	13,612	1.39
240	3	300	-	---	1	13,496	1.39
250	1	351	7	---	1	13,612	1.16
250	2	502	7	---	1	13,336	.87
250	3	613	7	---	1	13,496	.74
250	1	522	7	---	1	13,612	1.12
250	2	659	7	---	1	13,336	.93
250	3	770	7	---	1	13,496	.87
250	1	551	7	---	1	13,612	1.08
250	2	701	7	---	1	13,336	.89
250	3	812	7	---	1	13,496	.79
250	1	345	7	---	1	13,612	1.16
250	2	482	7	---	1	13,336	.89
250	3	593	7	---	1	13,496	.76
250	1	510	7	---	1	13,612	1.14
250	2	656	7	---	1	13,336	.93
250	3	767	7	---	1	13,496	.82
250	3	767	7	---	1	13,496	1.06
260	4	215	6	800	1	12,234	1.64
260	4	357	10	1,000	1	12,234	.81
260	4	336	10	1,000	1	12,234	.86
260	4	336	10	1,000	1	12,234	1.01
260	7	412	10	1,000	1	14,040	.88
260	4	215	6	400	1	12,234	1.57
260	2	351	6	400	1	13,336	1.08
260	8	342	6	400	1	13,663	1.15
260	4	424	6	400	1	12,234	.93
260	4	430	10	1,200	1	12,234	.81
260	4	445	10	1,200	1	12,234	.78
260	4	438	10	1,200	1	12,234	.79
260	4	348	10	4,000	1	12,234	1.05
260	1	400	10	4,000	2	13,612	1.06
260	1	400	10	4,000	1	13,612	1.17
260	4	252	9	---	1	12,234	1.15
260	4	315	9	---	1	12,234	.70
260	4	306	9	---	1	12,234	.73
260	4	323	9	---	1	12,234	.69
260	4	330	9	---	1	12,234	.67
260	4	331	9	---	1	12,234	.67
260	1	326	9	---	1	13,612	.99
260	7	395	9	---	1	14,040	.74
260	7	396	9	---	1	14,040	.75
260	7	393	9	---	1	14,040	.75
260	4	315	9	---	1	12,234	.88
260	4	306	9	---	1	12,234	.90
260	4	323	9	---	1	12,234	.85
260	4	330	9	---	1	12,234	.84
260	4	331	9	---	1	12,234	.83
260	1	326	9	---	1	13,612	1.16
260	7	395	9	---	1	14,040	.87

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point2/	Origin point3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment4/	Average Btu per pound	Cost, cents per ton-mile
260	7	396	9	---	1	14,040	.87
260	7	393	9	---	1	14,040	.88
260	4	315	9	---	1	12,234	.92
260	4	306	9	---	1	12,234	.95
260	4	323	9	---	1	12,234	.90
260	4	330	9	---	1	12,234	.88
260	4	331	9	---	1	12,234	.88
260	7	360	17	---	2	14,040	.49
260	7	361	17	---	2	14,040	.49
260	7	358	17	---	2	14,040	.49
260	4	215	6	11,000	1	12,234	1.85
260	2	351	6	11,000	1	13,336	1.26
260	8	342	6	11,000	1	13,663	1.34
260	8	424	6	11,000	1	13,663	1.08
260	4	348	7	11,000	1	12,234	1.56
260	4	274	7	11,000	1	12,234	1.83
260	4	451	7	11,000	1	12,234	1.43
260	4	279	7	11,000	1	12,234	1.95
260	4	239	7	11,000	1	12,234	1.93
260	4	266	7	11,000	1	12,234	1.88
260	4	233	7	11,000	1	12,234	2.15
260	4	231	7	11,000	1	12,234	2.17
260	4	215	6	11,000	1	12,234	1.65
260	2	351	6	11,000	1	13,336	1.14
260	8	342	6	11,000	1	13,663	1.22
260	8	424	6	11,000	1	13,663	.98
260	4	215	6	11,000	1	12,234	1.76
260	2	351	6	11,000	1	13,336	1.20
260	8	342	6	11,000	1	13,663	1.28
260	8	424	6	11,000	1	13,663	1.03
260	8	110	10	4,000	1	13,663	1.82
260	2	290	10	4,000	1	13,336	.83
260	2	110	10	4,000	1	13,336	2.05
260	2	290	10	4,000	1	13,336	.93
260	2	160	10	4,000	1	13,336	1.51
260	2	220	10	4,000	1	13,336	1.13
260	2	341	10	4,000	1	13,336	.83
260	2	244	10	2,500	1	13,336	1.10
260	2	351	10	2,500	1	13,336	.86
260	4	287	8	---	1	12,234	.77
260	4	281	8	---	1	12,234	.79
260	4	339	8	---	1	12,234	.65
260	4	346	8	---	1	12,234	.64
260	4	347	8	---	1	12,234	.64
260	4	287	8	---	1	12,234	.96
260	4	281	8	---	1	12,234	.98
260	4	339	8	---	1	12,234	.81
260	4	346	8	---	1	12,234	.80
260	4	347	8	---	1	12,234	.80
260	4	287	9	---	1	12,234	1.01
260	4	281	9	---	1	12,234	1.04
260	4	339	9	---	1	12,234	.86
260	4	346	9	---	1	12,234	.84
260	4	405	10	---	2	12,234	.86
260	4	422	10	---	2	12,234	.82

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point2/	Origin point3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment4/	Average Btu per pound	Cost, cents per ton-mile
260	4	429	10	---	2	12,234	.81
260	4	430	10	---	2	12,234	.81
260	4	405	10	---	1	12,234	.99
260	4	422	10	---	1	12,234	.95
260	4	429	10	---	1	12,234	.93
260	4	430	10	---	1	12,234	.93
260	4	373	6	900	1	12,234	1.45
260	2	509	6	900	1	13,336	1.19
260	8	500	6	900	1	13,663	1.21
260	4	582	6	900	1	12,234	1.04
260	8	800	-	---	1	13,663	.68
260	8	800	-	---	1	13,663	.70
260	8	800	-	---	1	13,663	.85
260	4	350	5	550	1	12,234	1.21
260	5	350	6	---	1	NA	1.45
260	5	350	6	---	1	NA	1.42
260	5	350	6	---	1	NA	1.41
260	5	320	6	---	1	NA	1.46
260	5	350	6	---	1	NA	1.47
260	5	350	6	---	1	NA	1.44
260	5	350	6	---	1	NA	1.46
260	2	560	6	---	1	13,336	.68
260	3	575	6	---	1	13,496	.64
260	3	412	9	---	2	13,496	.68
260	4	320	8	---	2	12,234	.83
260	4	575	6	---	1	12,234	.63
260	5	320	9	---	2	NA	.88
260	4	310	9	---	1	12,234	.93
260	4	274	7	---	1	12,234	1.64
260	4	252	10	---	1	12,234	.94
260	4	295	9	---	1	12,234	.98
260	4	315	9	---	1	12,234	.71
260	4	231	9	---	1	12,234	.96
260	4	272	10	---	1	12,234	.87
260	4	357	10	1,000	1	12,234	1.05
260	7	412	7	1,000	1	14,040	.88
260	4	376	10	1,000	1	12,234	.80
260	4	336	10	1,000	1	12,234	.85
260	4	268	10	---	1	12,234	.83
260	4	244	10	---	1	12,234	1.39
260	4	428	-	---	1	12,234	.91
260	4	329	6	900	1	12,234	1.58
260	7	371	7	---	1	14,040	.48
260	4	244	7	10,000	1	12,234	1.55
260	4	233	-	---	1	12,234	1.92
260	4	306	8	---	1	12,234	.72
260	4	272	10	---	1	12,234	.87
260	4	468	10	1,200	1	12,234	.74
260	4	400	10	1,200	1	12,234	.89
260	4	233	7	---	1	12,234	1.92
270	22	800	7	700	1	10,280	.52
270	22	789	10	400	1	10,280	.52
270	22	789	11	1,000	1	10,280	.45
270	22	789	11	1,500	1	10,280	.41
270	22	789	11	1,750	1	10,280	.39

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point2/	Origin point3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment4/	Average Btu per pound	Cost, cents per ton-mile
270	10	650	3	---	1	11,400	.72
270	10	727	6	150	1	11,400	.66
270	10	640	10	---	1	11,400	.72
270	22	802	7	300	1	10,280	.53
290	12	100	-	---	1	NA	2.28
290	22	218	6	---	1	10,280	.57
290	22	218	6	---	1	10,280	.83
290	22	218	6	300	1	10,280	.95
290	10	145	5	1,000	1	11,400	1.23
290	10	145	7	1,000	1	11,400	1.04
290	10	145	7	1,000	1	11,400	.91
290	10	145	7	2,000	1	11,400	.86
290	22	243	6	---	1	10,280	.70
290	22	128	7	1,500	1	10,280	.83
300	22	23	-	300	1	10,280	3.86
330	1	622	7	---	1	13,612	.99
330	2	754	7	---	1	13,336	.85
330	1	859	9	900	1	13,612	.55
330	1	859	9	900	1	13,612	.63
330	2	870	9	900	1	13,336	.54
340	1	344	7	---	1	13,612	1.36
340	3	591	7	---	1	13,496	.87
340	7	547	7	---	1	14,040	1.12
340	7	617	7	---	1	14,040	.99
340	1	346	7	---	1	13,612	1.36
340	2	480	7	---	1	13,336	1.04
340	3	595	7	---	1	13,496	.87
340	7	549	7	---	1	14,040	1.11
340	7	619	7	---	1	14,040	.99
340	1	302	7	---	1	13,612	1.50
340	2	401	7	---	1	13,336	1.21
340	3	539	7	---	1	13,496	.93
340	7	505	7	---	1	14,040	1.19
340	7	575	7	---	1	14,040	1.04
340	1	316	7	---	1	13,612	1.44
340	2	428	7	---	1	13,336	1.13
340	7	519	7	---	1	14,040	1.15
340	7	589	7	---	1	14,040	1.02
340	1	282	7	---	1	13,612	1.43
340	2	419	7	---	1	13,336	1.04
340	3	530	7	---	1	13,496	.86
340	1	345	7	---	1	13,612	1.25
340	2	482	7	---	1	13,336	.96
340	3	593	7	---	1	13,496	.81
340	1	335	7	---	1	13,612	1.36
340	2	442	7	---	1	13,336	1.10
340	7	628	7	---	1	14,040	.96
340	7	604	7	---	1	14,040	1.04
340	1	356	7	---	1	13,612	1.36
340	2	541	7	---	1	13,336	.95
340	3	652	7	---	1	13,496	.81
340	3	300	2	25	1	13,496	3.00
340	7	440	7	---	1	14,040	1.31
340	1	372	7	---	1	13,612	1.24
340	7	582	7	---	1	14,040	1.01
340	7	582	7	---	1	14,040	1.06

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point 2/	Origin point 3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment 4/	Average Btu per pound	Cost, cents per ton-mile
340	8	448	7	---	1	13,663	1.34
340	8	520	7	---	1	13,663	1.09
340	1	280	7	---	1	13,612	1.60
340	7	378	7	---	1	14,040	1.50
360	1	425	7	---	1	13,612	1.17
360	3	688	7	---	1	13,496	.79
360	1	550	7	---	1	13,612	.91
360	2	651	7	---	1	13,336	.81
360	3	762	7	---	1	13,496	.72
360	1	345	7	---	1	13,612	1.25
360	2	482	7	---	1	13,336	.96
360	3	593	7	---	1	13,496	.81
360	7	604	7	---	1	14,040	1.04
360	1	397	7	---	1	13,612	1.22
360	2	500	7	---	1	13,336	1.02
360	3	611	7	---	1	13,496	.87
360	1	395	7	---	1	13,612	1.26
360	2	528	7	---	1	13,336	1.00
360	3	639	7	---	1	13,496	.85
360	1	425	7	---	1	13,612	1.26
360	2	659	7	---	1	13,336	.86
360	3	770	7	---	1	13,496	.76
360	1	386	7	---	1	13,612	1.29
360	2	538	7	---	1	13,336	.98
360	3	649	7	---	1	13,496	.84
360	1	434	7	---	1	13,612	1.24
360	2	567	7	---	1	13,336	.99
360	3	678	7	---	1	13,496	.86
360	1	480	7	---	1	13,612	1.19
360	2	613	7	---	1	13,336	.97
360	3	724	7	---	1	13,496	.85
360	1	506	7	---	1	13,612	.99
360	2	607	7	---	1	13,336	.87
360	3	719	7	---	1	13,496	.76
360	1	481	7	---	1	13,612	.91
360	2	608	7	---	1	13,336	.77
360	3	719	7	---	1	13,496	.68
360	1	261	7	---	1	13,612	1.75
360	2	391	7	---	1	13,336	1.24
360	3	502	7	---	1	13,496	1.00
360	1	360	7	---	1	13,612	1.27
360	2	446	7	---	1	13,336	1.09
360	3	557	7	---	1	13,496	.90
360	1	408	7	---	1	13,612	1.22
360	2	543	7	---	1	13,336	.97
360	3	654	7	---	1	13,496	.83
360	2	300	7	---	1	13,336	1.37
360	2	393	7	---	1	13,336	1.09
360	1	305	7	---	1	13,612	1.34
360	1	209	7	---	1	13,612	1.86
360	2	178	6	---	1	13,336	1.74
360	2	147	7	---	1	13,336	2.37
360	2	229	7	---	1	13,336	1.62
360	2	335	7	---	1	13,336	1.21
360	2	477	7	500	1	13,336	.92
360	1	340	7	---	1	13,612	1.39

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point 2/	Origin point 3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment 4/	Average Btu per pound	Cost, cents per ton-mile
360	2	505	7	---	1	13,336	.99
360	3	748	7	---	1	13,496	.69
360	1	575	7	---	1	13,612	.87
360	2	676	7	---	1	13,336	.78
360	3	787	7	---	1	13,496	.69
360	2	376	7	---	1	13,336	1.14
360	2	434	7	---	1	13,336	1.03
360	1	313	7	---	1	13,612	1.37
360	1	266	7	---	1	13,612	1.54
360	1	312	7	---	1	13,612	1.46
360	2	426	7	---	1	13,336	1.14
360	3	537	7	---	1	13,496	.94
360	1	483	7	---	1	13,612	1.03
360	2	594	7	---	1	13,336	.89
360	3	705	7	---	1	13,496	.77
360	1	351	7	---	1	13,612	1.14
360	2	502	7	---	1	13,336	.86
360	3	613	7	---	1	13,496	.73
360	1	405	-	---	1	13,612	1.14
360	8	700	-	---	1	13,663	.90
360	1	400	-	---	1	13,612	1.16
360	3	600	-	---	1	13,496	.83
360	1	340	-	---	1	13,612	1.70
360	3	253	-	---	1	13,496	1.73
360	1	242	-	---	1	13,612	1.88
360	3	654	7	---	1	13,496	.83
360	8	532	10	---	1	13,663	.98
360	1	224	7	---	1	13,612	1.85
360	1	90	7	---	1	13,612	3.82
360	1	425	7	---	1	13,612	1.26
360	2	659	7	---	1	13,336	.86
360	3	770	7	---	1	13,496	.76
360	3	649	7	---	1	13,496	.84
360	1	451	7	500	1	13,612	.96
360	2	376	7	---	1	13,336	1.06
360	2	434	7	---	1	13,336	1.04
360	1	313	7	---	1	13,612	1.27
360	1	395	7	---	1	13,612	1.27
360	2	528	7	---	1	13,336	1.00
360	1	300	7	---	1	13,612	1.44
360	1	397	7	---	1	13,612	1.06
370	8	375	-	---	1	13,663	1.23
370	8	350	6	1,100	1	13,663	.86
370	8	350	9	1,540	1	13,663	.86
370	8	350	5	2,000	1	13,663	.86
370	8	265	5	2,500	1	13,663	1.55
370	8	265	-	1,000	1	13,663	1.55
370	8	235	-	350	1	13,663	1.03
370	8	350	9	1,540	1	13,663	1.13
370	8	275	-	---	1	13,663	1.59
370	8	312	6	1,100	1	13,663	.94
370	8	312	9	1,500	1	13,663	.90
370	8	312	10	1,750	1	13,663	.87
370	8	184	7	1,250	1	13,663	1.64
370	8	217	-	100	1	13,663	1.85
370	8	217	-	350	1	13,663	1.18

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point 2/	Origin point 3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment 4/	Average Btu per pound	Cost, cents per ton-mile
370	8	282	6	1,100	1	13,663	.80
370	8	282	9	1,500	1	13,663	.73
370	8	282	10	1,750	1	13,663	.71
370	8	313	5	1,200	1	13,663	1.00
370	8	313	9	1,200	1	13,663	.90
370	8	289	5	1,600	1	13,663	1.18
370	8	289	5	2,500	1	13,663	1.15
370	8	252	7	---	1	13,663	1.10
370	8	308	5	1,600	1	13,663	.96
370	8	308	5	2,500	1	13,663	.92
380	21	64	-	450	1	NA	1.50
390	4	93	10	2,500	1	12,234	2.02
390	4	138	10	---	1	12,234	1.49
390	4	143	8	---	2	12,234	1.50
390	4	165	8	---	2	12,234	1.58
390	4	101	8	---	2	12,234	2.05
390	4	145	8	---	2	12,234	1.68
390	4	159	8	---	2	12,234	1.53
390	4	134	8	---	2	12,234	1.82
390	4	158	8	---	2	12,234	1.54
390	4	120	8	---	2	12,234	2.03
390	4	156	8	---	2	12,234	1.56
390	4	22	3	600	1	12,234	4.45
390	4	35	3	---	1	12,234	2.80
390	4	43	3	---	1	12,234	2.28
390	4	36	3	---	1	12,234	2.72
390	4	24	3	---	1	12,234	4.08
390	4	196	10	720	1	12,234	1.34
390	4	330	10	480	1	12,234	1.26
390	4	240	-	---	1	12,234	1.68
390	4	270	10	720	1	12,234	.97
390	8	395	10	480	1	13,663	1.05
390	4	60	1	600	1	12,234	1.38
390	4	16	-	---	2	12,234	.75
390	4	60	-	---	1	12,234	1.93
390	8	408	-	---	1	13,663	1.25
390	8	325	-	---	1	13,663	1.46
390	4	155	10	2,500	1	12,234	1.21
390	4	143	8	---	2	12,234	1.50
390	4	250	-	850	1	12,234	1.90
390	4	125	-	---	1	12,234	2.82
390	4	262	-	---	1	12,234	1.81
390	4	133	7	---	1	12,234	2.52
390	6	56	-	---	1	12,762	.64
390	4	67	5	---	1	12,234	1.72
390	4	186	7	---	1	12,234	2.27
390	4	188	10	720	1	12,234	1.38
390	4	201	6	800	1	12,234	1.67
390	4	90	-	200	1	12,234	4.26
390	4	376	10	480	1	12,234	1.10
390	4	150	10	---	1	12,234	2.72
390	8	360	7	480	1	13,663	1.09
420	1	232	7	---	1	13,612	1.84
420	2	366	7	---	1	12,336	1.25
420	3	477	7	---	1	13,496	1.00

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point2/	Origin point3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment4/	Average Btu per pound	Cost, cents per ton-mile
420	1	259	7	---	1	13,612	1.76
420	2	399	7	---	1	13,336	1.22
420	3	510	7	---	1	13,496	.99
420	1	294	7	---	1	13,612	1.55
420	2	401	7	---	1	13,336	1.21
420	3	512	7	---	1	13,496	.99
420	1	263	7	---	1	13,612	1.73
420	2	390	7	---	1	13,336	1:25
420	3	501	7	---	1	13,496	1.01
420	1	207	7	---	1	13,612	1.92
420	2	315	7	---	1	13,336	1.39
420	3	426	7	---	1	13,496	1.07
420	1	275	7	---	1	13,612	1.66
420	2	421	7	---	1	13,336	1.15
420	1	267	7	---	1	13,612	1.71
420	1	272	7	---	1	13,612	1.68
420	2	417	7	---	1	13,336	1.17
420	3	528	7	---	1	13,496	.95
420	1	278	7	---	1	12,612	1.64
420	2	432	7	---	1	13,336	1.13
420	3	543	7	---	1	13,496	.93
420	1	222	7	---	1	13,612	1.92
420	2	360	7	---	1	13,336	1.27
420	3	470	7	---	1	13,496	1.02
420	2	356	10	---	2	13,336	.85
420	1	351	10	---	2	13,612	.86
420	1	321	10	---	2	13,512	.94
420	1	354	10	---	2	13,612	.85
420	1	361	10	---	2	13,612	.88
420	1	377	10	---	2	13,612	.84
420	1	364	10	---	2	13,612	.97
420	2	395	10	---	2	13,336	.90
420	2	356	10	---	1	13,336	1.16
420	1	351	10	---	1	13,612	1.17
420	1	321	10	---	1	13,612	1.28
420	1	361	10	---	1	13,612	1.14
420	1	377	10	---	1	13,612	1.09
420	1	364	10	---	1	13,612	1.13
420	2	395	10	---	1	13,336	1.04
420	1	354	10	---	1	13,612	1.16
420	1	286	7	---	1	13,612	1.59
420	3	548	7	---	1	13,496	.92
420	1	141	7	---	2	13,612	1.77
420	1	128	7	---	2	13,612	1.95
420	1	159	7	---	2	13,612	1.57
420	2	167	7	---	2	13,336	1.65
420	1	162	7	---	2	13,612	1.70
420	1	160	7	---	2	13,612	1.73
420	1	172	7	---	2	13,612	1.60
420	1	130	7	---	1	13,612	2.07
420	1	157	7	---	1	13,612	1.92
420	1	190	10	---	2	13,612	1.21
420	1	190	13	---	2	13,612	.89
420	2	187	10	1,800	2	13,336	1.08
420	1	182	10	1,800	2	13,612	1.11
420	1	190	10	1,800	2	13,612	1.06
420	1	152	10	1,800	2	13,612	1.33
420	1	175	10	1,800	2	13,612	1.23
420	1	208	10	1,800	2	13,612	1.03

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point2/	Origin point3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment4/	Average Btu per pound	Cost, cents per ton-mile
420	1	187	10	1,800	2	13,612	1.29
420	2	218	10	1,800	2	13,336	1.18
420	1	197	10	1,800	2	13,612	1.03
420	2	187	10	1,000	2	13,336	1.18
420	1	182	10	1,000	2	13,612	1.21
420	1	190	10	1,000	2	13,612	1.16
420	1	152	10	1,000	2	13,612	1.45
420	1	175	10	1,000	2	13,612	1.35
420	1	208	10	1,000	2	13,612	1.13
420	1	187	10	1,000	2	13,612	1.40
420	2	218	10	1,000	2	13,336	1.27
420	1	197	10	1,000	2	13,612	1.12
420	2	187	10	---	1	13,336	1.94
420	1	182	10	---	1	13,612	1.99
420	1	190	10	---	1	13,612	1.91
420	1	152	10	---	1	13,612	2.39
420	1	175	10	---	1	13,612	2.07
420	1	208	10	---	1	13,612	1.75
420	2	218	10	---	1	13,336	1.67
420	1	197	10	---	1	13,612	1.84
420	1	197	10	2	1	13,612	1.66
420	1	213	10	2	1	13,612	1.54
420	1	295	10	---	1	13,612	1.22
420	2	299	7	---	1	13,336	1.46
420	1	267	7	---	1	13,612	1.71
420	2	421	7	---	1	13,336	1.15
420	3	532	7	---	1	13,496	.95
420	1	263	7	---	1	13,612	1.66
420	2	400	7	---	1	13,336	1.17
420	3	511	7	---	1	13,496	.95
420	1	255	7	---	1	13,612	1.67
420	2	392	7	---	1	13,336	1.17
420	1	276	7	---	1	13,612	1.58
420	2	417	7	---	1	13,336	1.12
420	3	528	7	---	1	13,496	.92
420	1	282	7	---	1	13,612	1.41
420	2	419	7	---	1	13,336	1.04
420	3	530	7	---	1	13,496	.86
420	1	275	7	---	1	13,612	1.66
420	2	403	7	---	1	13,336	1.21
420	3	514	7	---	1	13,496	.95
420	1	258	7	---	1	13,612	1.77
420	2	398	7	---	1	13,336	1.22
420	3	509	7	---	1	13,496	.99
420	2	80	-	175	1	13,336	3.60
420	2	226	-	600	2	13,336	1.55
420	1	45	-	---	1	13,612	4.60
420	3	468	-	50	1	13,496	1.02
420	1	198	-	---	2	13,612	.97
420	1	145	1	300	1	13,612	2.28
420	2	12	-	---	1	13,336	7.50
420	3	292	7	---	1	13,496	1.54
420	3	362	7	---	1	13,496	1.27
420	2	88	-	---	1	13,336	3.14
420	2	339	10	---	1	13,336	.88

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point 2/	Origin point 3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment 4/	Average Btu per pound	Cost, cents per ton-mile
420	1	137	7	---	1	13,612	1.80
420	1	107	7	---	1	13,612	2.04
420	1	294	7	---	1	13,612	.12
420	2	139	10	1,800	1	13,336	1.60
420	2	139	10	---	1	13,336	1.43
420	1	186	7	---	1	13,612	2.18
426	2	150	5	4,000	1	13,336	1.46
426	2	178	5	4,000	1	13,336	1.43
426	2	178	5	4,000	1	13,336	1.55
426	2	300	5	4,000	1	13,336	1.01
426	4	170	5	---	1	12,234	1.59
426	2	178	6	4,000	1	13,336	1.55
426	2	239	6	4,000	1	13,336	1.20
426	2	300	6	4,000	1	13,336	1.01
426	4	160	5	---	1	12,234	1.61
440	1	345	7	---	1	13,612	1.16
440	2	482	7	---	1	13,336	.89
440	3	593	7	---	1	13,496	.76
450	8	583	-	225	1	13,663	.87
450	7	462	5	640	1	14,040	.90
450	8	575	5	2,000	1	13,663	.71
450	8	531	5	2,000	1	13,663	.63
450	8	683	5	2,000	1	13,663	.57
450	8	375	-	1,000	1	13,663	1.15
450	8	423	5	2,000	1	13,663	.97
450	8	379	5	2,000	1	13,663	.88
450	8	578	5	2,000	1	13,663	.66
450	8	454	5	2,000	1	13,663	.90
450	8	410	5	2,000	1	13,663	.81
450	8	562	5	2,000	1	13,663	.68
450	8	453	5	2,000	1	13,663	.90
450	8	450	5	2,000	1	13,663	.74
450	8	602	5	2,000	1	13,663	.64
450	8	396	7	---	1	13,663	1.32
450	8	516	5	1,500	1	13,663	.73
450	8	592	-	---	1	13,663	.88
450	8	532	7	---	1	13,663	.92
450	8	320	5	---	1	13,663	1.38
450	8	269	5	750	1	13,663	1.34
460	21	147	-	---	1	NA	1.95
470	9	272	6	1,000	1	12,285	.49
470	9	111	5	2,000	1	12,285	1.07
470	9	94	-	2,000	1	12,285	1.42
470	11	288	-	---	1	11,490	.95
470	7	174	-	---	1	14,040	2.37
470	7	105	-	---	1	14,040	2.32
470	7	93	-	---	1	14,040	1.66
470	11	454	-	---	1	11,490	1.11
470	9	179	-	---	1	12,285	1.00
470	8	320	5	1,000	1	13,663	.80
470	8	115	-	---	1	13,663	1.50
470	8	76	-	750	1	13,663	1.65
470	8	36	-	2,500	1	13,663	2.05

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point 2/	Origin point 3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment 4/	Average Btu per pound	Cost, cents per ton-mile
490	16	351	3	1,300	1	9,431	.88
490	20	128	3	1,300	1	12,610	1.52
490	16	360	3	350	1	9,431	.77
500	1	547	7	---	1	13,612	1.14
500	2	682	7	---	1	13,336	.98
500	3	793	7	---	1	13,496	.91
510	8	15	-	---	1	13,663	2.93
510	7	82	-	800	1	14,040	2.33
510	8	252	7	---	1	13,663	2.01
510	7	278	5	2,800	1	14,040	1.48
510	8	256	7	---	1	13,663	1.53
510	8	256	7	---	1	13,663	1.66
510	7	274	7	---	1	14,040	1.21
510	7	136	7	---	1	14,040	1.31
510	7	358	7	---	1	14,040	1.30
540	8	50	6	1,800	1	13,663	2.62
540	8	15	-	---	1	13,663	5.66
550	10	300	7	250	1	11,400	1.40
550	10	450	-	70	1	11,400	1.10
550	11	325	-	75	1	11,490	.73
550	10	250	9	850	2	11,400	1.69
550	11	225	1	300	1	11,490	1.94
550	10	212	9	1,100	1	11,400	.96
550	10	212	9	1,500	1	11,400	.93
550	10	271	9	1,100	1	11,400	.80
550	10	271	9	1,500	1	11,400	.79
550	10	375	9	1,100	1	11,400	.62
550	10	375	9	1,500	1	11,400	.61
550	10	471	10	1,000	1	11,400	.59
550	9	627	10	1,000	1	12,285	.50
550	10	438	10	1,000	1	11,400	.64
550	10	327	9	850	1	11,400	.55
NA	8	342	6	11,000	1	NA	1.34
NA	8	424	6	11,000	1	NA	1.08
NA	8	424	6	11,000	1	NA	.98
NA	8	342	6	11,000	1	NA	1.28
NA	8	424	6	11,000	1	NA	1.03
NA	8	342	6	11,000	1	NA	1.22
NA	8	450	-	---	1	NA	1.32
NA	4	215	6	11,000	1	NA	1.85
NA	4	348	7	11,000	1	NA	1.56
NA	4	274	7	11,000	1	NA	1.83
NA	4	451	7	11,000	1	NA	1.43
NA	4	279	7	11,000	1	NA	1.95
NA	4	239	7	11,000	1	NA	1.93
NA	4	266	7	11,000	1	NA	1.88
NA	4	233	7	11,000	1	NA	2.15
NA	4	231	7	11,000	1	NA	2.17
NA	4	233	7	11,000	1	NA	2.15
NA	4	215	6	11,000	1	NA	1.65
NA	4	215	6	11,000	1	NA	1.76
NA	4	215	6	11,000	1	NA	1.76
NA	4	320	8	---	2	NA	.83
NA	4	346	9	---	1	NA	.84
NA	4	576	6	---	1	NA	.63
NA	1	547	7	---	1	NA	1.23
NA	1	253	7	---	1	NA	1.73
NA	1	351	7	---	1	NA	1.16

See footnotes at end of table.

TABLE A-3. - Transportation cost characteristics of bituminous coal shipped to selected consumers 1/ -- continued

Consumption point 2/	Origin point 3/ (coal district)	Shipping distance, miles	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment 4/	Average Btu per pound	Cost, cents per ton-mile
NA	3	793	7	---	1	NA	.86
NA	3	539	7	---	1	NA	.93
NA	3	575	6	---	1	NA	.64
NA	3	412	9	---	2	NA	.68
NA	3	613	7	---	1	NA	.74
NA	3	613	7	---	1	NA	.74
NA	2	560	6	---	1	NA	.68
NA	2	502	7	---	1	NA	.87
NA	2	502	7	---	1	NA	.87
NA	2	239	6	4,000	1	NA	1.20
NA	2	757	7	---	1	NA	.92
NA	2	88	-	---	1	NA	3.14
NA	2	351	6	11,000	1	NA	1.20
NA	2	351	6	11,000	1	NA	1.14
NA	2	351	6	11,000	1	NA	1.26
NA	2	682	7	---	1	NA	1.04
NA	2	346	7	---	1	NA	1.36
NA	2	437	7	---	1	NA	1.11

NA Not available.
1/ Electric utility company consumers represent the largest share of the data. Cement manufacturing consumers are also represented.
2/ For identification of consumption point code numbers, see Table A-1.
3/ Several means of collection of data were used in developing this table. Consequently, the point from which coal was shipped is listed by the location of the tipple, the freight rate district, or the coalfield. For identification of origin point code numbers, see Table A-2.
4/ Cars owned by railroad are indicated by a "1"; "2" indicates shipper-owned railroad cars.
5/ Unspecified.

APPENDIX B.--METHODOLOGY FOR TABLES 2, 6, 7, AND 8 AND BEST PRACTICE

Tables 2, 6, 7, and 8

The equation for the cost of low-sulfur coal at a specific consumption point in table 2 is as follows:

$$\frac{\text{Cost of coal/ton}}{\text{Btu content/ton}} + \frac{33.0 + 0.38\ (\text{distance})}{\text{Btu content/ton}} = \text{cost of coal at consumption point (cents/million Btu)}$$

The method used to derive the cost of low-sulfur coal at a specific consumption point in table 2 was as follows:

1. The price of coal f.o.b. mine for each district was ascertained from the Bureau of Mines Minerals Yearbook (1970) (16).

2. The price per ton of coal f.o.b. mine (table B-1) was divided by the average calorific value for the coal from each district to obtain the cost of coal f.o.b. mine per million Btu.

3. The distance from the mine to the projected consumption point was estimated from the Rand McNally Railroad Guide (10) and multiplied by the cost, cents per ton-mile, estimated from the best practice equation for >8,000-ton unit trains ($Y = 33.0 + 0.38X$, where Y represents cost, cents/ton and X represents distance, miles).

The equation for the cost of high-sulfur coal at a specific consumption point in table is as follows:

$$\frac{\text{Cost of coal/ton}}{\text{Btu content/ton}} + \frac{103.5 + 1.124\ (\text{distance}) - 0.00081\ (\text{distance})^2}{\text{Btu content/ton}}$$

$$= \text{cost of coal at consumption point (cents/million Btu)}$$

The method used to derive the cost of high-sulfur coal at a specific consumption point in table 2 was as follows:

1. Steps 1 and 2 as above for low-sulfur coal equation.

2. The distance used was the least-cost-available high-sulfur coal source. If distance was less than 300 miles the average practice ($Y = 103.5 + 1.124X - 0.00081X^2$) was used. For shipping distances greater than 300 miles, the best practice equation was employed ($Y = 33.0 + 0.38X$).

The method used to derive the cost of coal at a specific consumption point in tables 6 and 7 was as follows:

1. The price of coal f.o.b. mine for each district was ascertained from the Bureau of Mines Minerals Yearbook (1970) (16).

2. The price per ton of coal f.o.b. mine was divided by the average calorific value for the coal from each district to obtain the cost of coal f.o.b. mine per million Btu.

3. The distance from the mine to the projected consumption point was estimated from the Rand McNally Railroad Guide (10) and multiplied by the cost, cents per ton-mile, estimated from the best practice equation for >8,000-ton unit trains in figure 6.

4. The average cost for oil (transportation and production cost) at a specific location (consumption point) was obtained from Steam Electric Power Plant Factors (1971 edition) (8).

The general method to derive tanker costs, which was used in table 8, is as follows:

1. A flat rate (Worldscale 100) in cents per million Btu was obtained from figure 13 for the ports of New York, Boston, Norfolk, and New Orleans.

2. The best practice cost was obtained by determining the largest size tanker able to dock at the port in question (80,000 dwt for the ports mentioned in step 1) and reading the corresponding Worldscale rate (Fixture) from the break-even cost curve (fig. 11). This fixture was in turn multiplied by the flat rate to obtain the tanker transportation cost.

3. A normal profit, which was estimated to be 12 percent, was added on to the best practice cost for each port.

4. For the cities that required barge transportation, figure 15 was utilized to obtain the best practice cost.

5. The total best practice cost is the summation of steps 3 and 4.

The coal transportation costs for table 8 were calculated as follows:

1. The transportation cost (best practice) was delineated from the total cost for the least cost combination.

2. Total transportation cost per ton was then divided by the calorific value for the coal to determine the cost per 10^6 Btu for shipping coal.

Best Practice

The best practice equation in figure 5 was derived by

1. Estimating the position of a least squares linear line by visual observation for the most efficient transportation hauls for several different distances, and

2. Defining the slope and intercept of the linear line so that it could be expressed in a quantitative form.

TABLE B-1. - Number of mines, production, and value at bituminous coal and lignite mines in the United States, in 1970, by district (16)

District	Number of active mines	Average Btu per pound of coal	Total production, thousand short tons[1]	Average value per ton, 1970[2]
1. Eastern Pennsylvania.........	656	13,612	44,644	$6.67
2. Western Pennsylvania.........	229	13,336	40,446	7.72
3. Northern West Virginia.......	370	13,496	43,143	6.44
4. Ohio.........................	306	12,234	55,351	4.74
5. Michigan.....................	-	-	-	-
6. Panhandle....................	20	12,762	8,814	5.55
7. Southern Number 1............	469	14,040	39,027	10.09
8. Southern Number 2............	3,013	13,663	164,056	7.15
9. West Kentucky................	98	12,285	52,803	4.22
10. Illinois....................	59	11,400	65,119	4.92
11. Indiana.....................	38	11,490	22,263	4.60
12. Iowa........................	13	9,900	987	4.11
13. Southeastern................	177	13,368	22,262	7.78
14. Arkansas-Oklahoma...........	13	12,293	895	9.67
15. Southwestern................	20	12,615	7,874	4.75
16. Northern Colorado...........	3	9,431	581	4.82
17. Southern Colorado...........	46	11,875	6,382	5.90
18. New Mexico..................	4	11,749	6,559	2.50
19. Wyoming.....................	13	10,860	7,222	3.38
20. Utah........................	20	12,610	4,733	7.28
21. North Dakota-South Dakota....	20	6,837	5,639	1.95
22. Montana.....................	8	10,280	3,447	1.85
23. Washington..................	6	10,056	586	7.73
Total........................	5,601	-	602,932	6.26

[1]Data may not add to total shown because of independent rounding.
[2]Value received or charged for coal, f.o.b. mine. Includes a value, estimated by producer, for coal not sold.

APPENDIX C.--DEFINITIONS

Annual trainload tonnage - A term contract made by the shipper with the railroad guaranteeing that a specific amount of coal will be shipped in a 1-year period.

Average practice - A least squares calculated line of best fit for selected transportation cost data.

Best practice - The most efficient available method for the transportation of goods (11).

Break-even cost - A point at which marginal cost equals marginal revenue.

Economies of haul - Economies of haul are realized when the marginal cost to transport a unit of product a mile is less for progressively longer distances. Alternatively, diseconomies of haul result when the marginal cost per unit increases progressively with greater distance.

Fixture rate - The negotiable percentage variations of Worldscale rate.

Flat rate - The flat rates, Worldscale 100, are expressed in pounds sterling and dollars and the schedule is meant simply as a standard of reference, with a percentage variation added or subtracted in order to find out the actual rate applicable in each fixture. The rates are jointly set and revised January 1 each year by a New York-based and a London-based shipbroker association. It is not intended to indicate either a normal level of rates or the freights actually agreed. These are determined solely by the owners or charterers. Calculation of the flat rate (Worldscale 100) is based on a long-ton shipped on a round trip voyage from loading port to discharge port and back to the first loading port. The flat rate also includes all hauling and terminal costs for a standard vessel.

High-sulfur coal - Bituminous coal and lignite with a sulfur content above 2 volume-percent.

Long run - The variations of price rates which occur when the period of time is long enough to allow all the factors affecting cost to be changed.

Low-sulfur coal - Bituminous coal and lignite with a sulfur content below 1 volume-percent.

Lower envelope - An estimated line of best fit drawn through the most efficient hauls for selected distances.

Medium-sulfur coal - Bituminous coal and lignite with a sulfur content between 1 and 2 volume-percent.

Minimum trainload tonnage - A contract made by the shipper or consumer with the railroad guaranteeing a specified cargo size per trainload shipped.

Spot rate - "Spot" is a technical term and in common industrial usage means single voyage. Both single-voyage and long-term charter agreements may specify "immediate" delivery; the term "spot" has acquired a one-sided connotation, and unless it is qualified, implies current rate for a single voyage. It is also for this reason that the "short term" is defined as the time it takes a vessel to complete a round-trip voyage for a specified run. See reference 17 for further explanation.

Unit train - The unit train is a management technique that permits efficient planning through long-range contractural commitment of producer and consumer and dedication of the equipment. Specifically, a unit train consists of a dedicated set of haulage equipment loaded at one origin, unloaded at one destination each trip, and moving in both directions on a predetermined schedule.

The unit train combines three principal factors: Design efficiency, equipment balance, and intensive use. To achieve the lowest possible transportation cost, all elements of the operation must be in balance: The loading, hauling, and unloading facilities must be designed and scheduled for intensive use but not to a degree that would bring intolerable maintenance costs; and the haulage capacity must be in balance with supply, with the consumer's needs, and with amortization requirements. See reference 5 for further explanation.

APPENDIX D.--PETROLEUM ADMINISTRATION DISTRICTS

District I	District II	District III	District IV	District V
Florida	Illinois	Alabama	Colorado	Alaska
New York	Indiana	Arkansas	Montana	Arizona
Pennsylvania	Kentucky	Louisiana	Utah	California
Virginia	Michigan	Mississippi	Wyoming	Nevada
West Virginia	Missouri	New Mexico		
Massachusetts	Nebraska	Texas		
Rhode Island	Ohio			
Georgia	Oklahoma			
Maryland	South Dakota			
New Jersey	Tennessee			
Delaware	Kansas			
	Minnesota			
	Wisconsin			
	Iowa			
	North Dakota			

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