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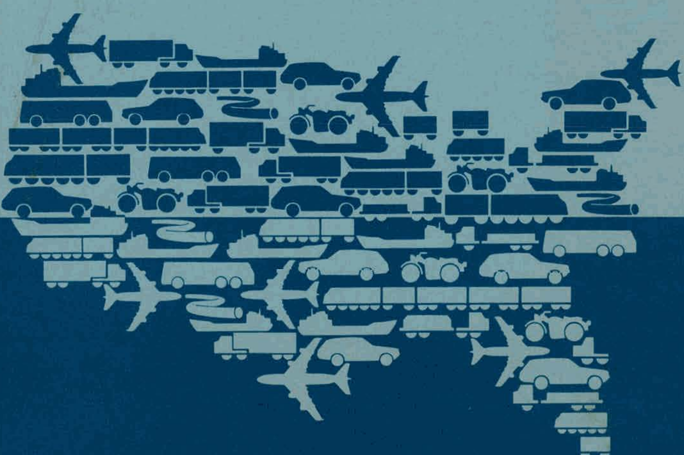

TRANSPORTATION ENERGY SYSTEMS

ENERGY & ENVIRONMENTAL SYSTEMS DIVISION

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Informal Report ANL/EES-TM-39

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DELIVERED COSTS OF WESTERN COAL SHIPPED ON THE GREAT LAKES VERSUS EASTERN COAL FOR EASTERN GREAT LAKES HINTERLAND UTILITY PLANTS

With Appendices on Relative Cost Impacts of Coal Scrubbing and on Other Western Coal Transport Systems

by

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TABLE OF CONTENTS

TABLES

FIGURE

EXECUTIVE SUMMARY

This report analyzes the present and projected delivered cost competitiveness of Great Lakes shipped, low sulfur Western coal with low and high sulfur Eastern coal at Eastern Great Lakes hinterland utility plants. Its findings are based upon detailed data acquired from appropriate transportation firms and four eastern utility companies which use or have studied using the appropriate coal types. Two appendices provide: 1) a tentative, preliminary analysis of this competition with additional costs required by likely EPA scrubbing (sulfur removal) requirements, and 2) background information on other Western coal transport systems.

Briefly, the findings of this report are that if Western coal is shipped via the Great Lakes to utility plants in the eastern Great Lakes hinterlands (i.e., inland from ports up to 200 miles):

1. Currently, based upon delivered costs only, it cannot compete with any type of Eastern coal.
2. By 1989, with favorable interim Western versus Eastern cost escalation rate advantages on minemouth coal and transportation costs, Western coal delivered costs can begin competing with those of Eastern low sulfur, but not high sulfur coal.
3. By 1999, with favorable relative cost escalation rate advantages, Western coal's delivered costs can become substantially less expensive than Eastern low sulfur coal's, and just begin to be competitive with Eastern high sulfur coal's.
4. Extremely high Eastern rail costs due to port area system characteristics are the main cost factor driving Western coal delivered costs to uneconomic levels.
5. With expected scrubbing required, Western coal is still not presently competitive with any Eastern coal. By 1989, probable differential scrubbing requirements (i.e., less scrubbing of very low sulfur coal) would only slightly enhance Western coal's competitiveness on a total cost basis for slight differences (e.g., Western 0.5 percent to Eastern 0.7 percent) in sulfur content. Differential scrubbing requirements plus high relative cost escalation rate advantages would enable Western coal to become competitive with Eastern high sulfur coal by the mid-1990's. Scrubbing will be required for new hinterland plants and may, through retrofitting, be required for existing plants.
6. If DOE's proposal for a higher allowable post-scrubbing sulfur content is accepted and Western coal has favorable relative cost escalation rates, it could compete with scrubbed Eastern low and high sulfur coal slightly before 1989.

DELIVERED COSTS OF WESTERN COAL SHIPPED ON THE GREAT LAKES VERSUS EASTERN COAL FOR EASTERN GREAT LAKES HINTERLAND UTILITY PLANTS

1 INTRODUCTION

This report has been prepared for the U.S. Maritime Administration (MARAD) for use in its planning efforts concerning Great Lakes shipping. The report estimates 1979, 1989 and 1999 delivered cost competitiveness of Western coal shipped via the Great Lakes versus Eastern coal for eastern Great Lakes hinterland* utility plants. Delivered costs to these plants are also compared with existing cost data on potential western coal movements to a planned Eastern Great Lakes lakeside plant. In addition, a sensitivity analysis of the impacts of differing cost escalation rates for both Western and Eastern minemouth coal and transportation costs on projected delivered costs is presented.

Three plants are considered. Two are located slightly over 100 miles inland in Dayton, Ohio and Dresden, New York, and one will be located on Lake Erie at Dunkirk, New York and begin operation in 1985. Western coal sources used were Decker Mines in Montana and Gillette, Wyoming. Eastern coal sources were those currently being used by the plants and were in Pikeville, Kentucky and Dixonville, Pennsylvania.

Empirical data was obtained for 1979 through personal communications with appropriate company officials. Projections were based upon probable ranges of Western versus Eastern coal escalation rates given their comparative coal mining and transport system characteristics. The report has two Appendices. Appendix A provides preliminary information on the probable cost impacts of anticipated, though still uncertain, U.S. Environmental Protection Agency coal scrubbing (sulfur removal) regulations. The information is based upon data received from Battelle Memorial Laboratories and an Argonne National Laboratory coal scrubbing cost analyst, and only portrays likely relative cost tendencies. More exact estimates would require an additional study. Appendix B consists of a few brief comments regarding alternative Western coal movement systems which are made to provide the reader with some perspective on the relative position of Great Lakes Western coal movement systems

*Hinterland plants are defined here as those located far enough inland (i.e, up to 200 miles) from ports so as to require intermodal transfer of coal arriving on ships to inland transport modes such as rail for movement inland.

with their Western competitors in this market. These competitors include coal unit trains, coal slurry pipelines, barges and intermodal combinations of these. As with Appendix A, this appendix is a preliminary overview.

2 METHOD AND DATA

2.1 ANALYSIS STRUCTURE

Present delivered coal costs were computed by breaking these costs down into their components, and obtaining the actual costs of current operations and estimated costs of potential operations.

Cost component breakdowns were the result of available levels of detail regarding these costs and the need to have components which, for forecasting purposes, could be or not be combined based upon whether they had the same cost escalation characteristics. Hinterland utility plants' current delivered costs from Eastern suppliers were obtained directly from purchasing officials of those utilities (New York State Electric and Gas Corporation,[1] and Dayton Power and Light Company[2]). Estimated component costs for delivered Western coal were developed through personal communications with purchasing cost analysts at the two Great Lakes utilities (Detroit Edison Company[3] and Niagara Mohawk Power Corporation)[4] most actively involved in these movements and/or analysis of them, plus appropriate transportation firm officials (American Steamship Company,[5] and CONRAIL[6]). The same procedure was followed for developing the lakeside plant's costs.[4] The essential details regarding each cost component on each coal routing studied are contained in the footnotes to Table 1. This information can be summarized and expanded as follows:

COST ITEM	DESCRIPTION
FOB Mine Coal	Also called "minemouth" coal; has been mined and transported a short distance via truck and/or conveyor to a railcar and loaded aboard it.
Rail - Western	All movements were by unit train from mine to Superior, Wisconsin transfer facility. It is important to note that these costs were provided by industry sources in terms of a cost range, with shipment consolidations required by small shippers to obtain the range's lower rates.
Transfer - Western Coal	Western transfer at Superior includes unloading railcars, conveyer movements, storage, and shiploading. Vice-versa for Eastern port transfers.
Lake Vessel	Super-freighter with capacity ranging from 40,000 to 70,000 tons.
Rail - Eastern	Western coal moves by unit train from port to hinterland plant. Eastern coal moves from minemouth to hinterland plant by unit train from Dixonville, PA and by conventional train from Pikeville, KY.

Because of this report's limited objective, only Western coal movement systems which use Great Lakes ships are analyzed. The report is designed to aid MARAD's Great Lakes shipping planning efforts by first acquiring a knowledge of whether Western coal, moved to Eastern Great Lakes hinterland utility plants via these lakes, can compete with current Eastern suppliers of these plants. Only if this is the case does competition with alternative Western coal movement systems to these plants become relevant. Appendix B does, however, provide some limited information on Great Lakes systems' relative position versus other Western coal transport systems.

Once present alternative system delivered coal costs and their component costs were identified, they were projected for 1989 and 1999 using current dollars escalated at assumed rates to conduct a sensitivity analysis. These rates and the assumptions upon which they are based are discussed next.

2.2 ASSUMPTIONS

Several assumptions guided the selection of the range of projected cost escalation rates for each component of delivered coal cost to the Eastern Great Lakes hinterland utilities. These assumptions describe a complex combination of interactions which will probably work both in favor of and against Western coal. Factors which will probably work in favor of the movement of Western coal in the long run are:

1. In general, the minemouth cost of Eastern coal is expected to escalate more rapidly than that of Western coal because of the mineworker unions in the East and the predominance of deep mining in the East, which are more expensive than the nonunion strip mining dominant in Western operations.

2. In general, Eastern rail rates are expected to increase more rapidly than Western rail rates because of the greater financial difficulties of the Eastern railroads.

However, the following factors explain why this apparent advantage will probably be somewhat reduced and perhaps significantly reduced. These counteracting factors are:

1. Western coal, and particularly Western rail rates, are also increasing and will no doubt continue in the future. These increases will probably not allow high Eastern cost escalation rates to be a major advantage for Western coal.

2. An important component (i.e., about one-fourth, see Table 1)* of Western delivered coal costs to Eastern hinterland utility plants is that of the rail movement from the Eastern Great Lakes port to the plants. As Eastern rail rates escalate, so will the cost of this Western system component, which will dilute the relative Western transport cost escalation rate advantage.

Differing cost escalation rates were assigned in Tables 6, 7 and 8 in order to perform a sensitivity analysis which establishes three separate cases of the amount of dilution of delivered Western coal's cost escalation rate advantage over the next 20 years. These dilution cases are labeled as minimum, medium and maximum. The word "dilution" is generally used in financial analyses to describe instances of reductions of a benefit, advantage or value. For instance, dilution of stockholder equity is used to describe a situation where additional shares of a corporation's stock are sold, even though funds from the new stock may generate increased corporate earnings, because total earnings will be divided among more shares. Similarly, the Eastern rail cost component in the Western transport system will dilute Western coal's cost escalation rate advantage to at least a minimum extent, as explained in the second counteracting factor above. In addition, if Western rail rates escalate more than expected, and/or Eastern rail rates escalate less than expected, this advantage will be further reduced, or diluted. This is what is assumed in the medium and maximum dilution cases.

The specific cost escalation rates assigned for the three dilution cases through 1989 and 1999 to the current costs in Tables 6, 7 and 8 are:

	Escalation Percentage Rates		
Cost Component/Group	Table 6 (Minimum Dilution Case)	Table 7 (Medium Dilution Case)	Table 8 (Maximum Dilution Case)
Western Coal	6	6	6
Eastern Coal	8-10	8-10	8-10
Western Transportation:			
Rail-Western; Transfer (Rail to Ship) - Western; Great Lakes Vessel; Transfer (Ship to Rail) - Eastern	5	6	6
Eastern Rail	9	9	8

*All tables are in the next section, where they are described.

Note that the minimum, medium and maximum dilution cases have 4, 3 and 2 percent differences between Western and Eastern transport costs, respectively. Also note that the same low escalation rates as for Western rail are assigned to the Great Lakes vessel and two transfer operations, which are assumed to have the same cost escalation characteristics.

The escalation rates were selected based upon the complex factors mentioned above which influence them, and how an experienced economist[7] in this field estimates they will translate into actual costs. The rates are designed to cover the full spectrum of probable cost escalation rates for each delivered cost component. It should be noted that a range (8 to 10%) was used in all three cases for escalating Eastern coal costs because that was considered the most uncertain cost item. This range, plus the ones used to estimate Western unit train costs in this study's development of present costs, combine to cause all projections to be in the form of ranges. The implication of these present and future ranges is that much current data (i.e., component and total costs in the form of ranges) and all projections must be viewed with extreme care, taking into account the optimistic or pessimistic assumptions about Western coal which are involved in a particular number. Specific examples of the impacts of these assumptions are given in this report's findings (Sections 3.1 and 3.2).

2.3 COMPUTATION METHODS

Two primary computational procedures were followed:

1. Costs were developed on a per ton basis and then converted to a per million Btu basis.

2. Costs were escalated by anticipated rates in terms of real, 1979 dollars.

Regarding the first procedure, the conversion from tons to million Btu was accomplished by the standard procedure of determining each prospective source coal's heat content per pound and then doing the necessary conversion calculations. This, for example, indicates that while the percentage difference between 1979 Montana (9,600 Btu/lb) and Eastern Kentucky (12,000 Btu/lb) delivered coal cost per ton is slight (\$39.52 versus \$36), the percentage difference between them per million Btu is great (\$2.06 - \$2.27 versus \$1.50).

The second computational procedure was used because only geographical cost escalation rates of component costs were important to this analysis, not any general, national or regional inflation rate. Use of inflation rates here would have only confused the analysis, whereas escalating all costs on the basis of current dollars (i.e., a common benchmark) accomplished the purpose of comparing the relative futures of all alternatives.

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3 FINDINGS AND CONCLUSIONS

3.1 CURRENT DELIVERED COAL COSTS

Table 1 summarizes current Western versus Eastern coal delivered cost estimates for two Eastern Great Lakes hinterland utility plants and one lakefront plant, and Table 2 presents a breakdown of the components of these costs. Movement from two potential Western sources via the Great Lakes* are compared with the costs of present Eastern sources to two hinterland plants. Niagara Mohawk costs from its present Eastern and a potential Western source to one of its planned lakefront power plants are also presented.

Table 1 indicates that Western low sulfur coal delivered costs can currently compete, and are indeed lower than Eastern high sulfur coal ($1.46/MM Btu versus $1.62/MM Btu**) at certain Eastern lakefront utility plants, such as Dunkirk, New York. On the other hand, it shows that neither Montana nor Wyoming low sulfur coal can presently compete on a delivered cost basis with the Eastern low or high sulfur coal at the Ohio and New York hinterland utility plants surveyed. At the Dayton, Ohio plant the current delivered cost from its present Eastern Kentucky low sulfur coal supplier is $1.50/MM Btu versus Montana and Wyoming low sulfur coal costs of $2.06-$2.27 and $2.44-$2.61/MM Btu, respectively. Similarly, the Dresden, New York plant now is served by $1.20/MM Btu delivered cost Pennsylvania high sulfur coal, whereas Montana and Wyoming coal would cost $2.08-$2.29 and $2.47-$2.71/MM Btu, respectively.

Three sets of data in Table 2 are very important to these findings. First, the Eastern rail costs of Western coal movement systems are quite high, reaching the same order of magnitude per ton for their short movements (under 200 miles) as long distance (over 1000 miles) Western movements. While Western unit train movements cost between one and two cents per ton-mile, Eastern unit train movements out of Great Lakes ports cost about seven cents per ton-mile. This may be explained partially by the fact that Eastern rail costs for coal are generally higher, with the Dayton and Dresden plants currently paying about three cents per ton-mile to CONRAIL. However, high

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* Appendix B discusses Western coal movements eastward to the Great Lakes area via transport systems not involving the Great Lakes.

** Per Million Btu.

TABLE 1

Estimated Current Delivered Coal Costs of Western[a] and Eastern Coal to Eastern Great Lakes Utilities

Destination	Delivery Date[d]	Origin	DELIVERED COST Minimum		Maximum
Hinterland Plants:			($/MM Btu)		
Dayton, OH	1979	Decker Mines, MT	2.06	-	2.27
		Gillette, WY	2.44	-	2.68
		Pikeville, KY		1.50[b]	
Dresden, NY	1979	Decker Mines, MT	2.08	-	2.29
		Gillette, WY	2.47	-	2.71
		Dixonville, PA		1.20[b]	
Lakefront Plant:					
Dunkirk, NY	1977	Gillette, WY		1.46[c]	
		PA/WV		1.62[c]	

Source: Summary of Table 2.

[a]Shipped via Great Lakes

[b]Actual

[c]Estimate

[d]Indicates that hinterland plant costs are not directly comparable to lakefront costs because they have two different time frames.

TABLE 2

Breakdown of Estimated Western versus Eastern Delivered Coal Costs to Three Eastern Utilities

Coal Heat Content and Cost Categories / Destination Origins	ESTIMATED DELIVERED COAL COSTS PER SHORT TON AND PER MILLION BTUs							
	DAYTON, OH[a]			DRESDEN, NY[b]			DUNKIRK, NY[s]	
	Decker Mines, MT	Gillette WY	Pikesville KY	Decker Mines, MT	Gillette WY	Dixonville PA	Gillette WY	PA/WV
	1979			1979			1977	
Heat Content (Btu/lb.)	9,600	8,300	12,000	9,600	8,300	12,000	8,300	12,000
Cost Category:	Dollars per ton							
Coal - FOB Mine (Loaded Rail Car)	11.00[c,d]	9.00[c,e]	27.75[r]	11.00[c,d]	9.00[c,e]	20.00[f]	7.50[g]	31.50[h]
Rail - Western	10.00-14.00[i]	13.00-17.00[j]		10.00-14.00[i]	13.00-17.00[j]		11.25[k]	
Transfer (Rail to Ship)-Western[l]	1.50	1.50		1.50	1.50		1.50	
Lake Vessel	4.32[m]	4.32[m]		5.10[m]	5.10[m]		4.00[n]	
Transfer (Ship to Rail) - Eastern[l]	2.00	2.00		2.00	2.00			
Rail - Eastern	10.70[o]	10.70[o]	8.25[r]	10.40[o]	10.40[o]	8.73[p]		7.30[q]
Total Delivered Cost	39.52-43.52	40.52-44.52	36.00	40.00-44.00	41.00-45.00	28.73	24.25	38.80
	Dollars per million Btu							
Total Delivered Cost	2.06-2.27	2.44-2.61	1.50	2.08-2.29	2.47-2.71	1.20	1.46	1.62

Notes (Sources in second column):

a - 153 miles from Port of Toledo, OH.

b - 129 miles from Port of Buffalo, NY.

c - Usually requires approximately 4 million tons annually, individually or jointly with other shippers. Source: A

d - Sulfur content 0.5%. Includes Montana 30% severance tax. Source: A

e - Sulfur content 0.5%. Includes Wyoming 17% severance tax. Sources: A and B

f - Average price paid for 2% sulfur coal. Source: C

g - Sulfur content 0.5%. Price includes 17% Wyoming severance tax. Source: B

h - Average price in range of $29 to $34 per ton for 2.3% sulfur coal. Source: B

i - Probable range of rail costs for 1031 mile trip with smaller volume new shippers more likely to pay $14. Source: A

j - Probable range for 1147 mile trip with Niagara Mohawk costs (see Note k) set as minimum. Extrapolated based on Note i.

k - Estimate, includes Niagara ownership of rail cars. Source: B

l - Detroit Edison costs, Niagara Mohawk estimates. Assumes use of highly efficient Duluth-Superior, WI transloading facility. Sources: A and B

m - Rate quotes. Source: D

n - Estimates of dedicated vessel plus conveyor tunnel (from Dunkirk unloading dolphins to shoreside plant) costs. Source: B

o - Rough CONRAIL estimates. Assume unit trains with railroad owned cars. Conventional (non-unit) train rates are $11.71 ton for Toledo-Dayton and $11.39 ton for Buffalo-Dresden. Source: F

p - Unit train rate for 316 mile trip with railroad owned cars. Source: C

q - Estimate, includes Niagara ownership of rail cars.

r - Delivered cost components for 0.7% sulfur coal. Includes conventional rail rate for 308 mile trip. Source: E

s - On Lake Erie.

Sources:

A - Paul Childs, Operations Engineer, Fuel Supply Dept., Detroit Edison Co.

B - Don Vrooman, Senior Fuel Buyer, Purchasing Department, Niagara Mohawk Power Corp.

C - R. P. Wendell, Manager, Purchasing Dept., N.Y. State Electric and Gas Corp.

D - Ward Fuller, Special Assistant to the Chairman, American Steamship Lines.

E - W. Dibert, Assistant Vice-President, General Services, Dayton Power and Light Co.

F - Don Burke, Open Top Hopper Business Group, CONRAIL.

operating cost in Great Lakes port areas is the key factor which drives these rail costs up to a level which renders total system costs noncompetitive.

The reasons for these high costs, as explained by CONRAIL,[6] are that at the Port of Buffalo, for instance, six switches would be required within the port railyards to get a rail unit train underway from there to Dunkirk. This, according to CONRAIL, would require six different train crews. In addition, they estimate that anticipated congestion at this and other points would result in frequent waits of from 3 to 12 hours for these unit trains to gain access to the single tracks in these areas. Further, it was pointed out that track system modifications in the Buffalo case, for example, would be impractical and extremely unlikely because of railside industrial plants which would have to be torn down. CONRAIL determined the above during a detailed study used to quote a rate to Niagara Mohawk of seven cents per ton-mile for proposed Buffalo to Dunkirk unit trains. They estimate that similar rates would be required for the Toledo to Dayton and Buffalo to Dresden moves analyzed here.

Secondly, Table 2 uses a range for Western unit train rail costs. The range is wide, with about a 40 percent difference between its low and high ends. The reason for it is that discussions with Detroit Edison, the only major Great Lakes shipper of Western coal, indicated that they think a new Western coal buyer's costs for Western rail movement of that coal will depend largely upon his volume and negotiating expertise. Detroit Edison is not overly optimistic that even large new shippers of Western coal will be able to secure the low end of the rates, and says small (e.g., one million tons or less annually) buyers, unless they combine, probably will not get them.[3] However, since Niagara Mohawk, which will not begin operating its Dunkirk plant until 1985, assumes they will be able to secure the lower rates in their 1977 study data presented in Table 2, this report considers the lower rates reasonably possible. The reader is cautioned, though, that the lower Western coal costs in Table 1 involve these lower rates, as do the lower ends of all projected Western coal cost ranges presented in the next sub-section.

The third important data set in Table 2 is Eastern minemouth coal costs. The almost eight dollar difference in current average minemouth coal prices received by Dresden and Dayton is the result of the differing sulfur contents of the coals they burn, which are determined by their local allowable air pollution regulations. Dresden regulations allow high (2%) sulfur, $20 coal.

Dayton is in an area where 0.7%, low sulfur "compliance" $28 coal is required to meet existing air pollution regulations. Note that while at present this $28 coal still is far less expensive on a delivered price basis than Western coal ($1.50/MM Btu versus $2.06-$2.61), this gap is far smaller than that for Dresden coal which costs $1.20/MM Btu versus $2.08 to $2.71 for Western coal. These gaps are indicative of the fact that the delivered cost of Western low sulfur coal shipped via the Great Lakes has far less ground to make up against Eastern low sulfur than high sulfur coals. How quickly this ground can be made up is the subject of the discussion to follow.

3.2 PROJECTED DELIVERED COAL COSTS

These findings are presented in three levels of detail to enable the reader to more easily focus upon data being discussed and then trace its development. The first level of findings, presented in Tables 3 and 4, summarize projected Western* versus Eastern delivered coal costs at Eastern Great Lakes hinterland utility plants based upon this report's three dilution cases (see Section 2.2 for discussion). A summary of the sensitivity analysis (dilution cases) used to develop these costs is then shown in Table 5 to facilitate analyses of the 20 year projection period. Tables 6 through 8 then present each dilution case in full detail, including breakdowns of the components of projected total delivered costs, to enable analyses of the interaction of these component costs.

For 1989, Table 3 indicates that the only situation in which a delivered cost of a Western coal is strongly competitive with Eastern low sulfur coal is under the most optimistic Western situation in the "Minimum Dilution" case. Here Montana coal cost for Dayton is assumed to be at the minimum end of its projected range ($3.86/MM Btu), and Eastern Kentucky coal is at the high end of its projected range ($3.81/MM Btu). This assumes that: 1) Western transportation cost has its maximum annual escalation rate advantage (5% versus 9%, see Table 5), 2) minimum current potential Western unit train costs projected (see Tables 2 and 6), and 3) Eastern low sulfur coal cost escalates at its maximum likely rate (10%, see Table 5). These are very optimistic assumptions for Western coal, but it should be noted that Montana coal cost

*Shipped via the Great Lakes.

TABLE 3

1989 Projected Delivered Coal Costs of Western[a] and Eastern Coal to Eastern Great Lakes Hinterland Utilities

Destination	Origin	Dilution of Western Versus Eastern Cost Escalation Rate Advantages	DELIVERED COSTS Minimum		DELIVERED COSTS Maximum
			($/MM Btu)		
Dayton, OH	Decker Mines, MT	MINIMUM[b]	3.86	-	4.20
	Gillette, WY		4.54	-	4.93
	Pikeville, KY		3.31	-	3.81
Dresden, NY	Decker Mines, MT		3.89	-	4.23
	Gillette, WY		4.57	-	4.97
	Dixonville, PA		2.66	-	3.02
Dayton, OH	Decker Mines, MT	MEDIUM[b]	4.02	-	4.38
	Gillette, WY		4.74	-	5.17
	Pikeville, KY		3.31	-	3.81
Dresden, NY	Decker Mines, MT		4.04	-	4.42
	Gillette, WY		4.78	-	5.34
	Dixonville, PA		2.66	-	3.02
Dayton, OH	Decker Mines, MT	MAXIMUM[b]	3.89	-	4.26
	Gillette, WY		4.61	-	5.04
	Pikeville, KY		3.24	-	3.74
Dresden, NY	Decker Mines, MT		3.93	-	4.30
	Gillette, WY		4.65	-	5.09
	Dixonville, PA		2.58	-	2.95

Source: Summary of Table 5 1989 Data.

[a]Shipped via Great Lakes.

[b]See Table 5 for rates, Section 2.2 for discussion.

TABLE 4

1999 Projected Delivered Coal Costs of Western[a] and Eastern Coal to Eastern Great Lakes Hinterland Utilities

Destination	Origin	Dilution of Western Versus Eastern Cost Escalation Rate Advantages	DELIVERED COSTS Minimum		DELIVERED COSTS Maximum
			($/MM Btu)		
Dayton, OH	Decker Mines, MT	MINIMUM[b]	7.42	-	7.98
	Gillette, WY		8.68	-	9.32
	Pikeville, KY		7.32	-	9.70
Dresden, NY	Decker Mines, MT		7.44	-	8.00
	Gillette, WY		8.73	-	9.34
	Dixonville, PA		5.92	-	7.64
Dayton, OH	Decker Mines, MT	MEDIUM[b]	7.94	-	8.61
	Gillette, WY		9.37	-	10.15
	Pikeville, KY		7.32	-	9.70
Dresden, NY	Decker Mines, MT		7.98	-	9.65
	Gillette, WY		9.42	-	10.20
	Dixonville, PA		5.92	-	7.64
Dayton, OH	Decker Mines, MT	MAXIMUM[b]	7.41	-	8.08
	Gillette, WY		8.77	-	9.54
	Pikeville, KY		6.99	-	9.38
Dresden, NY	Decker Mines, MT		7.47	-	8.14
	Gillette, WY		8.83	-	9.60
	Pikeville, KY		5.58	-	7.30

Source: Summary of Table 5 1989 Data.

[a]Shipped via Great Lakes.

[b]See Table 5 for rates, Section 2.2 for discussion.

TABLE 5

Summary of Sensitivity Analysis on Projected Delivered Coal Costs Using Differing Dilutions of Western Coal's Cost Escalation Rate Advantages

Destination	Origin	(1) Average Coal Sulfur Content	(2) FOB Mine Coal Cost	(3) Western Transport System Cost	(4) Eastern Transport System Cost	Difference Between (4) and (3)	Delivered Coal Cost Per Million Btu 1979	1989	1999
		Percent					Dollars		
		MINIMUM DILUTION CASE[a]							
Dayton, OH	Decker Mines, MT	0.5	6	5	9	4	2.06-2.27	3.86-4.20	7.42-7.98
	Gillette, WY	0.5	6	5	9	4	2.44-2.68	4.54-4.93	8.68-9.32
	Pikeville, KY	0.7	8-10		9		1.50	3.31-3.81	7.32-9.70
Dresden, NY	Decker Mines, MT	0.5	6	5	9	4	2.08-2.29	3.89-4.23	7.44-8.00
	Gillette, WY	0.5	6	5	9	4	2.47-2.71	4.57-4.97	8.73-9.34
	Dixonville, PA	2.0	8-10		9		1.20	2.66-3.02	5.92-7.64
		MEDIUM DILUTION CASE[a]							
Dayton, OH	Decker Mines, MT	0.5	6	6	9	3	2.06-2.27	4.02-4.38	7.94-8.61
	Gillette, WY	0.5	6	6	9	3	2.44-2.68	4.74-5.17	9.37-10.15
	Pikeville, KY	0.7	8-10		9		1.50	3.31-3.81	7.32-9.70
Dresden, NY	Decker Mines, MT	0.5	6	6	9	3	2.08-2.29	4.04-4.42	7.98-9.65
	Gillette, WY	0.5	6	6	9	3	2.47-2.71	4.78-5.34	9.42-10.20
	Dixonville, PA	2.0	8-10		9		1.20	2.66-3.02	5.92-7.64
		MAXIMUM DILUTION CASE[a]							
Dayton, OH	Decker Mines, MT	0.5	6	6	8	2	2.06-2.27	3.89-4.26	7.41-8.08
	Gillette, WY	0.5	6	6	8	2	2.44-2.68	4.61-5.04	8.77-9.54
	Pikeville, KY	0.7	8-10		8		1.50	3.24-3.74	6.99-9.38
Dresden, NY	Decker Mines, MT	0.5	6	6	8	2	2.08-2.29	3.93-4.30	7.47-8.14
	Gillette, WY	0.5	6	6	8	2	2.47-2.71	4.65-5.09	8.83-9.60
	Dixonville, PA	2.0	8-10		8		1.20	2.58-2.95	5.58-7.30

Sources: Summarizes Tables 6, 7, and 8.

a - See discussion in Section 2.2.

TABLE 6

Dilution of Western Coal's Cost Escalation Rate Advantage - Minimum Dilution Case[a]

Destination, Source and Cost Category	1979	1989	1999
	- $/Ton (except as noted) -		
To Dayton, OH from:			
Decker Mines, MT			
Coal (FOB Mine) - 6% Cost Escalation	11.00	19.70	35.28
Western Transportation System[b] - 5% Cost Esc.	17.82-21.82	29.03-35.54	47.28-57.89
Eastern Rail Transport - 9% Cost Escalation	10.70	25.33	59.96
Total Cost Per Ton	39.52-43.52	74.06-80.57	142.52-153.13
Cost Per Million BTU (@9600 BTU/lb.)	2.06-2.27	3.86-4.20	7.42-7.98
Gillette, WY			
Coal (FOB Mine) - 6% Cost Escalation	9.00	16.12	28.86
Western Transportation System[b] - 5% Cost Esc.	20.82-24.82	33.92-40.43	55.24-65.85
Eastern Rail Transport - 9% Cost Escalation	10.70	25.33	59.96
Total Cost Per Ton	40.52-44.52	75.37-81.88	144.06-154.67
Cost Per Million BTU (@8300 BTU/lb.)	2.44-2.68	4.54-4.93	8.68-9.32
Pikeville, KY			
Coal (FOB Mine) - 8 to 10% Cost Escalation	27.75	59.91-71.98	129.34-186.67
Eastern Rail Transport - 9% Cost Escalation	8.25	19.53	46.23
Total Cost Per Ton	36.00	79.44-91.51	175.57-232.90
Cost Per Million BTU (@12,000 BTU/lb.)	1.50	3.31-3.81	7.32-9.70
To Dresden, NY from:			
Decker Mines, MT			
Coal (FOB Mine) - 6% Cost Escalation	11.00	19.70	35.28
Western Transportation System[b] - 5% Cost Esc.	18.60-22.60	30.30-36.81	49.35-59.96
Eastern Rail Transport - 9% Cost Escalation	10.40	24.62	58.28
Total Cost Per Ton	40.00-44.00	74.62-81.13	142.91-153.52
Cost Per Million BTU (@9600 BTU/lb.)	2.08-2.29	3.89-4.23	7.44-8.00
Gillette, WY			
Coal (FOB Mine) - 6% Cost Escalation	9.00	16.12	28.86
Western Transportation System[b] - 5% Cost Esc.	21.60-25.60	35.19-41.70	57.30-67.92
Eastern Rail Transport - 9% Cost Escalation	10.40	24.62	58.28
Total Cost Per Ton	41.00-45.00	75.93-82.44	144.94-155.06
Cost Per Million BTU (@8300 BTU/lb.)	2.47-2.71	4.57-4.97	8.73-9.34
Dixonville, PA			
Coal (FOB Mine) - 8 to 10% Cost Escalation	20.00	43.18-51.88	93.22-134.54
Eastern Rail Transport - 9% Cost Escalation	8.73	20.66	48.92
Total Cost Per Ton	28.73	63.84-72.54	142.14-183.46
Cost Per Million BTU (@12,000 BTU/lb.)	1.20	2.66-3.02	5.92-7.64

Source: Calculated from Table 2.

Notes:

[a]Eastern rail transport costs inflate at rate 4 percent higher than Western transport system costs.

[b]Includes costs for Western rail, Great Lakes ship, and intermodal transfer of coal at both ends of Great Lakes. See discussion in Section 2.2.

TABLE 7

Dilution of Western Coal's Cost
Escalation Rate Advantage - Medium
Dilution Case[a]

Destination, Source and Cost Category	1979	1989	1999
	- $/Ton (except as noted) -		
To Dayton, OH from:			
Decker Mines, MT			
Coal (FOB Mine) - 6% Cost Escalation	11.00	19.70	35.28
Western Transportation System[b] - 6% Cost Esc.	17.82-21.82	31.92-39.07	57.15-69.98
Eastern Rail Transport - 9% Cost Escalation	10.70	25.33	59.96
Total Cost Per Ton	39.52-43.52	77.15-84.10	152.39-165.22
Cost Per Million BTU (@9600 BTU/lb.)	2.06-2.27	4.02-4.38	7.94-8.61
Gillette, WY			
Coal (FOB Mine) - 6% Cost Escalation	9.00	16.12	28.86
Western Transportation System[b] - 6% Cost Esc.	20.82-24.82	37.29-44.45	66.77-79.60
Eastern Rail Transport - 9% Cost Escalation	10.70	25.33	59.96
Total Cost Per Ton	40.52-44.52	78.74-85.90	155.59-168.42
Cost Per Million BTU (@8300 BTU/lb.)	2.44-2.68	4.74-5.17	9.37-10.15
Pikeville, KY			
Coal (FOB Mine) - 8 to 10% Cost Escalation	27.75	59.91-71.98	129.34-186.67
Eastern Rail Transport - 9% Cost Escalation	8.25	19.53	46.23
Total Cost Per Ton	36.00	79.44-91.51	175.57-232.90
Cost Per Million BTU (@12,000 BTU/lb.)	1.50	3.31-3.81	7.32-9.70
To Dresden, NY from:			
Decker Mines, MT			
Coal (FOB Mine) - 6% Cost Escalation	11.00	19.70	35.28
Western Transportation System[b] - 6% Cost Esc.	18.60-22.60	33.31-40.48	59.65-72.48
Eastern Rail Transport - 9% Cost Escalation	10.40	24.62	58.28
Total Cost Per Ton	40.00-44.00	77.63-84.80	153.21-166.04
Cost Per Million BTU (@9600 BTU/lb.)	2.08-2.29	4.04-4.42	7.98-8.65
Gillette, WY			
Coal (FOB Mine) - 6% Cost Escalation	9.00	16.12	28.86
Western Transportation System[b] - 6% Cost Esc.	21.60-25.60	38.68-45.85	69.27-82.10
Eastern Rail Transport - 9% Cost Escalation	10.40	24.62	58.28
Total Cost Per Ton	41.00-45.00	79.42-88.59	156.41-169.24
Cost Per Million BTU (@8300 BTU/lb.)	2.47-2.71	4.78-5.34	9.42-10.20
Dixonville, PA			
Coal (FOB Mine) - 8 to 10% Cost Escalation	20.00	43.18-51.88	93.22-134.54
Eastern Rail Transport - 9% Cost Escalation	8.73	20.66	48.92
Total Cost Per Ton	28.73	63.84-72.54	142.14-183.46
Cost Per Million BTU (@12,000 BTU/lb.)	1.20	2.66-3.02	5.92-7.64

Source: Calculated from Table 2.

Notes:

[a]Eastern Rail transport costs inflate at rate 3 percent higher than Western transport system costs.

[b]Includes costs for Western rail, Great Lakes ship, and intermodal transfer of coal at both ends of Great Lakes. See discussion in Section 2.2.

TABLE 8

Dilution of Western Coal's Cost Escalation Rate Advantage - Maximum Dilution Case[a]

Destination, Source and Cost Category	1979	1989	1999
	- $/Ton (except as noted) -		
To Dayton, OH from:			
Decker Mines, MT			
Coal (FOB Mine) - 6% Cost Escalation	11.00	19.70	35.28
Western Transportation System[b] - 6% Cost Esc.	17.82-21.82	31.92-39.07	57.15-69.98
Eastern Rail Transport - 8% Cost Escalation	10.70	23.10	49.87
Total Cost Per Ton	39.52-43.52	74.72-81.87	142.30-155.13
Cost Per Million BTU (@9600 BTU/lb.)	2.06-2.27	3.89-4.26	7.41-8.08
Gillette, WY			
Coal (FOB Mine) - 6% Cost Escalation	9.00	16.12	28.86
Western Transportation System[b] - 6% Cost Esc.	20.82-24.82	37.29-44.45	66.77-79.60
Eastern Rail Transport - 8% Cost Escalation	10.70	23.10	49.87
Total Cost Per Ton	40.52-44.52	76.51-83.67	145.50-158.33
Cost Per Million BTU (@8300 BTU/lb.)	2.44-2.68	4.61-5.04	8.77-9.54
Pikeville, KY			
Coal (FOB Mine) - 8 to 10% Cost Escalation	27.75	59.91-71.98	129.34-186.67
Eastern Rail Transport - 8% Cost Escalation	8.25	17.81	38.45
Total Cost Per Ton	36.00	77.72-89.79	167.79-225.12
Cost Per Million BTU (@12,000 BTU/lb.)	1.50	3.24-3.74	6.99-9.38
To Dresden, NY from:			
Decker Mines, MT			
Coal (FOB Mine) - 6% Cost Escalation	11.00	19.70	35.28
Western Transportation System[b] - 6% Cost Esc.	18.60-22.60	33.31-40.48	59.65-72.48
Eastern Rail Transport - 8% Cost Escalation	10.40	22.45	48.47
Total Cost Per Ton	40.00-44.00	75.46-82.63	143.40-156.23
Cost Per Million BTU (@9600 BTU/lb.)	2.08-2.29	3.93-4.30	7.47-8.14
Gillette, WY			
Coal (FOB Mine) - 6% Cost Escalation	9.00	16.12	28.86
Western Transportation System[b] - 6% Cost Esc.	21.60-25.60	38.68-45.85	69.27-82.10
Eastern Rail Transport - 8% Cost Escalation	10.40	22.45	48.47
Total Cost Per Ton	41.00-45.00	77.25-84.42	146.60-159.43
Cost Per Million BTU (@8300 BTU/lb.)	2.47-2.71	4.65-5.09	8.83-9.60
Dixonville, PA			
Coal (FOB Mine) - 8 to 10% Cost Escalation	20.00	43.18-51.88	93.22-134.54
Eastern Rail Transport - 8% Cost Escalation	8.73	18.85	40.69
Total Cost Per Ton	28.73	62.03-70.73	133.91-175.23
Cost Per Million BTU (@12,000 BTU/lb.)	1.20	2.58-2.95	5.58-7.30

Source: Calculated from Table 2.

Notes:

[a]Eastern rail transport costs inflate at rate 2 percent higher than Western transport system costs.

[b]Includes costs for Western rail, Great Lakes ship, and intermodal transfer of coal at both ends of Great Lakes. See discussion in Section 2.2.

for Dayton also is within 6% of Eastern low sulfur coal's under the Medium ($4.02 versus $3.81/MM Btu) and Maximum ($3.89 versus $3.74/MM Btu) Dilution cases and their less optimistic assumptions.*

On the other hand, Table 3 shows that even under the most optimistic "Minimum Dilution" case assumptions, Wyoming coal never is less than 18% more expensive ($4.54 versus $3.81/MM Btu) than Eastern low sulfur coal, and neither Montana nor Wyoming coal is less than 29% more expensive ($3.89 and $4.57 versus $3.02/MM Btu) than Eastern high sulfur coal to Dresden.

In 1999, Table 4 indicates that the most optimistic Western situation in the "Minimum Dilution" case for Montana coal to Dayton would render it far less expensive than low sulfur Eastern coal ($7.42 versus $9.70/MM Btu). Slightly smaller advantages could be obtained for the most optimistic Medium and Maximum Dilution cases ($7.94 versus $9.70/MM Btu and $7.41 versus $9.38/MM Btu). Even with high Western rail costs, Montana coal would maintain a significant advantage ($7.98 versus $9.70/MM Btu). Further, even with the lowest likely Eastern coal cost escalation rate of 8%, Montana coal to Dayton could be competitive ($7.42 versus $7.32 MM/Btu) with a low 1979 rail rate escalated with minimum dilution of the Western advantage. Similar situations are found for Montana coal to Dayton under the Medium and Maximum Dilution cases.

Wyoming coal, in 1999 (Table 4), may achieve a moderately lower cost ($8.68 versus $9.70/MM Btu) than Eastern low sulfur coal to Dayton under the most optimistic assumptions of the Minimum Dilution case, and could even achieve slight advantages ($9.37 versus $9.70/MM Btu and $8.77 versus $9.38/MM Btu) under the Medium and Maximum Dilution cases. This coal's delivered cost could even compete in the Maximum Dilution case ($9.54 versus $9.38/MM Btu) if high 1979 Western rail rates are escalated.

On the other hand, Western (Montana) coal's delivered cost requires the benefit of the most optimistic Minimum Dilution case to become slightly less expensive ($7.44 versus $7.64/MM Btu) than Eastern high sulfur coal to Dresden. In the Medium and Maximum Dilution cases, Montana coal's delivered

* Similar detailed analyses are made for each finding here by using Tables 5 through 8 to determine what particular cost escalation rates caused specific results, and the impact of these rates upon particular cost components. Only Tables 3 and 4 are usually referenced, however, to preserve the flow of the discussion.

cost can be within 4% of Eastern coal's ($7.98 versus $7.64/MM Btu and $7.47 versus $7.30/MM Btu).

Wyoming coal, even in the most optimistic Minimum Dilution case, does not come closer in 1999 than 14% higher than Eastern high sulfur coal's cost ($8.73 versus $7.64/MM Btu). This and the above-mentioned cases show Wyoming coal to be somewhat less competitive than Montana coal with Eastern coals. This is because, as Table 2 indicates, Wyoming coal must move further than Montana coal to the Superior, Wisconsin, transfer facility (1147 miles versus 1031 miles), which more than offsets Wyoming's slightly lower mine-mouth cost per million Btus (57 cents versus 59 cents). Thus, Wyoming coal's delivered 1979 cost is roughly 20% more than Montana's (e.g., $2.44 minimum versus $2.06 minimum), which takes longer to make up with a cost escalation rate advantage.

3.3 CONCLUSIONS

Based upon the above findings, it is concluded that the delivered costs of Western coal, if it is shipped via the Great Lakes to utility plants in the Eastern Great Lakes hinterlands:

1. Cannot presently compete with any type of Eastern coal.

2. Can by 1989, with favorable interim Western versus Eastern cost escalation rate advantages on minemouth coal and transportation costs, begin competing with Eastern low sulfur, but not high sulfur coal. This situation will also require that escalated Western rail rates be relatively low ones. Given this, however, Western (i.e., Montana, not Wyoming) costs will be at least reasonably competitive (i.e. within 6%) even with Medium or Maximum Dilution of anticipated Western cost escalation rate advantages.

3. By 1999, even with high 1979 Western rail rates being escalated and a Maximum Dilution of Western cost escalation rate advantages, Montana coal could be substantially less expensive than Eastern low sulfur coal. Competitiveness with Eastern high sulfur coal would require escalation of low 1979 Western rail rates. Given those, however, Montana coal could compete even with Maximum Dilution of Western cost escalation rate advantages.

4. High port to hinterland Eastern rail costs of Western coal transport systems are the key factor which renders them currently uneconomic and delays their ability to become competitive in the future. The future situation is also difficult because as Eastern rail costs increase faster than Western rail costs, so will the cost of this component of Western transport systems. Similarly, the low Western rail rates inherent in the cost competitive situations found for Western coal in this report may very likely not be easy for new shippers to negotiate according to Detroit Edison.

APPENDIX A

RELATIVE COST IMPACTS OF COAL SCRUBBING

A set of conclusions regarding scrubbing cost impacts, while beyond the scope of this study of delivered coal costs, is presented here on a *preliminary* basis. These conclusions concern the ultimate relative costs of Great Lakes shipped Western versus Eastern low and high sulfur coal at Eastern Great Lakes hinterland utility plants, after scrubbing costs required by still uncertain U.S. Environmental Protection Agency (EPA) sulfur removal regulations are applied.

The conclusions are based upon data received from Paul Farber, an Argonne National Laboratory (ANL) pollution control cost analyst, and a to be published report prepared for ANL by Battelle Columbus Laboratories.[8,9] Based upon an anticipation that EPA's proposed floor of 0.2 pounds of sulfur per million Btu (0.2 lb/MM Btu) of coal input will be enacted, Figure 1 indicates that the relative costs of scrubbing high (2%) sulfur coal were found to be about 50% higher (or about 20 cents per million Btu)[8] than low (0.5%) sulfur coal. For higher (3 to 4%) sulfur coal, the cost is about 100% higher, but this very dirty coal was not used in this report's examples.

Using the delivered costs per million Btu in Table 2 and adding differentially higher scrubbing costs of 20 cents for the high (2%) sulfur coal at Dresden, New York, coal costs would rise from \$1.20 to \$1.40/MM Btu. This would still be somewhat below Dayton's \$1.50 for <u>low</u> (0.7%) sulfur Eastern coal, and suggests that Western coal's cost escalation rate advantages would tend to help it become competitive with Eastern <u>high</u> (2%) sulfur coal in Table 5 sooner, but not quite as soon as with Eastern <u>low</u> (0.7%) sulfur coal. In other words, with its differential scrubbing cost advantages and favorable cost escalation rate advantages, Western low sulfur coal could probably compete with Eastern <u>high</u> sulfur coal by the mid-1990's. This is compared to the report's finding of its becoming competitive on a delivered cost basis, under favorable cost escalation rate advantages but no scrubbing cost advantages, with Eastern <u>low</u> sulfur coal by 1989 and with Eastern <u>high</u> sulfur coal by 1999. Further, if and when existing hinterland plants using high sulfur coal are required to retrofit and install scrubbers, Western coal will become competitive at these locations in slightly less than the approximately 15 years estimated above. This would be due to higher costs of installing <u>high</u> sulfur scrubbers at existing hinterland plants than new plants.[8]

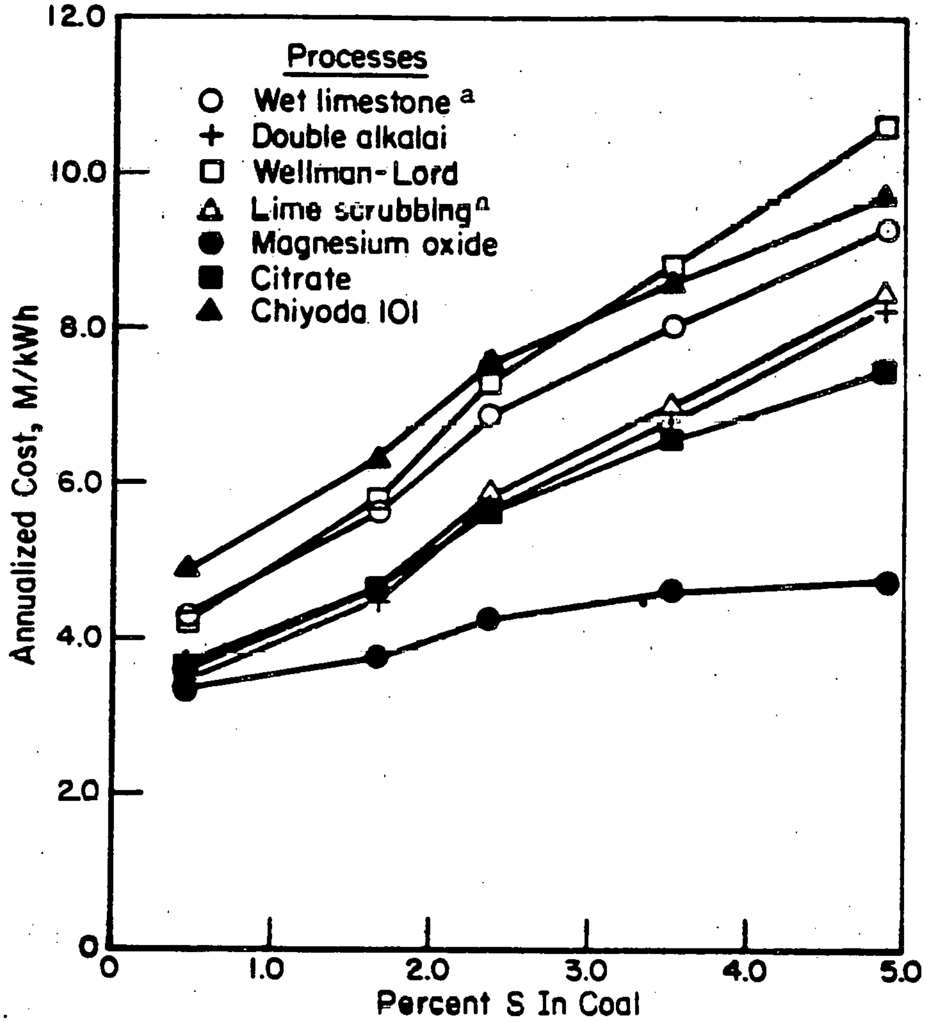

Figure 1 ANNUALIZED COSTS VERSUS SULFUR IN COAL FOR 90% SO_2 REMOVAL (72.83% FOR 0.47% S IN COAL)

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[a]These are the most likely scrubbing processes to be used at utility plants according to Paul Farber, Coal Scrubbing Cost Analyst, Argonne National Laboratory.

Source: Reference 9, p. 62.

On the other hand, Western coal's position against Eastern low sulfur coal will not change appreciably from Table 5's projections at new or existing utility plants under the expected EPA regulations according to Battelle's estimates. Battelle estimates only slightly higher scrubbing costs for 0.7% versus 0.5% low sulfur coal (see Fig. 1).

Finally, there is some chance that DOE's proposed sulfur floor of 0.55 lb/MM Btu input will be accepted by EPA. The implication of this for low (0.5%) sulfur coal would be that only 47% sulfur removal would be required instead of 73% removal, and that nearly one-half the coal burned would not have to be scrubbed. This could approximately double the $.20 differential scrubbing cost advantage of low sulfur coal versus high sulfur coal at new plants. Adding $.40/MM Btu to Table 2's high sulfur coal cost would raise that cost to $1.60/MM Btu , slightly higher than Eastern low sulfur coal's $1.50/MM Btu. This would imply that under maximum Western coal escalation rate advantages, its coal could compete with Eastern high sulfur coal slightly before 1989 (see Table 5). Further, requirements for scrubbers at existing plants would favor Western coal even more at these locations.

In summary, the scrubbing costs required by proposed regulations of EPA and DOE would affect Great Lakes shipped Western coal's competitive position at Eastern Great Lakes hinterland plants as follows:

1. Under EPA or DOE proposed regulations, there will be no appreciable change from its delivered cost's position versus Eastern low sulfur coal's at new or existing plants.
2. Under EPA proposals, it becomes competitive at new plants with Eastern high sulfur coal by mid-1990's under favorable Western cost escalation rate advantages.
3. Under DOE proposals, it becomes competitive at new plants with Eastern high sulfur coal slightly before 1989 under favorable Western cost escalation rate advantages.
4. At existing plants, if scrubbing requirements are instituted, Western coal would become competitive over slightly shorter time periods than those shown in 2 and 3 above.

In conclusion, very favorable circumstances, both in terms of differential scrubbing requirements (e.g., acceptance by EPA of DOE proposals) and in terms of Western cost escalation rate advantages, are necessary for Great

Lakes shipped Western low (0.5%) sulfur coal to be competitive with any type of Eastern coal before 1989 at Eastern Great Lakes hinterland plants. Without the favorable DOE scrubbing proposals, Western low sulfur coal can only compete at these plants with Eastern low sulfur by 1989 and high sulfur coal by the mid-1990's under the expected EPA scrubbing requirements and very favorable cost escalation rate advantages.

APPENDIX B

OTHER WESTERN COAL TRANSPORT SYSTEMS

Depending upon particular Eastern* utility plant locations, differing Western coal transport systems have been found most economical by Eastern utilities. Lakeside plants with locations which allow routings using the Great Lakes without uneconomic amounts of circuity, such as Michigan plants on Lake Huron, have found Great Lakes systems most economical. On the other hand Indiana plants, depending upon whether or not they will be located on the Ohio River, have chosen rail unit train-barge or unit train only systems, respectively. This Appendix identifies these and other actual and/or planned Western coal transport systems which illustrate how the most economical Western coal transport system can vary with an individual plant's location.

Rail coal unit train plus barge systems are planned for transporting Wyoming Powder River Basin coal to Indiana and Michigan Electric Company's plant at Rockport, Indiana, on the Ohio River.** An additional study beyond the scope of this analysis would be needed to determine how far eastward barges can economically move Western coal. However, it is known that Dayton Power and Light Company's planned Manchester, Ohio (near Cincinnati) plant on the Ohio River has contracted for Eastern Kentucky low sulfur coal.[10]

Coal unit trains only are planned for transporting already contracted Wyoming coal to Northern Indiana Public Service Company's plant in Wheatfield, Indiana (near Gary).[10] This surface system movement and the Rockport one are about half as far as Great Lakes movements.

On the other hand, for plants further east, Great Lakes movements become less circuitous and systems using the Lakes become more economical. For example, Detroit Edison's analysis of a Great Lakes system versus direct coal unit train movement of Western coal from Montana to St. Clair, Michigan, found the former to cost $7, or 50%, less per ton ($14.25 versus $21.35).[3] The firm therefore developed the Great Lakes system for its Montana coal. If an Eastern intermodal transfer cost ($2) and hinterland rail cost (over $10) are added to that Great Lakes system move, its $7 advantage evaporates and unit

*Defined as from Indiana eastward.

**Eastern Kentucky low sulfur coal is also under consideration by the firm but they indicate that at least some of the plant's 8.9 million tons annually will come from Wyoming.[10]

trains have a $5 advantage for high volume (e.g., 4 million tons annually) operations. For the smaller plants in this study with annual coal volumes of one million tons or less, however, CONRAIL estimates an additional $2 to $3 per ton unit train rate.[6] So for hinterland plants such as Dayton, which is about as far from Montana as Detroit Edison's St. Clair plant, Great Lakes systems are roughly comparable to entirely unit train systems. For plants as far eastward as Dresden, New York, CONRAIL indicates that the Eastern portion of direct unit train costs would double,[6] while incremental Great Lakes ship costs would increase only slightly. This results in the latter being far less expensive.

Coal slurry pipelines, while a possible alternative for moving Western coal to Eastern locations, are not considered likely in this corridor because no such pipelines are under study.[11] In addition, for this distance (i.e., about 1300 miles from Wyoming to Ohio) pipelines would be uneconomical for even a large (i.e., 5 million annual tons) plant.[12]

REFERENCES

1. Wendell, R.P., Manager, Purchasing Department, N.Y. State Electric and Gas Corp., personal communications (Dec. 1978 - Jan. 1979).

2. Dibert, W., Assistant Vice President, General Services, Dayton Power and Light Co., personal communications (Dec. 1978).

3. Childs, Paul, Operations Engineer, Fuel Supply Dept., Detroit Edison Co., personal communications (Dec. 1978 - Jan. 1979).

4. Vrooman, Don, Senior Fuel Buyer, Purchasing Dept., Niagara Mohawk Power Corp., personnal communications (Dec. 1978 - Jan. 1979).

5. Fuller, Ward, Special Assistant to the Chairman, American Steamship Lines, personal communications (Dec. 1978).

6. Dooley, Michael, Manager, Utility and Industrial Coal, CONRAIL, personal communications (Jan. 1979).

7. Krohm, Dr. Gregory, Manager, State of Wisconsin Planning and Energy Office, personal communications (Dec. 1978 - Jan. 1979). Dr. Krohm led the team that developed the Argonne National Laboratory Coal Market Model.

8. Farber, Paul, Assistant Chemical Engineer (Coal Scrubbing Cost Analyst), Energy and Environmental Systems Division, Argonne National Laboratory, personal communications (Dec. 1978 - Jan. 1979).

9. Bloom, S.G., et al., *Appendix: Modelling of Economic and Energy Impacts of Flue Gas Desulfurization Systems* in *Environmental Control Implications of Generating Electric Power from Coal - Technology Status Report*, Battelle Columbus Laboratories, Columbis, Ohio (Sept. 1978).

10. Asbury, J., et al., Special Projects Group, Energy and Environmental Systems Division, Argonne National Laboratory, unpublished data, (1978).

11. George, Norman S., *1979 Shaping Up as Great Pipeline Year*, Pipeline and Gas Journal, p. 19 (Jan. 1979).

12. Rieber, Michael, and Soo, Shao Lee, *Comparative Coal Transportation Costs: An Economic and Engineering Analysis of Truck, Belt, Rail, Barge and Coal Slurry and Pneumatic Pipelines, Volume 3: Coal Slurry Pipelines*, Illinois University at Urbana-Champaign, pp. 318-319 (1977).