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ANALYSIS OF BROKERAGE FEASIBILITY FOR UNIT COAL TRAIN SHIPMENTS TO THE MIDWEST

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by

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ABSTRACT

The purpose of this study is to determine the feasibility of aggregating industry and utility demand for coal and serving the demand through a local brokerage operation to reduce transportation cost. This cost saving is associated with the economy of scale of unit train shipments. The delivered price of western coal is calculated for local users in a given midwest subregion based on present utility and industrial coal demand. The broker operation would consist of unit train hauls from western mines, a receiving and storage terminal, local truck or rail transportation from the terminal to each user, and possible transshipment to distant waterfront users. The research focuses on the Green Bay, Wisconsin area. Applicability of this brokerage concept to other areas receiving western coal shipments is also discussed.

1 INTRODUCTION

In order to decrease the country's dependence on foreign energy products by utility and industrial users, the Carter Administration has mandated increasing the share of coal-fired industrial and utility boilers. This will create the need for more coal that is capable of meeting clean air standards. Western mines are the obvious source due to the plentiful amount of low sulfur coals. Western mines have entered long term contracts with many large utilities (1). These long term commitments allow for reduced delivered cost of the coal due largely to the use of unit trains. Small users are unable to capture these reduced costs by virtue of their low volume shipment sizes. As utilities increasingly desire to convert to western coal, and industrial coal-fired boilers become more prevalent, alternative distribution methods may be required to make coal a more cost effective energy alternative for these users.

The objective of this report is to present a concept called a coal brokerage, whereby the coal demand of an area is aggregated and served through a single facility in order to achieve the high volumes necessary to justify unit train service. Once such a system is initiated, it is conjectured that those users too small to individually receive unit trains can begin to capture the cost savings associated with unit train service.

In order to examine the coal brokerage concept closely, the Green Bay-Kewaunee, Wisconsin region was chosen as the site for analysis because: 1) there had been speculation by lower peninsula Michigan utilities concerning a Wisconsin transshipment site for western coal, 2) the area's paper industry is a large coal user, 3) the Wisconsin Energy Office has researched coal consumption in depth, and has an available data base for industrial boilers and their fuel type, 4) line haul rail routes allow for adequate access from western mines to utility and industrial coal users, and 5) there is no single user or facility currently large enough to handle unit train shipments.

In this paper, the existing geographical traits of the Green Bay-Kewaunee region, including the local transportation network, are detailed. Alternative brokerage set-ups and operational strategies are discussed. Total coal demand necessary to substantiate a brokerage and transshipment site is estimated. A detailed description of the line haul rail, terminal/transshipment, and local distribution prices now being paid is given in order to calculate the total costs of coal to the subscribers of a brokerage operation, and these figures are compared with current local coal prices. Finally, the advantages and disadvantages of the brokerage concept are outlined and their application to other sites and bulk commodities is summarized.

2 SITE DESCRIPTION

The Green Bay-Kewaunee region is in northeastern Wisconsin and includes Outagamie, Brown and Kewaunee counties. The area is delimited by Lake Michigan, Green Bay, and the Fox River as shown in Figure 1. The Fox River is navigable only six miles upriver from the bay where the port facilities and major industries are located. The industry in Green Bay primarily revolves around paper products. The paper and pulp mills are located along the riverfront due to their needs for coal shipments and for water. No significant industry is located in Kewaunee.

The industry of the area is relatively stable with no major growth trends evident. No riverfront land is readily available for new industries, and the navigation aspects of the river channel restrict the use of larger vessels now under construction. However, a vacant industrial area along the bay not far from the river, called Bayport, is available for new industry and is the most likely location for a coal broker terminal. The present industrial area has been declared as an environmental nonattainment area, meaning that air pollution levels may force any new industries to locate further away from the present industrial core.

Northeastern Wisconsin's transportation system consists of three railroad companies, adequate highways and streets, and port facilities for Great Lakes shipping. The Chicago and North Western Railway (CNW) and the Milwaukee Road are major railroads serving Green Bay. The Green Bay and Western Railroad (GBW) serves points west to the Mississippi River, where it connects with the Burlington Northern, and a transshipment point at Kewaunee to the east. Figure 1 shows the rail lines which would play a role in increased coal traffic. Potential problems of increased coal traffic are: 1) greater

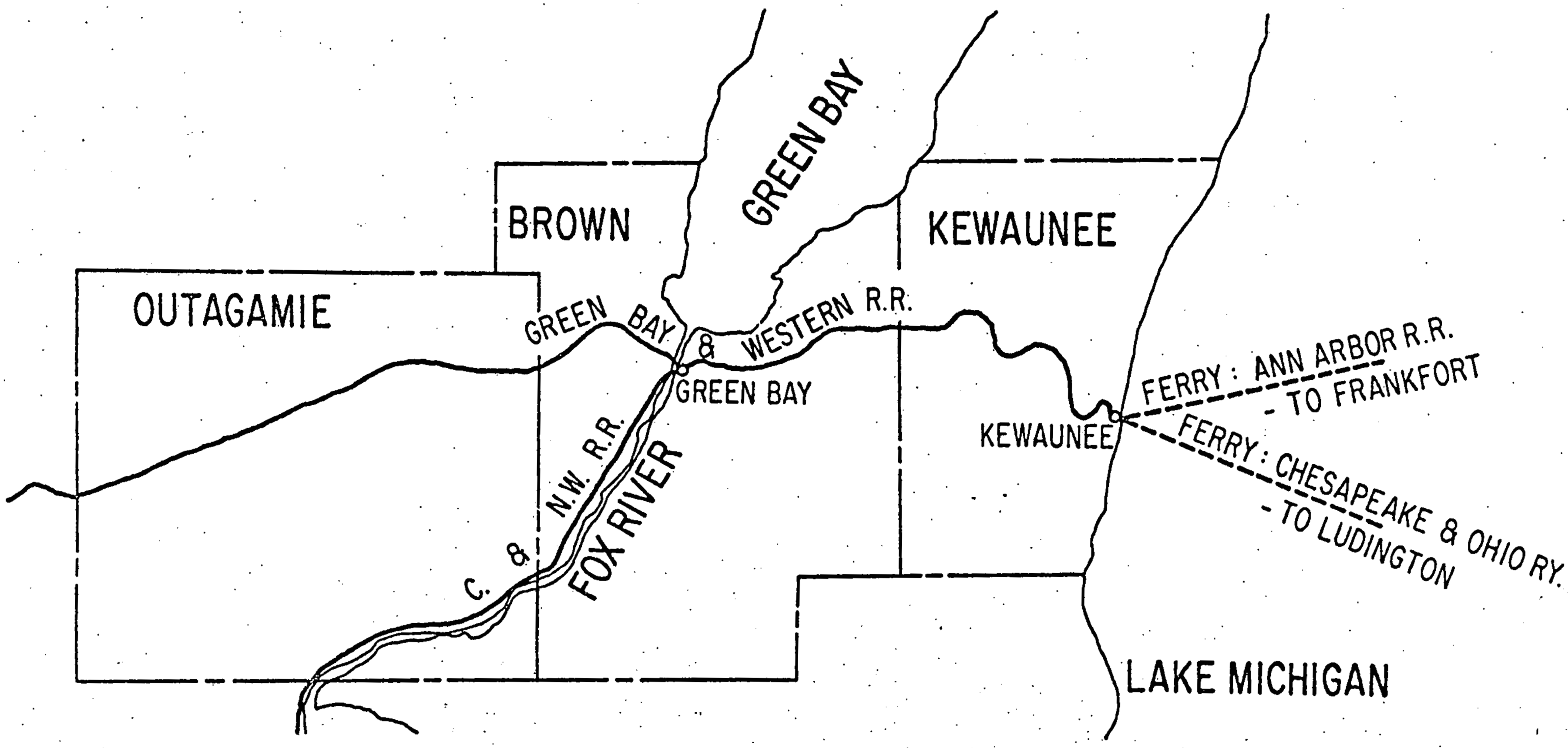

Figure 1. The Green Bay-Kewaunee Region

use of an old GBW bridge over the Fox River which is regularly out of service, 2) the need for heavier rail on the GBW main line, and 3) increased rail traffic in certain residential areas. These problems can be resolved by rerouting and investment.

Green Bay is served by highways linking it with Fox River Valley cities, points along the Lake Michigan shoreline including Kewaunee, and the upper peninsula of Michigan. Three highways form a divided highway belt around the city. The street system is a basic grid adapted to the Fox River, with adequate arterials through main corridors which serve industrial areas well.

Kewaunee and Green Bay both serve as Great Lakes ports and each offer potential advantages as coal transshipping points. The port of Kewaunee is capable of year-round operations and offers a more direct route to Michigan utilities than Green Bay. The port and surrounding area has an acreage constraint affecting coal storage and track layout due to the Kewaunee River wetlands which are protected by the State Department of Natural Resources, and steep bluffs which rise to fifty feet. The Green Bay area has an adequate transshipment site (Bayport) which has plenty of available land for a coal terminal. The Port of Green Bay is planning to build an L-shaped peninsula into the bay to serve larger ships presently unable to navigate the Fox River, but environmental questions about impacts upon the bay and nearby wetlands have been raised. A disadvantage of a Green Bay site is that the port is closed for three to four months of the year due to ice conditions.

3 THE COAL BROKERAGE

The coal brokerage concept focuses on aggregating user demands and utilizing high volume transportation and handling to meet those demands. The concept of consolidating bulk commodity shipping is not new, but its application to coal delivery is uncommon. In agriculture, terminals collect grain from farms for transfer onto rail or barge. In the eastern coal industry, individual carloads of coal from area mines are collected to form unit trains. The coal brokerage concept is different in that coal from one source is distributed to several end users, as opposed to commodities from several points which are collected and transported to one user. The high output of western coal mines allows for the use of one source.

The coal brokerage operation centers on a bulk handling facility. A terminal is necessary for receiving high volume line haul shipments, for storing these shipments, and for distribution to local users. Storage is necessary to smooth out the disparity between batch arrival and continous use of coal. Therefore the operation consists of: 1) high volume transportation from the mine, 2) a receiving and storage terminal, and 3) transportation from the terminal to the user.

The terminal can have a variety of set-ups dependent on site advantages and constraints. A train unloading system is necessary, and can involve bottom dumping, in which hopper cars are emptied from the bottom into a coal pit beneath the track, or involve rotary dumping, in which cars are individually turned over and the coal dumped into a bin. A track layout which minimizes switching and uncoupling is most efficient, but land constraints may require a less favorable layout. A track loop is preferred to parallel holding tracks because of its continuous operating capabilities. A stacking and reclaiming system is needed to move coal from the dumping area onto a stockpile (stacking) and for removal from the stockpile (reclaiming). These tasks can be accomplished by a single stacker/reclaimer, which both dumps and removes coal from the top of the stockpile, or by a system which dumps coal from the top and reclaims from tunnels beneath the stockpile. Lastly, equipment is needed for transfer to other modes, such as stationary shovelers or mobile front-end loaders for trucks and rail cars, and dock-mounted shiploaders for transshipping. Conveyor belts typically connect the unloading, stacking/reclaiming, and loading systems.

3.1 BROKERAGE ALTERNATIVES

The relative advantages and disadvantages of broker sites at Kewaunee and Green Bay, as well as their potential as transshipping sites, created the need for various brokerage alternatives. Each alternative is a type of operation and terminal set-up which could conceivably serve coal demand using the brokerage concept.

The first alternative consists of a major bulk terminal at the Bayport site in Green Bay. Unit train coal would be stockpiled, distributed locally by rail or truck, and also be loaded onto lake vessels for delivery to lower peninsula utilities. Advantages of a Green Bay site include nearness to users, (many within a 3 mile radius), and plentiful land for efficient train unloading and stockpiling. A disadvantage includes the suspension of transshipping in winter months, thereby requiring stockpiling by the Michigan users.

Another alternative is to send a proportion of unit trains to a Kewaunee facility. This would exploit the advantages of year round shipping from Kewaunee. For example, unit train deliveries might alternate between Kewaunee and Green Bay. Therefore the second alternative would include building two smaller terminals. The Green Bay site would receive, store, and distribute coal as before, but without transshipping. The Kewaunee site would receive, store, and transship the coal to Michigan utilities. Disadvantages include the loss of scale economies from using two smaller terminals, and limited land for storage at the Kewaunee site.

A third alternative is a modification of the second, and addresses the storage problem at Kewaunee. The need for storage can be eliminated if coal is loaded directly onto a vessel from the unit train. Less equipment and less land are meeded in this set-up. A disadvantage is the requirement of accurate timing between rail and vessel arrivals.

Other alternatives were considered but rejected for various reasons. A single central facility in Kewaunee was rejected because of the storage problem and because of the 35 mile westward "backtrack" from Kewaunee to the Green Bay users. The distance is not economically wise for a large volume trucking operation and could have serious local roadway maintenance and environmental impacts. Another idea involved the unit train dropping off a specified number of full hopper cars in Green Bay on its way to Kewaunee. The cars would be locally distributed without the need for a terminal facility in Green Bay, while the rest of the train was unloaded at a Kewaunee facility. The major problem here is that unit train rates would not apply due to the breaking of the train.

4 UTILITY AND INDUSTRIAL COAL USE

The utilities in Wisconsin and Michigan that will be most likely to benefit from any new western coal distribution from the Green Bay-Kewaunee area are Pulliam in Wisconsin and Muskegon, West Olive, Holland, and a new power plant to be sited in Grand Haven, on Michigan's lower peninsula. Demand data for 1972-1978 utility coal use along with new power plant coal utilization data from a telephone survey was used to get base year and projected coal utilization for each utility site (1). The data consists of a listing of all coal using utilities, their source of coal, the type of haul, heat content, sulphur emissions, and price.

Wisconsin utility coal demand studied was at the Pulliam plant in Green Bay. Coal demand was relatively constant throughout the 1972-1978 period. No new boilers have come on line, and it is expected that this will be the case in the future due to the stable nature of the area economy. Table 1 shows the present demand at the Pulliam plant and the projection demand based on no new boilers or increase in coal demand.

The present and projected coal tonnage requirements for the Michigan plants are shown in Table 1. The table shows that there is growth only in the Muskegon site where additional facilities are under construction. The new Grand Haven power plant is scheduled to be operational by 1982.

Projected industry coal use in Green Bay is included in Table 1. The total industrial coal use is about 810,000 tons per year based on Wisconsin Energy Office data. The industry coal demand, largely generated by paper and pulp mills, is projected to remain constant.

Boiler conversions from oil and natural gas to coal may occur as a result of decontrol of prices for these fuels. Location will play a role in the extent

TABLE 1

Projected Coal Demand of Industries and Utilities

(10^3 Tons)

Site	Base Year Value 1978	1980	Projection Years 1985	2000
WISCONSIN				
Green Bay industries	810	810	810	810
Pulliam utility	767	767	767	767
MICHIGAN				
Muskegan utility	1366	3308	3308	3308
West Olive utility	1416	1416	1416	1416
Holland utility	146	146	146	146
Grand Haven utility	0	0	212	212
Total	4505	6447	6659	6659

Source: Ref 1, and Wisconsin Energy Office data.

of conversions due to the designation of the industrial core as a nonattainment area. Users that are potentially the strongest candidates for conversions will not alter the aggregate industrial demand substantially.

5 COST ANALYSIS

5.1 BROKERAGE OPERATION COST COMPONENTS

An important aspect of brokerage feasibility is its cost competitiveness with present coal delivery operations. If the delivered price of western coal to users via a broker is not competitive with present prices, the brokerage will not be economically feasible. A way of deriving the delivered price is to identify the cost of each component for a mine-to-user journey. Such components include FOB mine costs, unit train rates, brokerage facility costs, local distribution costs, and Great Lakes shipping costs for Michigan users. Estimates of these costs by the alternatives are shown in Table 2 and were obtained by surveying similar present day operations.

FOB (freight-on-board) mine cost is the price charged for mining coal and loading it onto a railcar. This price is primarily dependent upon the type of mine and the amount of coal purchased. Since our interest centers on western coal, the FOB mine cost shown is for the Decker Mines of Montana and assumes the purchase of 4 million tons per year (II). The total of Green Bay utility and industry demands and eastern Lake Michigan utility demands is likely to exceed this amount.

Unit train rates are dependent on distance traveled and annual tonnage. It is difficult to obtain a point estimate for a given distance and tonnage, so rate ranges are shown in Table 2. This data applies to a 1031 mile Decker-Superior route, and is used due to geographical similarities with a Decker-Green Bay route (II). The latter route is roughly 100 miles longer, and is not likely to significantly affect this rate range.

Handling costs at the brokerage facility depend on the capacity and capabilities of the terminal. The transshipping cost of $1.50/ton shown in

TABLE 2

Estimated Costs of Western Coal for
Three Alternative Locations ($/ton)

Price Component	Green Bay	Green Bay/ Kewaunee	Green Bay/ Kewaunee (no storage)
	Western Coal for Terminal Location Alternatives		
FOB Mine*	11.00	11.00	11.00
Unit Train	10-14.00	10-14.00	10-14.00
Broker Facility			
a. Green Bay	1.50- 2.25	1.50- 2.25	1.50- 2.25
b. Kewaunee	-	1.50- 2.25	.50- .85
Great Lake Vessel			
a. Green Bay to Mich.	1.11		
b. Kewaunee to Mich.		.63	.63
Local Distribution			
a. Rail	1.68- 2.84	1.68- 2.84	1.68- 2.84
b. Truck	1.00- 1.50	1.00- 2.50	1.00- 2.50
Delivered Price:			
Wisconsin, by local rail	24.18-30.09	24.18-30.09	24.18-30.09
Wisconsin, by local truck	23.50-28.75	23.50-28.75	23.50-28.75
Pulliam	22.50-27.25	22.50-27.25	22.50-27.25
Michigan	23.61-28.36	23.13-27.88	22.13-26.48

*Freight-on-board mine Costs

the table has been confirmed by a coal terminal engineering firm as an industry standard for a facility of medium to high capacity (10 million tons per year or more) with rail dumping, storage, and shiploading capability (II, III). Such a facility would be required in the first alternative if the brokerage operation is located in Green Bay. The second alternative requires two smaller terminals, and the throughput cost rises as expected. The $1.95/ton price is interpolated from estimates of $1.50 for a 10 million ton per year facility and $2.25/ton for a 2 million ton per year facility, assuming the need for a five million tons per year facility at each site (III). A range of $.50/ton to $.85/ton for direct rail-to-water transfer without storage capability is shown under the third alternative. The price of $.85 has been quoted by an Illinois mining company and by a New York utility (IV, V).

Transshipping coal to Michigan utilities involves a Great Lakes shipment from the brokerage site. The figures in the table assume 6 mills per ton-mile with an average trip length of 105 miles from Kewaunee to Michigan and 185 miles from Green Bay to Michigan (II, VI). The Michigan utilities considered are on lakefront sites, and the assumption is made that there is no need for local truck or rail transfer. The cost of unloading is assumed to be included in the Great Lakes vessel shipping cost.

Local rail and trucking figures were obtained from conversations with local railroads and paper companies, since such rates are very site specific. The tariff ranges from $1.68/ton for a local switch by the Green Bay and Western Railroad to $2.84 for a 20 mile movement between Green Bay and Kimberly, Wisconsin by the Chicago and North Western Railway (VII, VIII). The two rates thus set a range for local rail distribution. The local truck haul rate paid is $1.00/ton for a 2 to 3 mile truck haul (IX).

5.2 COST COMPARISON

The delivered prices for the various delivery modes and destinations are obtained by adding appropriate price components. For example, delivered price to Green Bay by rail (shown in Table 2 as "Wisconsin by local rail") is the sum of FOB mine, unit train, Green Bay broker facility, and local rail costs, while delivered price to Michigan utilities is the sum of FOB mine, unit train, Kewaunee or Green Bay facility, and lake shipping costs. The Pulliam price is a special case in that the utility's location next to the brokerage site decreases or eliminates local distribution costs.

Before a comparison of present prices and estimated broker prices can be made a conversion is necessary. Eastern and western coals differ in their heat content, so that examining prices paid per ton of coal is not an accurate method of comparing prices paid for energy. The estimated delivered prices of Table 2 have been converted to dollars per million Btus, assuming a heat content of 9600 Btu/lb. for Decker coal (II), and are shown in Tables 3 and 4. Current prices paid by Green Bay and Michigan utilities and Wisconsin industries are also shown and were obtained by assuming 12000 Btu/lb for the eastern and midwestern coal presently used.

In comparing current prices with estimated broker prices, several observations can be made. Broker prices to the Pulliam generating plant in Green Bay are within the same range of prices presently paid (see Table 3). This means that western coal prices via a broker do not offer substantial cost savings for the plant but are competitive. Western coal through a Wisconsin terminal costs more than current prices for the Michigan utilities, however (see Table 3).

It is understandable that broker coal does not offer substantial cost savings to utilities because the volumes of coal used are relatively high and

TABLE 3

Price of Coal Delivered to Pulliam Green Bay and Lower Michigan Utilities ($/MBtu)

Utility Sites	Eastern and Midwestern Coals*	Western Coal for Terminal Location Alternatives: Green Bay	Green Bay/ Kewaunee	Green Bay Kewaunee (no storage)
Pulliam (Wisc.)	1.22-1.33	1.17-1.42	1.17-1.42	1.17-1.42
Muskegon (Mich.)	.98-1.35	1.23-1.48	1.20-1.45	1.15-1.38
West Olive (Mich.)	1.15-1.64	1.23-1.48	1.20-1.45	1.15-1.38
Holland (Mich.)	1.69	1.23-1.48	1.20-1.45	1.15-1.38

*Assumes 12,000 Btu/lb

Ref I

TABLE 4

Delivered Coal Prices to Industrial Users ($/MBtu)

Annual Amount Used (10^3 Tons)	Eastern and Midwestern Coals*	Western Coal for Terminal Location Alternatives: Green Bay	Green Bay/ Kewaunee	Green Bay/ Kewaunee (no storage)
0 - 50	1.87-2.08	1.22-1.56	1.22-1.56	1.22-1.56
51 -100	1.66-1.87	1.22-1.56	1.22-1.56	1.22-1.56

*Assumes 12,000 Btu/lb.

Ref I

have already enabled high volume purchases and forms of delivery. Industrial users, however, are more likely to realize cost savings from a broker due to the higher purchase and transportation prices paid for lower volumes of coal. For example, the Pulliam plant pays \$30 to \$35 per ton of eastern coal, whereas Green Bay industries using less than 50,000 tons per year pay \$45-50 per ton. Table 4 shows that a coal brokerage would indeed provide substantial cost savings to Green Bay industries. The magnitude of possible savings can be illustrated by the fact that a saving of \$.50/MBtu for a plant presently burning 50,000 tons of eastern coal per year will result in a total saving of \$600,000 per year.

6 FINDINGS

A cost analysis of brokerage alternatives shows that western coal via a broker can offer significant savings for the Green Bay industrial users. Prices of broker coal are competitive with prices presently paid at the Pulliam plant in Green Bay; however, the brokerage coal does not seem to be cost competitive for Michigan utilities.

The Michigan utility demands comprise a significant portion of the total demand (Table 1) and are important in supporting the volume assumed in the cost analysis. Therefore, the feasibility of a brokerage in this area appears to be contingent upon the Michigan utilities' decision to use western coal despite the price disadvantage.

Air quality standards play a large role in the decision and will favor western coal if they are not relaxed. It is likely that Michigan utilities may favor western coal due to its slower price escalation, since Eastern coal prices have risen faster than western coal prices, due to labor demands and mining techniques. These factors suggest that western coal use on the lower peninsula of Michigan may well become widespread enough to justify the volumes assumed in this study.

Other issues and assumptions underlie the above conclusions of this study, such as: 1) demand projections have been based upon present stringent air quality standards, 2) it has been assumed that all coal users are capable of using western coal, 3) infrastructure issues affect the feasibility of a brokerage and have not been addressed, e.g., the owner or operator of a brokerage could be a utility, coal company, shipping company, or railroad company, which could affect the type of operation, location, and prices charged, and 4) pricing policies, such as pricing based on quantity purchased, have not been examined.

7 FURTHER CONSIDERATIONS OF A COAL BROKERAGE

The criteria for evaluating the feasibility of a coal delivery system, such as the brokerage operation, include more than the delivered prices per unit of coal. Environmental, economic, land-use, and regulatory considerations need also be explored.

By allowing for unit train movement, western low-sulphur coal can be made available to small users. Depending on federal policy, the use of low-sulphur coal can be an alternative to large investments in high-cost scrubbing equipment. By burning the low-sulphur coal, government-imposed air quality standards are more easily met, possibly resulting in increased coal use even in non-attainment areas.

The broker/terminal operation simplifies the process of contracting for coal supplies for certain individual firms (particularly utilities). Rather than contracting volumes and rates separately with the mine, railroad or line haul mode, and intermodal facilities, the firm need only deal with the broker representative who will have made these separate contracts as part of his/her operation and include them in the single rate negotiated and agreed upon.

Since all coal users, large and small, will be served by a local high-volume broker, there is less need for individual firms to stockpile coal at their respective plant sites. The single local storage location of coal would allow local plants to more productively utilize land currently set aside for on-site coal storage. In those regions where land rents are high, or the availability of vacant land is tight, this can allow a firm to expand its plant without being restricted by local land constraints.

Aggregating the demands of a number of relatively small coal users and serving them through a single broker presents some possible disadvantages, also. In order to justify unit train service and for the terminal to receive and locally distribute the coal, some commitments must be made by large users in order to insure that minimum volumes can be achieved. Without such support, the establishment of a broker operation is too risky an investment. Small users, on the other hand, may not be willing to commit themselves to one source of coal, preferring instead to buy coal on the spot market in hopes of purchasing coal at the lowest current rates.

To achieve the necessary volumes for cost savings, a single coal broker will be the sole distributor to a region. The local supply of coal to the region's industries and utilities is tied closely to the operation of the broker system. If any component fails or closes down for any number of reasons (equipment breakdowns, weather, strikes, etc.), the local economy may be affected. The lack of any individual firm storing coal, though it means that the land can be put to more productive uses, also means that coal supply is tied directly to the smooth operation of the broker. Interrupted service for even a day can conceivably lead to disruption of plant operation. Measures must be taken to insure that such a relationship does not exist and that the local economy will be protected from short-term interruptions.

Depending on the organizational infrastructure of the broker, a monopoly or cartel on coal for the subregion results. Though the economies of scale and their resulting cost savings are achieved, smaller local users may not be able to achieve a corresponding price reduction if the broker decides to price as a monopolist and maximize his profits.

The brokerage concept is applicable to other regions and commodites as well. An area with total coal demand high enough to justify unit train delivery can be considered a candidate for a brokerage operation. Other necessary attributes include adequate rail access to western coal mines, moderate concentration of coal users to minimize distribution costs, adequate roadway or rail access to local users, adequate land for coal storage, and minimal environmental impacts of site development. Access to waterborne transportation is desirable because the ability to serve distant coal users on waterfront sites will increase the volume handled and enable further cost reductions associated with such higher volumes. A brokerage can serve other commodities as well so long as an area's transportation, location, and demand attributes are similar to those mentioned above.

A trend is developing in new terminals which indicates potential growth of the brokerage concept. New terminals are being designed for several users and/or commodities. For example, the Hall Street Coal Terminal in St. Louis was designed to use excess handling capacity for customers other than its primary customer, and is capable of storing several types of coal separately. Also, Detroit Edison is seeking coal customers to buy excess capacity at its new Superior terminal. The emergence of such multi-user bulk terminal facilities indicates a growing interest in exploiting the scale advantages of large shipments and terminals.

REFERENCES

I. Asbury, J., Caruso, J., et al., A Survey of Electric Utility Demand For Coal, Energy and Environmental Systems Division, Argonne National Laboratory, SP6-10, September 1979.

II. Bertram, K., Delivered Costs of Western Coal Shipped on the Great Lakes Versus Eastern Coal for Eastern Great Lakes Hinterland Utility Plants, Informal Report, Energy and Environmental Systems Division, Argonne National Laboratory, ANL/EES-TM-39, February 1979.

III. Norwood, J., Dravo Corporation, personal communication, July 1979.

IV. Roberts, G., Freeman United Coal Company, personal communication, July 1979.

V. Vrooman, D., Niagara Mohawk Power Corporation, personal communication, August 1979.

VI. Greene, R., Economics of Barge Transportation of Coal, Critical Issues in Coal Transportation Systems: Proceedings of Symposium, Maritime Transportation Research Board, National Research Council, 1979.

VII. ICC tariff 17104-C, item 234.

VIII. ICC tariff 6639, item 570

IX. Prince, C., Proctor Gamble Co., personal communication, August 1979.

X. The Direct Use of Coal, Prospects and Problems of Production and Combustion, Office of Technology Assessment, Congress of the United States, Washington, D. C., OTA-E-86, April 1979.

Xo. The Minnesota Coal Study, An Interim Report to the Legislature, Minnesota Energy Agency, St. Paul, Minnesota, January 1978.