MARKETING CONSIDERATIONS FOR AN EASTERN OIL SHALE DEMONSTRATION PLANT

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Under funding from the United States Department of Energy and the Indiana Corporation for Science and Technology, Cliffs Engineering Inc. and Allis-Chalmers carried out a design study in 1986 for a 600 barrel per day shale oil demonstration plant in southern Indiana.

A part of that study included a marketing analysis of the problem of finding a market for the raw shale oil plus approximately 100 tons per day of sulfuric acid which would be produced as a by-product.

The project would be located near Henryville, Indiana as shown in Figure 1. The design basis for the marketing study was 643 barrels of shale oil per day, and 105 tons per day of 96 percent sulfuric acid. The study did not address possible minor by-products, such as uses for the spent shale.

It was assumed that the project would operate for a period of one and a half to two years. It is unlikely that operation would be continuous during the whole time period. The marketing study addressed only the

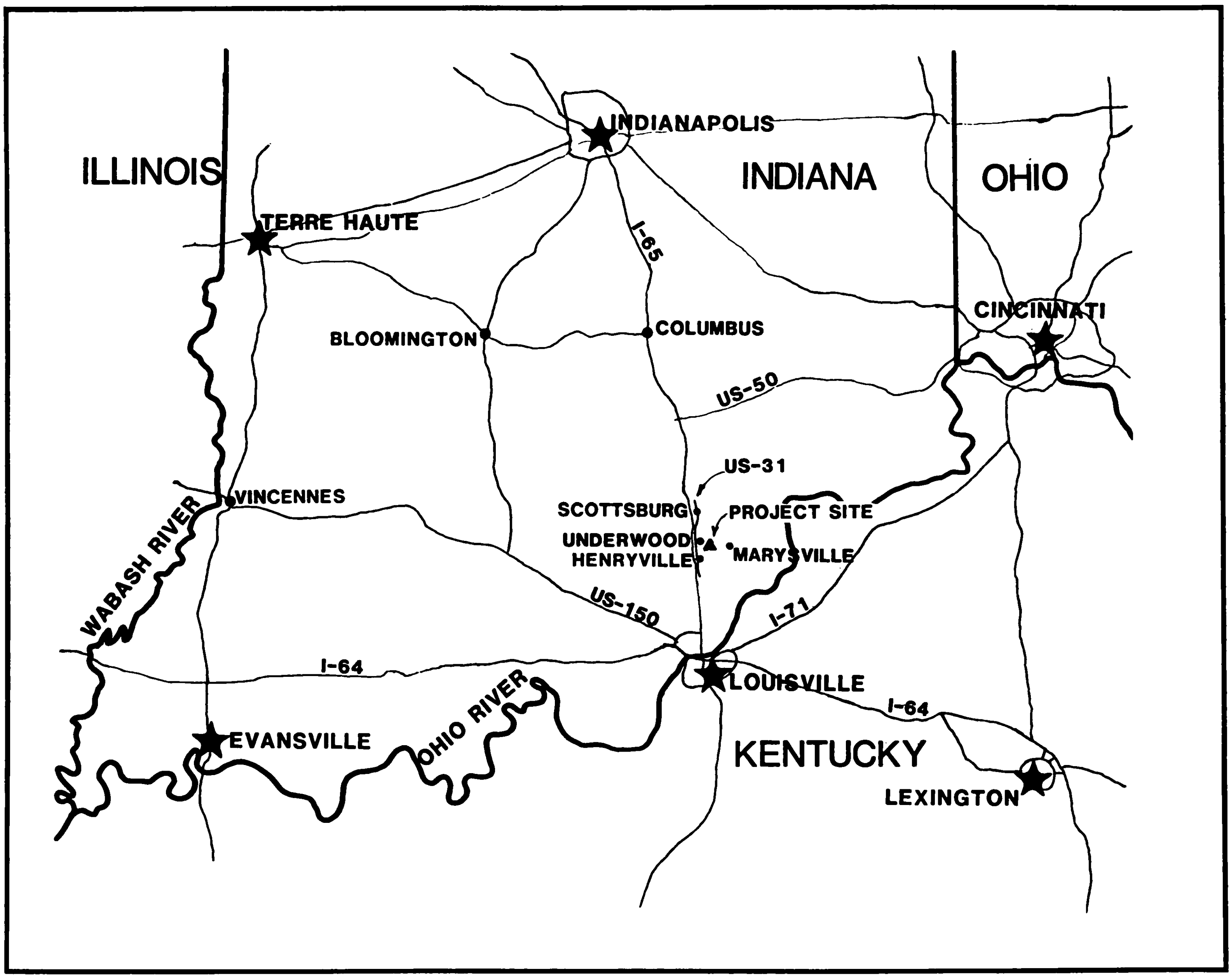

FIGURE 1. Project Site Location

production from the demonstration plant. It did not consider the problem of marketing from an eventual commercial-size operation.

PRODUCT CHARACTERISTICS

The plant design resulted in four different oil streams to be recovered at different condenser temperatures. Calculated compositions of these four streams are given in Table 1.

Allis-Chalmers estimated that the total combined stream would have an API gravity of 29. Oil which was collected from the Allis-Chalmers Process Demonstration Unit was analyzed by J & A Associates of Golden, Colorado, with the results given in Table 2. The PDU did not have efficient enough condensers to capture all the light ends. Nevertheless, the bulk of the oil was expected to be similar to the "whole oil" column in Table 2. Those properties were used as the basis for marketing analysis.

POTENTIAL MARKETS

For refining purposes, shale oil produced by the Allis-Chalmers process is expected to have a moderate sulfur content, but very high nitrogen content. In addition, it may contain appreciable concentrations of oxygen, arsenic, and finely dispersed particulate matter. Because of these qualities, the shale oil would be considered an unacceptable feedstock to conventional refineries in the project region. The major problem is the nitrogen content. Both the operation of the refinery (catalyst poisoning) and the quality of the products could be adversely affected. Although the nitrogen content of eastern shale oil may be slightly lower than for the western shale oils on which extensive refining research has been done, the problems would be expected to be equivalent.

The relatively small production rate planned, and the limited production period mean that developing refinery capability for upgrading would not be practical. The study therefore focused on sale of the raw shale oil as a fuel oil blend stock.

TABLE 1

APPROXIMATE COMPOSITIONS OF OIL STREAMS
FLOW RATES, LBS/HR

Component	Stream 1	Stream 2	Stream 3	Stream 4
Methane	0.1	0.1	2.6	0.1
Ethylene	0.0	0.0	1.0	0.1
Ethane	0.2	0.4	8.8	0.9
Propane	0.6	1.40	25.4	5.7
N-Butane	1.5	4.3	61.0	25.6
N-Pentane	4.0	14.4	123.0	60.7
N-Hexane	10.4	43.8	177.1	49.5
N-Heptane	24.9	106.4	170.0	19.1
N-Octane	56.6	185.8	103.4	4.1
N-Nonane	112.0	223.5	44.2	0.6
Cut 362	270.6	154.7	8.2	0.0
Cut 409	335.1	75.6	1.1	0.0
Cut 454	510.3	43.9	0.2	0.0
Cut 499	768.4	23.9	0.0	0.0
Cut 544	843.9	9.0	0.0	0.0
Cut 589	901.8	3.1	0.0	0.0
Cut 657	1,763.4	1.0	0.0	0.0
Cut 763	838.4	0.0	0.0	0.0
TOTAL	6,442.2	891.2	726.2	166.4
Temperature, F	200	100	100	-43
Pressure, PSIA	14.86	14.86	215	15.5
Molecular Wt	198	119	74	60
Density, lb/cu ft	56.4	46.5	38.8	44.7
Viscosity, cp (at temp)	0.84	0.56*	0.29*	0.50*

*Computer generated values

NOTE: Stream 1 is oil recovered in the coalescer/cooler and the electrostatic precipitator
Streams 2, 3, & 4 are dewatered oils recovered at various points in the light hydrocarbon recovery system

TABLE 2

ANALYSES OF DISTILLATION CUTS

	Whole Oil	Naphtha IBP-400F	Diesel 400-650F	Gas Oil 650-837F	Resid 837F+
Vol % of Whole Oil	100.0	4.1	28.6	26.5	40.6
Wt % of Whole Oil	100.0	3.4	26.1	26.4	43.6
API Gravity	11.3	42.5	25.2	11.6	1.7
Carbon, w%	85.4	85.3	85.5	85.5	86.2
Hydrogen, w%	9.9	12.5	11.1	9.9	8.9
Nitrogen, w%	1.4	0.2	0.6	1.4	2.0
Sulfur, w%	1.3	1.2	1.3	1.4	1.3
Ash	0.3	NA	NA	NA	0.4
Oxygen (by diff)	1.8	0.8	1.5	1.9	1.3
Ramsbottom C, w%	4.9	NA	NA	0.6	NA
Conradson C, w%	8.0	NA	NA	NA	18.6
Arsenic, ppm	19	NA	NA	17	36
Nickel, ppm	16	NA	NA	2	35
Vanadium, ppm	5	NA	NA	1	11

Fuel oils No. 4 through No. 6 are usually produced from residual oils, blended with varying proportions of distillate. To differing degrees, raw shale oil can meet the ASTM specifications for residual fuel oils.

For all grades of fuel oil, the flash point of the whole shale oil is likely to be lower than the minimum acceptable fuel oil flash point (130°F to 140°F). This problem of low flash point could potentially be solved by blending the shale oil with conventional residual fuel. Alternately, the raw shale oil flash point could be modified by adjusting the condenser temperature so that the low-boiling compounds are pulled off in a separate stream.

Some samples have shown a high pour point for shale oil which exceeds the maximum allowable value for No. 4 fuel oil (20°F). For fuel oils No. 5 and No. 6 a high pour point should not present any problems.

Viscosity specifications should not present a serious problem when using raw shale oil as a residual fuel oil. However, it is estimated that the viscosity will be less than fuel oil specifications. ASTM specifications note that "fuel oil falling in the viscosity range of a lower numbered grade down to and including No. 4 may be supplied by agreement between purchaser and supplier". Hence, a low viscosity raw shale oil should not be a problem if a customer can modify the equipment and/or mode of operation to accommodate the low viscosity. This normally means changing burner nozzle orifices to give the proper flow rate at the lower viscosity. Otherwise, the viscosity could be increased by blending with another residual fuel oil. Some shale oil samples have shown an ash level which is above specifications (0.1 weight percent for No. 4 and No. 5) and would be a problem for some customers. Allis-Chalmers anticipates filtering the oil and therefore ash would not be a problem if filtering is successful.

In order to meet user specifications for sulfur, viscosity and flash point, shale oil would have to be blended into other residual fuel stocks. It is possible that compatibility problems could arise. Distillate fuels with inadequate solvent power will precipitate asphaltenes when blended into severely vis-broken residual fuels. Tests with shale oil would be necessary to assure that a similar problem would not occur.

POTENTIAL BUYERS

Although some oil is burned by electric power plants in the project region, the only viable market for sporadically produced raw shale oil appears to be the industrial fuel oil market.

The fact that the shale oil will have to be blended to meet flash point, sulfur and ash specifications for many customers means that it would be impractical to sell to final consumers directly from the plant. The shale oil will have to be sold to an intermediate dealer with blending capabilities.

There are relatively few dealers and distributors of residual fuel oils in the region. The members of the Indiana Oil Marketers Association basically handle nothing heavier than No. 2 oil. Only three of the independent oil marketers supplying burner fuel to military installations in Region 3 handle No. 6 oil. The most likely buyers are composed of the closest local refineries plus a few large regional resellers.

Cincinnati is the location of the largest independent blender and distributor of black fuel oils (higher numbers than No. 2) in the nearby area. This is probably the only location handling enough fuel oil volume to take 600 barrels per day and blend to a low sulfur level. Because they also do blend No. 2, No. 4, and No. 5 oils, they could perhaps blend off the light ends successfully.

TRANSPORTATION

Approximate highway mileages from the project site to major industrial centers are given in Table 3. No road problems would be expected for oil tank trucks once on Highway 31. From the project site to Highway 31, a distance of something less than a mile, will require special road considerations.

TABLE 3

APPROXIMATE HIGHWAY MILEAGE FROM PROJECT SITE TO MAJOR CENTERS

Louisville, Kentucky	24
Cincinnati, Ohio	113
Indianapolis, Indiana	94
South Bend, Indiana	234
Gary, Indiana	247
Terre Haute, Indiana	134
Evansville, Indiana	135

Oil shippers and trucking companies in the region offered a wide range of cost estimates for transporting the oil overland, from $1.00 to $1.90 per barrel per 100 miles. Since some of these estimates are based on experience with hauling No. 6 oil, which has to be kept hot, the lower range should apply to shale oil, which does not have to be heated.

Within the expected mileage radius (113 miles), there would be no advantage to shipping by rail. Hauling from the project site to a rail siding would have to be by truck in any case.

Based on data for the regional usage of No. 6 fuel oil, it is possible that the market in the project region will simply be too thin to absorb the project output as blending stock, particularly if the sulfur level comes out slightly higher than expected. In that case, the logical solution will be to move the shale oil down river to the Gulf Coast, where large markets as No. 6 fuel oil or as bunker C can be found. The project output of 600 barrels per day would take about two weeks to fill a small barge, so an intermediate storage tank in the dock area might be required. Barges can be loaded at Jeffersonville, Indiana, directly south of the project site and across the river from Louisville, Kentucky.

In essence there are two potential markets for the shale oil as a blending stock for residual fuel oil. One is the local regional market, for which Cincinnati is the closest outlet which might be large enough to absorb the total production. The other is the Gulf Coast market, which would be reached by barge. Netback calculations for the two cases are given in Table 4. These calculations have been updated to March, 1987. If adequate regional markets can be found, an increased netback of about $1 per barrel should be realized.

TABLE 4

NETBACK PRICES TO PROJECT SITE
(BASED ON MARCH, 1987 PRICES FOR NO. 6 FUEL OIL)

	Case 1 Cincinnati Market	Case 2 New Orleans Market
Gulf Coast Posting	16.00	16.00
Truck Transport	-1.40	-0.67
Intermodal Transfer		-0.35
Barge Transport to Gulf		-1.50
Brokerage fee	-0.25	-0.25
Netback to Project	$14.35	$13.23

SULFURIC ACID

Disposing of 100 tons per day of sulfuric acid from the project site in southern Indiana would probably require a marketing radius of 100 to 150 miles. Using 125 miles as the average haul, transportation costs would be in the neighborhood of $17.50 per ton.

The characteristics of the Haldor-Topsoe sulfuric acid process and of the Allis-Chalmers retorting process suggest that a high-quality product should result. One possible concern is for nitrogen oxides. Until operating data are available, however, there is no way of knowing if this will be a problem.

The chief problem which will be faced in marketing acid production from the pilot is the planned short-term duration of the project. Also, because pilot plants normally encounter numerous start-ups and shut-downs, production will not be constant during the project period. It will be impossible to guarantee delivery to satisfy a customer's needs. An output of 100 tons per day is too large to absorb into the local merchant sulfuric acid market. Repackagers who buy acid in bulk and then repackage into drums and tank truck quantities indicate that they would not be able to take such a large quantity.

Because of the obvious difficulties in attempting to market directly to the consumers in this situation, the most logical approach would be selling through an established broker. Such a broker will have a number of potential buyers to whom he can supply acid from this source or others, depending on the plant's operating schedule.

An estimated breakdown of the netback price components is given in Table 5.

Thus the netback revenue from sulfuric acid could amount to more than half as much as the revenue from the shale oil.

TABLE 5

NETBACK PRICES TO PROJECT SITE FOR SULFURIC ACID

Competitive Delivered Cost	\$55-\$65/ton
Minus Transportation	\$15-\$20/ton
Minus Brokerage Fees	\$5/ton
Netback to Plant	\$40-\$45/ton