TRANSPORTATION AND MARKETING OF SHALE OIL

Gary L. Baughman, Ph. D.
Ronald L. Gist
Edwin H. Bentzen

Colorado School of Mines Research Institute
Box 112
Golden, Colorado 80402

Historically, oil shale developers have tacitly assumed that if and when they began producing shale oil and other products, somebody would be ready and willing to buy them. Considering all the technical, economic, environmental, political, and institutional problems facing the developers, this assumption was reasonable. In fact, during recent "severe" liquid fuels shortages, the assumption may have been perfectly valid. With the current energy situation, fuels pricing structure, political environment, and the nearing commercial reality of oil shale development, the assumption that a ready market exists for oil shale products requires further examination.

Not only must a developer determine whether someone will buy the products, but he must also determine what that prospective buyer will pay. The selling price of shale oil was historically assumed to be the price of conventional crude oil less some penalty for its high nitrogen content and pour point. Because the economics of oil shale production were not very precise, this was a reasonable approach. As the day of commercial production nears, however, construction cost estimates are becoming more refined, and costly design decisions are being made based on the marketing and transportation options anticipated. Estimates must be made, then, as accurately as possible regarding the ultimate disposition of the products to ensure that costly design errors are not made at this critical point in the planning program.

One interesting aspect of the transportation and marketing question is that the constraints and input parameters keep changing with new technology developments, revised product pricing structures, new environmental regulations, and changes in the availability of and demand for conventional and alternate fuels. A perfectly logical choice of transportation method and market made today may be totally unrealistic next year. For instance, several years ago a suggested market for raw shale oil was as a boiler fuel in California, with transport by a pipeline. Today, the EPA questions the acceptability of burning shale oil, California has more than an adequate supply of boiler fuel, and existing pipelines are now pumping Alaskan oil eastward out of California. Similar observations can also be made regarding coproducts such as ammonia, sulfur, and coke. Even the perceived demand for nahcolite and soda ash may fall victim to as yet unforeseen events.

Because the information that must be processed to arrive at a final decision is constantly changing, developing a system to manage this information is necessary. This system must permit the information to be processed quickly, yet be flexible enough to respond to changing conditions. A methodology developed by Colorado School of Mines Research Institute satisfies these criteria, but to discuss the solution would be premature until the scope of the problem is first defined. Disposing of shale oil in the most economical fashion consists of two separate, but related, problems -- marketing and transportation. Addressing the marketing question, the first task is to define what is being marketed. That is, either raw shale oil, an upgraded product, or some intermediate-quality product can be marketed. Next, the quantity of the particular product to be marketed must be defined. In the initial stages of production, whether that be from a so-called demonstration plant or a single train of a larger operation, the output will likely be several thousand barrels per day. At full commercial production levels, perhaps as much as 50,000 to 100,000 barrels per day will be produced. Some markets will be more amenable to one production level than another and the costs per barrel for processing, in particular upgrading, will be significantly different for the two production rates.

Raw or upgraded shale oil may be marketed at a number of locations and may be used for several different purposes. In general, three basic uses exist for raw or upgraded shale oil -- as a boiler fuel, a refinery feedstock, and a petrochemical feedstock. Some market sites exhibit all three uses; others, only one or two.

Associated with each of these markets, by both location and use, is a selling price -- the price the shale oil product would bring at the buyer's plant gate. However, these figures are based on the assumption that the buyer wants the product, and this may not be a valid assumption. For instance, a particular shale oil product may be physically and chemically equivalent to a No. 6 fuel oil currently being fired in a utility boiler. The market value of the product could then be assumed to be equivalent to the price paid for the fuel oil, but if the utility company has a long-term contract with a dependable fuel oil supplier, the calculated market value is meaningless because a market really does not exist.

A similar example is the marketing of raw shale oil as a refinery feedstock. To calculate the market price of the product, it is possible to determine a value that could be subtracted from the price of a conventional feedstock to adjust the price of the shale-derived product downward to account for high pour point, nitrogen, and trace metals content. However, the refiner would only pay that price if the necessary equipment were available for processing the raw shale oil, and very few refineries currently possess that capability. Likely, he would rather pay the higher price for an oil he can handle.

Simplistic economic approaches are, therefore, inadequate for properly evaluating a potential marketing strategy, because associated with each marketing option is a market "quality" rating. This rating is a function of many factors, including availability of other crude supplies, long-range corporate plans, market size, and others. Figure 1 illustrates the market-related aspects that have been discussed so far.

Having now defined the market location and end use, the expected price, and the quality of the market, the next question to be addressed is how to get the product from the oil shale plant to the buyer's plant. Several transportation methods may be available, but it may not be advantageous to use the same method all the way to the buyer's plant. Rather, intermediate transfer points may be used to change from one mode to another, often to great advantage.

Essentially three transportation methods are available for shale oil transport -- railroads, pipelines, and trucks -- each with its own advantages and disadvantages. Except for some situations in which truck transport may be ruled out, several options exist for transporting the shale oil product between any two adjacent points. Therefore, many possible transportation combinations for moving oil between the oil shale plant and the market should be considered.

Having defined the choices of where to go and how to get there, the cost and feasibility of moving the shale oil by each possible method must next be determined. Costs are the easiest information to acquire, in that this type of information is available from the respective pipeline companies and railroads, or can be calculated based on realistic capital and operating cost estimates. Any cost estimate, however, assumes that transport by that particular method is feasible -- which it may not be. For instance, published tariff rates by Amoco Pipeline for the line between Sinclair, Wyoming, and Sterling, Colorado, indicate the cost to be $0.15 per barrel to transport oil over the route. However, closer investigation reveals that the capacity of that line is only about 40,000 barrels per day, and it is likely that the excess capacity in the 1990 time frame will be considerably less. In addition, the contaminants in raw shale oil may adversely affect the quality of the conventional oil subsequently shipped through the line, and the pipeline companies may have a legal right to refuse shipment of raw oil through their common carrier lines, even if the pour points and viscosities meet their standards. Thus, the quality of a particular transportation method must be considered as well as its cost. Figure 2 illustrates the complexity of the overall problem, including the transportation-related aspects.

The complexity of marketing and transporting shale oil; the time required to design, permit, and construct transportation systems; and the risks involved in any decision requires that more than just intuition be used in establishing a prospective marketing and transportation strategy.

With the problem thus defined, the next logical step is to solve it. CSMRI has developed a methodology to organize and evaluate all the various transportation and marketing options. The approach is geared to the specific needs of a particular project, the unique marketing constraints of the respective developers, and the particular stage of project development. It is a flexible methodology capable of providing quick evaluations and yet providing a basis for sophisticated operations research-oriented studies.

Knowledgeable input is required in four basic areas to make accurate evaluations:

- Market prices
- Transportation costs
- Market quality
- Transportation segment quality

It would seem that market prices would be the most easily acquired values, being based merely on the prices paid for equivalent fuels or feedstocks. Unfortunately, determining what fuels are "equivalent" to shale oil products requires an understanding of conventional petroleum refining and marketing, and some sage engineering judgment. In some cases, there is no equivalent fuel, so some economic extrapolation is required.

Transportation costs fall into three general categories: (1) estimates based on known tariffs, (2) estimates provided by transportation companies using data from similar systems, and (3) estimates based on capital and operating costs for new systems. In those rare instances where tariffs exist, rates are readily available. The costs estimated by the transportation companies may be overly optimistic or excessively conservative, depending on which poses the least risk for the company. Finally, costs based on capital and operating cost estimates are difficult to develop due to the multitude of assumptions inherent in such calculations.

Nevertheless, it is relatively easy to subtract from each market price the appropriate transportation costs (including transfer charges for changing modes at intermediate transfer points) to arrive at a consistent "plant-site" value. When appropriate, an upgrading cost can also be subtracted, leaving a value of raw shale oil at the retort site.

The development of economic cost estimates should reasonably be based on objective analyses, but a considerable degree of subjective input is required as well. Therefore, the individuals using the results of these studies must be directly involved in the development of the assumptions to ensure that the conclusions accurately reflect a particular oil shale developer's unique situation.

While the first two items, market prices and transportation costs, require some subjective input, market quality and transportation quality require even more. Market quality itself is determined by a number of factors, including the following:

1. Long-term potential
2. Short-term potential
3. Market flexibility
4. Independence from legislation
5. Independence from other oil shale developers

To use the method developed by CSMRI, subjective ratings are made for each market in each category, and each category is given a "weighting factor" to indicate its relative importance for a particular evaluation. Applying the weighting factors to the respective quality ratings then yields a single quality value for each market option. The value calculated for each market is then used to compare the relative "goodness" of the options. By changing the weighting factors, different aspects of the marketing problem can be emphasized and studied.

A similar rating system is also applied to the transportation options, except that each transportation option involves a set of individual transportation segments. A transportation quality for the entire option is calculated by combining the ratings for the component segments. For each transportation segment, the quality rating may be based on several factors including:

1. Ease of permitting
2. Short-term viability
3. Long-term viability

As with the market evaluations, each category is assigned a weighting factor which in turn is applied to the quality ratings for each segment to yield an overall segment quality. These values are then combined to yield a quality rating for each transportation option.

Having acquired all of the necessary objective and subjective inputs for the market and transportation options under investigation, and performing all of the necessary mathematical calculations, three values for each option are developed that may be used for comparison purposes to determine the most viable transportation and marketing option. These values are plant-site value of the raw shale oil, the quality of the market, and the quality of the transportation made.

A hypothetical example, shown in Table 1, can be used to illustrate the value of this approach. A purely economic evaluation would indicate that the best option is to sell raw shale oil as a boiler fuel in the Midwest and transport it there by pipeline. The economics do not take into account that the common carrier pipelines may not transport the raw oil or that government regulations may preclude the use of oil as a boiler fuel. The economic evaluation only implies that a good profit could be made if you could do it. On the other hand, there may exist a good market for hydrotreated shale oil as a refinery feedstock in the Midwest, and it is quite feasible to transport it there by pipeline, but the economic return is very low, principally because of the high cost of hydrotreating such a small quantity of product. Shipping raw shale oil by rail to refiners in the Midwest with capacities to handle the raw oil, however, provides a reasonable economic return, while at the same time maintaining high market and transportation qualities. As may be noted, however, should any of the fundamental assumptions concerning either transportation or market quality change, the relative ranking of the options will be changed as well.

Option selection must also be based on considerations about the preliminary tasks required to implement the options. That is, emphasis must be placed on selecting options that do not preclude implementation of alternative options, should the assumptions used in the evaluation change. For instance, the highest rated option may involve transport of raw shale oil whereas the next five highest rated options may involve on-site upgrading. Due to the time required to design an upgrading facility and incorporate it into the overall oil shale plant, dismissing the concept of upgrading would not be prudent, as conditions may change prior to commercial production, thus reducing the ranking of the raw oil transport concept. The lack of preliminary planning efforts regarding upgrading facilities might jeopardize the implementation of the now more desirable upgrading options.

This brief description is certainly not adequate to explain all of the complexities and problems involved in acquiring the data for this type of study, or with the finer points of data manipulation. Hopefully, it has conveyed the scope of the problem and introduced the methodology developed by CSMRI to evaluate the available options. The methodology can address the many problems, prejudices, and desires of each specific shale oil producer, thus making the approach very project-specific. Additionally, it is capable of being quickly and easily updated to evaluate the effects of new information as it becomes available. The time is fast approaching when major decisions are going to be made based on predicted shale oil transportation and marketing strategies and these predictions must be based on comprehensive evaluations that account for option qualities as well as hard economics.

TABLE 1

Typical Option Evaluation

Basis: 10,000 Barrels Per Day Production Level

Option	Plant Site Value ($/bbl)	Market Quality (0-100)	Transportation Quality (0-100)
1. Raw shale oil/boiler fuel/Midwest/ pipeline	30	45	50
2. Hydrotreated shale oil/refinery feedstock/Midwest/pipeline	15	95	90
3. Raw shale oil/refinery feedstock/ Midwest/rail	25	80	90

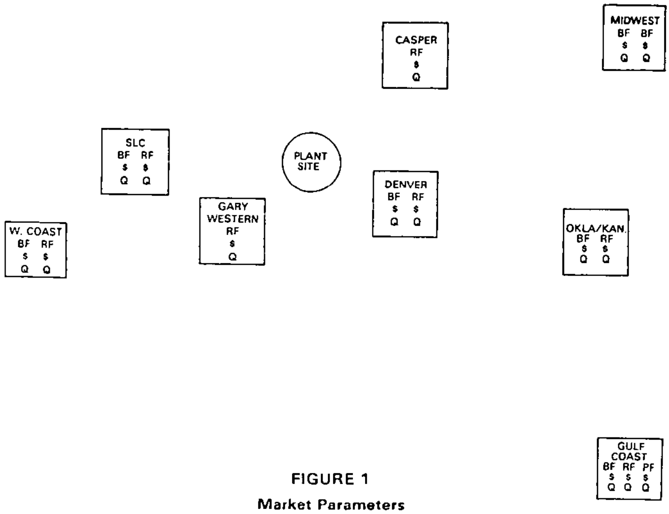

FIGURE 1

Market Parameters

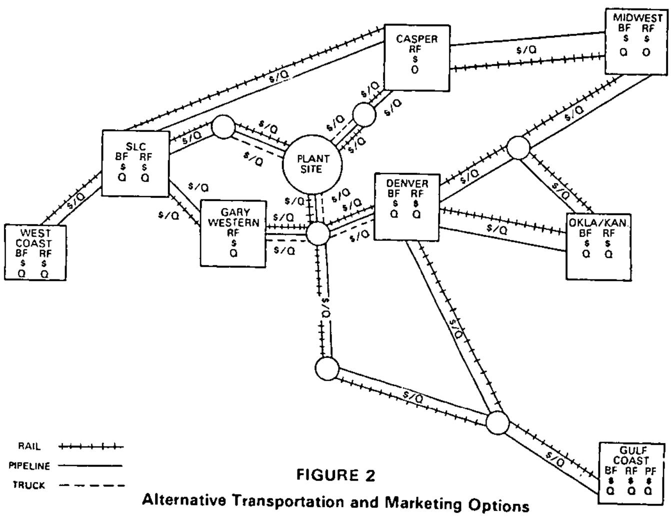

FIGURE 2

Alternative Transportation and Marketing Options