# ENHANCED OIL RECOVERY

# FOCUS GROUP RESULTS

Prepared for

The Department of Energy



Prepared by:

Market Facts - Washington
1750 K Street, N.W.
Washington, D.C. 20006

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The viewpoints that comprise the findings and major conclusions of this report are those of the focus group discussants and not those of the Department of Energy or its contractor, Market Facts, Inc.

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# SECTION I

# INTRODUCTION

This is a report of the focus group research on enhanced oil recovery development prepared for the Deparment of Energy as part of the commercialization program. The purpose of this research is to evaluate the potential for commercialization of enhanced oil recovery, to determine the barriers to development of this resource, and to judge what actions are required by the federal government to promote commercialization.

The research reported herein discusses the issues of commercialization as examined by a focus group consisting of key individuals from various organizations involved in enhanced oil recovery development. The report addresses the following questions:

- Is enhanced oil recovery feasible for commercialization?
- What is the nature and extent of the market for enhanced oil recovery?
- What barriers and opportunities are critical to the commercialization of enhanced oil recovery?
- What actions, if any, should be taken by the Federal Government to bring about successful commercialization of enhanced oil recovery?

These questions are examined from the perspective of the respondents in the focus group. Their attitudes, perceptions, opinions and knowledge provide the basis for the data and conclusions presented in this report.

## A. BACKGROUND

Recent energy "crises" of various types, combined with growing public awareness of the depletion of natural resources and the deterioration of the environment, have led to increased efforts to discover alternative energy sources and new methods of conserving energy.

The petroleum shortage is an example of an energy crisis. The United States is increasingly dependent on uncertain foreign oil supply. This fact was underscored by the Arab oil embargo of 1973-74. Total imports of petroleum products have grown from approximately 20 percent of our requirements in 1970 to nearly 50 percent in 1977. According to long-range government projections, if present consumption trends continue, domestic and and world sources combined may not be adequate to meet the expected U.S. demand for petroleum.

Faced with these and other energy problems, the Federal Government and the Department of Energy (DOE) have become increasingly involved in the area of energy consumption and conservation. The result of this involvement has been the promulgation of a growing body of regulations, on the one hand, and the active support of the research, development and implementation of energy technologies, on the other hand. These activities will ultimately have a tremendous impact on American society with strong implications for economic, physical, social and psychological issues.

In the area of energy conservation, a number of technologies have been supported. Some examples of these technologies are given to illustrate their impact. High-efficiency electric motors have already been developed in private industry. DOE is considering what actions could be taken to increase their use by the nation's industries since these motors account for a substantial proportion of the electricity we consume. The further development of electric or hybrid vehicles could reduce the amount of gasoline consumed, thus decreasing our dependence on foreign oil imports. Retrofitting home oil furnaces with the more efficient flame retention heads could reduce fuel oil consumption. In light of recent oil shortages during harsh winters, this conservation measure could have a broad impact on the economy as a whole in addition to reducing the owner's fuel bills.

There is a need to develop new sources of energy that will reduce our vulnerability to energy crises and foreign energy supplies. The variety of sources is illustrated by the following examples. The development of shale oil resources could provide a substantial supply of domestic oil. The installation of low-head hydropower plants in existing dam sites could provide a widespread source of clean energy that would have minimal effect on the environment. The development of wind energy technology is another source of new energy that could reduce oil consumption by replacing some of the use of oil-fired generating plants.

To further these goals of energy conservation and development, the Department of Energy is conducting a program of commercialization for a number of energy related technologies. The intent of this program is to promote conservation of energy and use of new energy sources by bringing these technologies to the market place. By encouraging the widespread use of the appropriate technologies, DOE can attain the goal of energy efficiency.

The commercialization program requires that DOE evaluate a number of energy technologies in terms of their commercialization potential. The particular questions that need to be answered for each technology are these:

- Is the commercialization of this technology feasible?
- What is the extent and nature of the market for this technology?
- What barriers or opportunities can be identified as critical to the commercialization effort and what is the relative importance of each?
- What actions, if any, should the federal government take to promote commercialization of these technologies?

Since the technologies that are candidates for this program vary widely in their technical maturity and economic circumstances, the answers to these questions will have a substantial impact on the course of the commercialization processes.

## B. RATIONALE FOR FOCUS GROUPS

The commercialization program is now at the stage of evaluating the commercialization potential of various energy technologies. As a means of guidance in decision-making, DOE requires comprehensive input from key individuals associated with these technologies. Such individuals include representatives from government, industry, and environmental groups whose knowledge and expertise enable them to provide input to the decision-making process. The complexity of the issues and interrelationships surrounding those energy problems makes the contributions of such qualified people essential.

The focus group methodology is ideally suited to such an information gathering effort. A focus group brings together a number of individuals whose discussion of the relevant issues is led by a trained moderator. The rationale for such a group discussion is that the interaction of the respondents will produce a more thorough understanding of the topic than would interviews conducted individually. This effect is due in part to each respondent's contribution to the others as well as to the nature of the leadership exerted by the moderator.

The information needs of DOE require input to policy decisions from outside DOE. Such input is best obtained by identifying target populations of organizations and individual roles within those organizations. From these populations, qualified respondents can be selected who represent a variety of opinions about and attitudes toward the commercialization of a particular technology. Such representation helps assure coverage of the commercialization issues from many viewpoints - developers, manufacturers, distributers, purchasers and users.

The reader should be aware that focus groups have certain critical limitations that must be kept in mind when interpreting data derived from this technique. One must be cautious in making generalizations and drawing definitive conclusions from any qualitative research data, since the information obtained is not only based on a small number of cases, but relies upon a volunteer sample. Such a sample could not be statistically representative of its assumed universe even if it were many times larger. As a result, these findings should be viewed primarily in the context of discovery, offering working hypotheses to be validated with quantitative techniques, if that is the desired goal.

Overall, this report should be read as primarily qualitative, providing insights into perceptions and knowledge of these technologies. The major questions to be answered by the research will describe WHAT, HOW and WHY participants know, think and feel about the issues, with less emphasis to be placed on HOW MANY know or think and feel in given ways. As a result, not every respondent would agree with each conclusion of the report.

Finally, the conclusions presented in this report and the findings on which they are based represent Market Facts' objective analysis of the information derived from the focus group respondents. That is, they do not represent any particular point of view held by Market Facts. Instead, the report is based on the knowledge, perceptions, attitudes and opinions of the respondents as brought forth in the focus group.

## C. PROFILE OF GROUP

The research reported herein concerns enhanced oil recovery development. The meeting took place from noon to 3PM on July 24, 1978. Dr. Morris Gottlieb, Vice President of Market Facts, Inc., served as moderator for the group.

There were 9 respondents present at the focus group representing the following types of organizations and viewpoints:

- Thermal recovery equipment manufacturer
- Major oil company (economic planning)
- Major oil company (production)
- Major oil company (engineering)
- Oil field equipment manufacturer (marketing)
- Major oil company (research)
- Gulf University Research Consortium
- Chemical supplier (research chemist)
- Finance

# SECTION II

# SUMMARY AND MAJOR CONCLUSIONS

The group was in agreement with the DOE assessment of EOR with some reasonably predictable difference in emphasis probably traceable to the domination of the group by representatives from the major oil companies. Some of the specific differences are:

> The group agreed that EOR was competing directly with oil shale development for investment capital. The major point of similarity between the two is that relatively little is known for certain about the cost of exploiting the resource (except for steam recovery as applied to the California fields). The key area of uncertainty in the case of EOR is the heterogeneity of the reservoirs and their geologic definition and the consequent uncertainty about the optimum technique. Because of the long time that it takes for the chemical to be effective and the high cost of chemicals, a wrong guess is virtually irreversible.
>
> EOR is much more sensitive to timing than is shale oil recovery. If chemical flooding is not started before the reservoir has been exhausted by conventional methods, the resource is effectively lost because of the prohibitive cost of replacing the existing infrastructure. A delay in initiating an oil shale project involves only a linear displacement. Thus even though shale oil may be a recoverable resource, approximately three times as plentiful as EOR oil, most of the participants in the group felt that priority should be given to EOR.

The group felt that price controls placed a particularly heavy burden on EOR not only because of the disincentive effect of the (then) current price (since the meeting the ERA has recommended a higher price for EOR oil), but because of the dislocation caused by two-tier pricing. Specifically, multi-tier pricing makes it difficult to get companies together for field unitization.

While the industry, as represented in the meeting, welcomes government support of pilot projects and of basic geologic research to facilitate reservoir description and evaluation, it feels that industry might be capable of doing it alone, given:

- Price decontrol
- IRS treatment of the cost of chemicals as an expense
- An investment tax credit based on investment rather than production
- Accelerated depreciation.

Except for the banking representative, this group did not favor loan guarantees, which they saw as primarily benefiting the less experienced and less knowledgeable independent producers.

They did not view environmental constraints as a major barrier to EOR development.

They did view the existence of an in-place infrastructure as a major advantage which might be irretrievably lost with undue delay.

# SECTION III

# MAJOR FINDINGS

This section of the report presents the detailed results of the focus group. These results are the basis for the conclusions drawn in the previous section.

## A. CURRENT STATE OF ENHANCED OIL RECOVERY

There was general agreement in the group that of the three major enhanced oil recovery techniques:

- Thermal methods,
- Miscible gas processes,
- Chemical processes,

only the thermal method -- in particular, steam flooding in California -- has so far resulted in any appreciable enhanced oil recovery oil production. One of the participants had been involved in a major project using miscible $CO_2$. It was the belief of the group that there was only one active chemical injection project (Marathon) that approached commercial size.

The representative of the oil company involved in steam flooding operations pointed out that the major difference between steam flooding and the other two enhanced oil recovery approaches was in the long time lag required to know whether a chemical injection would be successful. Steam flooding, in a suitable reservoir, was more likely to produce some results quickly. In his opinion chemical injection was much less certain. As he put it, it was a "one-shot affair." He feels steam methods were more accessible: "If you can't do anything else, you can get some oil out by 'huffing and puffing'".

There was general agreement that extremely detailed knowledge of the geologic character of the field was required for the successful application of the chemical and gas-miscible methods.

In illustrating the complexity of the relation between reservoirs and techniques, one participant, who had some experience with miscible methods, pointed out:

> "You can say for sure that miscible gases are controlled by gravity. If you have a field that has some depth you can put the gas on top and it will displace the oil slowly ... flat reservoirs are not suitable. They will yield a slow return -- 50-70 percent in suitable reservoirs; less than 10 percent in others (flat reservoirs). Other (micellar) methods will yield 50 percent."

The following exchange describes the problem of the time lag between injecting the chemicals and getting production:

> "Generally you inject the chemicals or miscible gases when you still have some water flooding recovery to get and you're still producing for awhile until the injectants start producing. This might be 5 to 10 years down the road. You're spending money today to get production later."

> "Marathon claims it will be six years at least before they know anything -- it might be in 1986."

> "To answer your question: How long do you have to wait? You have to wait a long time."

The issues of time lag, complexity, and uncertainty kept cropping up throughout the discussions; for example, the following comments were made in a discussion of chemical supplies:

"The important problem is you don't know what kind of soap to make. You have to make one kind for one field and another kind for another field. You've got to know enough in advance so you can plan what kind of soap you need to make. If you're going to use $CO_2$ you have to explore for $CO_2$ sources or else start cornering the market on the gas generating thing and separate $CO_2$ from the flue gas and use that as your source. In any event it involves a lot of lead time. You need a large plant and lots of money to get these things going and that's another limitation to the quick application of these so-called tertiary recovery methods that you don't know a long time in advance exactly what you're going to do. You spend a lot of energy and manpower in generating that source of material. This is another technical problem and it's a high risk problem.

"We've all been talking about enhanced oil recovery as though it is only one method -- a ball of wax that can be molded, squeezed, and you know where it is all the time. That's not the situation. Enhanced oil recovery could be a multitude of methods with a multitude of reservoirs, each of which has many variations and you can't generalize. You have to decide which particular method is used for any particular reservoir. You can't say because you have to know more about the physics and chemistry you say 'let's use method A -- say chemical flooding -- on a particular field', but you don't know what it's going to do until you get it in the ground."

Despite these problems of time lag and the technological complexities of matching reservoir and technique,there was a clear consensus that enhanced oil recovery was feasible given the right economic climate and that chemical methods would play a crucial job in tertiary recovery.

## B. BARRIERS

### 1. Price

The group was in general agreement with the description of the constraints and barriers to enhanced oil recovery development outlined in the DOE Commercialization Candidate Description. However, there was a marked emphasis on price level and price control as the key barriers. The following comments give the flavor of the reaction to current (7/24/78) price levels:

> "The current price is a disincentive to private investors. With a higher price there would be a lot more projects and the chemical companies would be a lot more interested in this market.

> "There is a national crisis. Also there are other sources of energy. Also within the industry there are several sources of investment. If you leave it up to the industry they're going to invest their money in the way they think best. (In that context) enhanced oil recovery doesn't have a chance. With prices as they are you'd rather invest your money elsewhere. If it's in the national interest that the resource be available then the nation has to back it."

In addition to the disincentive effect of a low price for enhanced oil recovery, price controls and multi-tier pricing are seen as exacerbating some of the other enhanced oil recovery barriers. For example, multi-tier pricing makes unitization more difficult.

> "There are all sorts of problems with the existing regulations preventing us from putting units together ... people don't want to get in with you because they're already getting world prices for their oil. Why should they join the other people and disturb the leases that need to be unitized? There are all sorts of things that can be done with the DOE regulations that would improve our ability to form units.

"Are these real basic economic conflict of interest or can they be resolved by modifying the regulations?

"Both. There are rules that could be implemented now that could allow you to pull units together. Basically if you have the same price for all production you'd resolve a lot of these conflicts immediately because now you have conflicts because one fellow is getting $13 for his oil and the next fellow is getting $5. Multi-tier pricing presents some real barriers to unitization."

Another perceived difficulty with price control is that it introduces another source of uncertainty relating to unpredictable government action with respect to price changes. For example, the government may make pricing allocations based on the company's estimate of production. If the company's estimate turns out to be wrong, then the decision has to be renegotiated. This makes for considerable uncertainty.

While price is considered a barrier, price decontrol in itself would not, according to one respondent (who reiterated this point several times with agreement from the rest of the group), make enhanced oil recovery sufficiently attractive to obtain the required funding from the private sector. Some form of tax incentive would be required. Particularly, one that would be based on investment rather than income.

"What would the price of oil have to be for the industry to undertake the job? What price would make it sufficiently attractive to the industry?"

"If all crude oil could be sold at whatever price you could get -- if that's all you did -- then enhanced oil recovery isn't going to move an inch. You will need additional tax benefits based on the investment and not the results."

"What kind of tax measure might affect the investment decisions?"

"Do what Alberta is doing. They have a tax structure there where they take the front-end load off it."

"Is there general agreement that an uncontrolled price would eliminate the constraint? "

"That wouldn't be enough. You'd need that incentive and then more."

"The principal thing that's needed here is treating the cost of chemicals as an expense rather than an investment and quicker depreciation of operating and equipment costs comes second. Is that right?"

"The OTA report says that would not generate much activity. They also investigated the investment tax credit and concluded they would need more than that. They would have to find a sufficient tax credit so it would be an incentive. I don't know how it could be done."

2. Tax Policy

The issue uppermost in the minds of all participants was the disincentive effect of the front-end tax on the chemicals used for enhanced oil recovery. The consensus of the group was that taking the chemicals as an expense rather than a capital investment would stimulate enhanced oil recovery development.

3. Environmental Impacts

The group did not think that the chemical or gas miscible processes posed any serious environmental problems:

"The chemicals that we would add are less damaging than the salt we are injecting at the present time."

"The effects of the chemicals are self-limiting because they are absorbed. If they were contaminating the aquifer this would mean that they are less productive and we'd be looking for less contaminating chemicals. The chemicals we're using cost so much we're not going to let them get away from us."

> "I think there's an important environmental point in enhanced oil recovery that lies in the fact that whatever method of acquiring energy that we use will produce some effect on the environment. If you produce shale oil you have to go out to the desert and do something to the environment. If you damage the environment by enhanced oil recovery that's already been done -- the pump's already there and it's environmentally unacceptable that we don't take advantage of what's already there. In terms of environmental impact, enhanced oil recovery is a very positive step. We often find that the environmentalists are supporting the oil industry in this specific area. It's to everybody's interest to take advantage of what's already been done."

4. Labor Requirements

The principal impact on labor requirements is that technical personnel will be more visible in the field, because the new technology will require more professional and on-the-job training. This does not call for any additional government support in the way of training.

> "Industry now provides enough incentives. With a master's degree you can now get $16,000 per year or more. That's incentive enough."

## C. INCENTIVES FOR COMMERCIALIZATION

The following list of incentives was submitted to the group for discussion. The general attitude was not enthusiastic -- except for tax credits. Almost all the participants felt that with the right kind of tax credits (i.e., based on expenditure rather than production), there would be sufficient incentives within the industry if prices were decontrolled:

| Type of Programs | Group That Pays |
|---|---|
| 1 Price Guarantees | |
| 2 Loan Guarantees | Taxpayers |
| 3 Tax Credits | |
| 4 Cost Sharing | |
| 5 R&D Activities | |
| 6 Price Manipulations Within the Composite | Current Oil Producers |
| 7 Price Manipulations Outside the Composite | Oil Consumers |

The bank representative was the only one who was enthusiastic about loan guarantees.

> "Loan guarantees would certainly make it neat. We would see some of the smaller companies requiring project financing and that might make it difficult for some of the banks to handle something like that. Some of the major companies might want project financing in order to get it off their balance sheet. So a loan guarantee would certainly make it a lot easier."

> "Would large companies be against loan guarantees because if they ever needed to use the guarantee this would damage their position in the finance markets?"

> "I don't think that's so at all. It would just show that they were pretty bright operators. It could get a guarantee instead of taking a risk."

> "Company X would hesitate to use guarantees."

> "Company X now has all sorts of guaranteed loans now -- on marine equipment, and other things. I personally hate to see the government guaranteeing anything. But from the point of view of the bank it makes it a lot easier for the banks to finance anything."

In view of the fact that no independent producers were represented at the meeting, it is not surprising that several participants expressed and agreed with the view that loan guarantees would be a high risk use of public funds because only the small companies with the least knowledge and experience would take advantage of them.

D. THE POTENTIAL FOR ENHANCED OIL RECOVERY

Participants were reluctant to commit themselves to an estimate of the total volume of enhanced oil recovery oil that could be produced commercially because of the many qualifications and assumptions involved in making such an estimate. Most of them were familiar and in general agreement with two reports which gave such estimates (The National Petroleum Council Report on EOR (1976) and the OTA Report released this year). When the figure 36 million barrels was used by one of the participants as a working estimate of the total commercially producible enhanced oil recovery oil, this figure was accepted as reasonable.

The group agreed that this was approximately 1/3 of the commercially producible oil that could be extracted from oil shale. One of the participants made the point that since shale oil represented about three times the amount of energy resource of enhanced oil recovery oil, the industry and public efforts should be allocated to those two competing technologies in those proportions. However, most of the group took strong exception to this view for these reasons:

- The time frame for the production of enhanced oil recovery oil is much closer than for shale oil. Enhanced recovery oil is being produced now.

- While the shale oil will remain in the ground until you're ready to mine it, there is an optimum enhanced oil recovery for any reservoir. A delay for any reason will reduce the efficiency of the process enormously. If you have a reservoir in the process of being depleted by primary recovery or water flooding, there's an optimum time to initiate chemical flooding to recover the most oil. "When the well becomes non-commercial, the regulation of ownership requires that you flood and dam the well. When you do that you have the ground full of lean ore and you can no longer afford to start new wells to recover it...there's urgency because of the risk of losing oil that's left in the ground because of the need to close down wells that have been exhausted by conventional methods."

# APPENDIX

## EN[illegible] OIL RE[illegible]

MF MATH

| Barrier Importance / [illegible] | Technical & Economic: [illegible] | Technical & Economic: [illegible] Oil | Technical & Economic: Knowledge of Geological Definition of Reservoir | Technical & Economic: High Front End Cost | Technical & Economic: Uncertain Rate of Return | Technical & Economic: Cost of Injectant | Technical & Economic: Cost of Injection Facilities | Initial Deployment: Heavy Oil Market (West Coast) | Environment: Emission Standards | Environment: Fresh Water Demand | Environment: Ground Water Contamination | Resource Availability: Oil Field Equipment & Drilling Rigs | Resource Availability: Skilled & Unskilled Labor | Resource Availability: Availability of Injectant | Institutional: Price Controls (GF) | Institutional: Pipeline & Facility Permits (GF GH) | Institutional: Unitization Procedures (GN) | Institutional: Gravity Differential (NG) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (weight) | 5 | 4 | 4 | 4 | 5 | 3 | 3 | 4 | 5 | 2 | 1 | 1 | 1 | 3 | 2 | 4 | 4 | 3 |
| [illegible] R&D (FP) | [illegible] | 2 | [illegible] | 3 | 3 | NA | NA | NA | 1 | 2 | 1 | NA | NA | 1 | NA | NA | NA | NA |
| Equipment R&D (FP) | NA | 4 | 4 | 2 | 2 | NA | 3 | NA | 2 | NA | 1 | 2 | NA | NA | NA | NA | NA | NA |
| Transport R&D (FP) | 2 | NA | NA | 2 | 2 | 3 | NA | NA | NA | 3 | 1 | NA | NA | 3 | NA | NA | NA | NA |
| [illegible] (F) | 3 | [illegible] | 2 | 2 | 2 | NA | 1 | NA | 1 | 1 | 1 | NA | NA | NA | NA | NA | NA | NA |
| | | | | | | | | | | | | | | | | | | |
| [illegible] (F) | 2 | 1 | 1 | 3 | 1 | 1 | 2 | NA | 1 | NA | NA | 1 | 1 | 1 | 1 | NA | NA | 1 |
| [illegible] (F) | 4 | 2 | 2 | 4 | 4 | 3 | 3 | NA | 2 | NA | NA | 2 | 2 | 2 | 3 | NA | NA | 2 |
| [illegible] (F) | 2 | 1 | 1 | 3 | 4 | 3 | 3 | NA | 1 | NA | NA | 2 | 2 | 2 | 4 | NA | NA | 2 |
| [illegible] (F) | 2 | NA | NA | 3 | 3 | 4 | NA | NA | NA | NA | NA | NA | NA | 3 | 2 | NA | NA | NA |
| | | | | | | | | | | | | | | | | | | |
| [illegible] (F) | 1 | NA | NA | 2 | 1 | 2 | 3 | NA | 2 | NA | NA | 3 | NA | NA | [illegible] | NA | NA | NA |
| [illegible] (F) | [illegible] | NA | NA | 3 | 3 | 4 | NA | NA | NA | NA | NA | NA | NA | 3 | 1 | NA | NA | NA |
| | | | | | | | | | | | | | | | | | | |
| [illegible] | [illegible] | [illegible] | NA | 1 | 1 | 2 | 2 | NA | 4 | NA | NA | NA | NA | NA | NA | 2 | NA | NA |
| [illegible] | [illegible] | [illegible] | NA | NA | 1 | NA | NA | 4 | NA | NA | NA | NA | NA | 3 | NA | 4 | NA | NA |
| [illegible] | [illegible] | [illegible] | NA | NA | NA | [illegible] | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 4 | NA |
| [illegible] | NA | NA | NA | NA | 1 | NA | NA | 3 | NA | NA | NA | NA | NA | NA | 3 | NA | NA | 3 |

INTERNAL Team Views

| Federal Action | Technical & Economic: Reservoir Performance | Technical & Economic: Accumulation, Volume & Distribution of Oil | Technical & Economic: Knowledge & Definition of Reservoir | Technical & Economic: High Front End Cost | Technical & Economic: Uncertain Rate of Return | Technical & Economic: Cost of Injectant | Technical & Economic: Cost of Injection Facilities | Initial Deployment: Heavy Oil Market (Market Cost) | Environment: Emission Standards | Environment: Fresh Water Demand | Environment: Ground Water Contamination | Resource Availability: Oil Field Equipment & Drilling Rigs | Resource Availability: Skilled & Unskilled Labor | Resource Availability: Availability of Injectant | Institutional: Price Controls (GE) | Institutional: Pricing & Facility Permits (GE,GN) | Institutional: Unitization Procedures (GN) | Institutional: Gravity Differentials (NG) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Barrier Importance | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 4 | 5 | 2 | NA | 1 | 1 | NA | 2 | 4 | NA | 3 |
| **Information** | | | | | | | | | | | | | | | | | | |
| Reservoir R&D (E,P) | 3 | 2 | 2 | 1 | 3 | 1 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Equipment R&D (E,P) | NA | 4 | 4 | 2 | 1 | 1 | 3 | NA | 3 | NA | NA | 2 | NA | NA | NA | NA | NA | NA |
| Injectant R&D (E,P) | NA | NA | NA | NA | NA | 1 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| [illegible] Information (E,P) | 2 | 2 | 2 | 1 | 2 | 1 | 2 | NA | 1 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Economic Incentives** | | | | | | | | | | | | | | | | | | |
| Loan Guarantee (F) | 2 | [illegible] | 1 | 3 | 1 | 1 | 1 | NA | 1 | NA | NA | 1 | 1 | NA | 1 | NA | NA | 1 |
| Front End Assistance (F) | 4 | 1 | 1 | 4 | 4 | 2 | 4 | NA | 2 | NA | NA | 2 | 2 | NA | 3 | NA | NA | 2 |
| Long Term Tax Provisions (F) | 2 | 1 | 1 | 3 | 3 | 3 | 2 | NA | 1 | NA | NA | 2 | 2 | NA | 2 | NA | NA | 2 |
| Injectant Subsidy (F) | NA | NA | NA | 1 | 2 | 2 | NA | 1 | NA | NA | NA | NA | NA | NA | 2 | NA | NA | 1 |
| **Tax & Royalties** | | | | | | | | | | | | | | | | | | |
| Investment Tax Credit (F) | 1 | NA | NA | 2 | 1 | NA | 2 | NA | 2 | NA | NA | 2 | NA | NA | NA | NA | NA | NA |
| Injectant Expensing (F) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Regulation** | | | | | | | | | | | | | | | | | | |
| [illegible] Standards (F,L) | NA | NA | NA | 1 | 1 | NA | 2 | NA | 4 | NA | NA | NA | NA | NA | NA | 3 | NA | NA |
| [illegible] Permits (F,S,L) | NA | NA | NA | 1 | 2 | 1 | 2 | 4 | NA | NA | NA | NA | NA | NA | 4 | 3 | NA | NA |
| [illegible] Guidelines (F,S) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| [illegible] (F) | NA | NA | NA | 1 | 1 | 1 | 1 | 3 | 1 | NA | NA | NA | NA | NA | 4 | NA | NA | 3 |

THERMAL - In Situ Combustion

| Action | Technical & Economic: [illegible] | Technical & Economic: [illegible] | Technical & Economic: [illegible] | Technical & Economic: High Front End Cost | Technical & Economic: Uncertain Rate of Return | Technical & Economic: Cost of Transport | Technical & Economic: Cost of Treating Facilities | Initial Deployment: Heavy Oil Market (High Cost) | Environment: Emission Standards | Environment: Fresh Water Demand | Environment: Ground Water Contamination | Resource Availability: Oil Field Equipment & Drilling Rigs | Resource Availability: Skilled & Unskilled Labor | Resource Availability: Availability of Transport | Institutional: Price Controls (GS) | Institutional: Decline & Facility Permits (GSGN) | Institutional: Unitization Procedures (GW) | Institutional: Gravity Differentials (NG) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Barrier Importance | 5 | 4 | 4 | 3 | 5 | NA | 1 | 4 | 4 | NA | NA | 1 | 1 | NA | 2 | 4 | NA | 3 |
| [illegible] R&D (S,P) | 3 | [illegible] | [illegible] | [illegible] | 3 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| [illegible] R&D (S,P) | NA | 4 | 4 | 3 | 2 | NA | 3 | NA | 3 | NA | NA | 2 | NA | NA | NA | NA | NA | NA |
| [illegible] R&D (F,P) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| [illegible] (F) | [illegible] | [illegible] | 2 | 1 | 2 | NA | 1 | NA | 1 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Loan Guarantee (F) | 2 | 1 | 1 | 2 | 1 | NA | 2 | NA | 1 | NA | NA | 1 | 1 | NA | 1 | NA | NA | NA |
| [illegible] (F) | 4 | 3 | 3 | 4 | 4 | NA | 3 | NA | 2 | NA | NA | 2 | 2 | NA | 3 | NA | NA | NA |
| [illegible] Provisions (F) | 3 | 2 | 2 | 3 | 3 | NA | 2 | NA | 1 | NA | NA | 2 | 2 | NA | 2 | NA | NA | NA |
| [illegible] (F) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| [illegible] (F) | 1 | 1 | 1 | 2 | 1 | NA | 2 | NA | 2 | NA | NA | 1 | NA | NA | NA | NA | NA | NA |
| [illegible] (F) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| [illegible] (F,L) | NA | NA | NA | 1 | 1 | NA | 2 | NA | 4 | NA | NA | NA | NA | NA | NA | 3 | NA | NA |
| [illegible] (F,S) | NA | NA | NA | 1 | 3 | NA | 1 | 4 | NA | NA | NA | NA | NA | NA | 3 | 3 | NA | NA |
| [illegible] (F,S) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| [illegible] (F) | NA | NA | NA | 1 | 2 | NA | 1 | 3 | NA | NA | NA | NA | NA | NA | 3 | NA | NA | 3 |

[illegible]

| Barrier Importance / Policy Action | Technical & Economic: Reservoir Performance | Technical & Economic: Knowledge of Volume & Definition of Oil | Technical & Economic: Knowledge of Geology / Definition of Reservoirs | Technical & Economic: High Front End Cost | Technical & Economic: Uncertain Rate of Return | Technical & Economic: Cost of Injectant | Technical & Economic: Cost of Injection Facilities | Initial Deployment: Heavy Oil Market (Outlet Cost) | Environment: Emission Standards | Environment: Fresh Water Demand | Environment: Ground Water Contamination | Resource Availability: Oil Field Equipment & Drilling Rigs | Resource Availability: Skilled & Unskilled Labor | Resource Availability: Availability of Injectant | Institutional: Price Controls (GE) | Institutional: Pipeline & Facility Permits (GE&GN) | Institutional: Unitization Procedures (GN) | Institutional: Gravity Differentials (HG) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Barrier Importance | 5 | 4 | 4 | 4 | 5 | 3 | 3 | NA | 2 | 2 | NA | 1 | 1 | 3 | 2 | 4 | 4 | NA |
| Process R&D (F,P) | 3 | 2 | 2 | 3 | 3 | NA | NA | NA | NA | 2 | NA | NA | NA | NA | NA | NA | NA | NA |
| Equipment R&D (F,P) | NA | 4 | 4 | 2 | 2 | NA | 3 | NA | 3 | NA | NA | 2 | NA | NA | NA | NA | NA | NA |
| Injectant R&D (F,P) | 2 | NA | NA | 2 | 2 | 3 | NA | NA | NA | 3 | NA | NA | NA | 3 | NA | NA | NA | NA |
| [illegible] Characterization (F,P) | 2 | NA | NA | 2 | 2 | NA | NA | NA | 1 | 1 | NA | NA | NA | NA | NA | NA | NA | NA |
| Loan Guarantees (F) | 2 | 1 | 1 | 3 | 1 | 1 | 2 | NA | 1 | NA | NA | 1 | 1 | 1 | 1 | NA | NA | NA |
| [illegible] (F) | 4 | 2 | 2 | 4 | 4 | 3 | 4 | NA | 2 | NA | NA | 2 | 2 | 2 | 4 | NA | NA | NA |
| [illegible] Provisions (F) | 3 | 1 | 1 | 3 | 4 | 3 | 3 | NA | 1 | NA | NA | 2 | 2 | 2 | 3 | NA | NA | NA |
| [illegible] (F) | 3 | 1 | 1 | 3 | 3 | 5 | NA | NA | NA | NA | NA | NA | NA | 3 | 2 | NA | NA | NA |
| [illegible] (F) | 1 | NA | NA | 2 | 1 | 2 | 3 | NA | 2 | NA | NA | 3 | NA | NA | 2 | NA | NA | NA |
| [illegible] (F) | 1 | NA | NA | 3 | 3 | 3 | NA | NA | NA | NA | NA | NA | NA | 3 | 2 | NA | NA | NA |
| [illegible] Standards (F,S,L) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| [illegible] Permits (F,S,L) | NA | NA | NA | NA | NA | 1 | NA | NA | NA | NA | NA | NA | NA | 4 | NA | 4 | NA | NA |
| [illegible] Guidelines (F,S) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 4 | NA |
| [illegible] (F) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

# CHEMICAL - Surfactant Polymer & Polymer

| | Technical & Economic | | | | | | | Initial Deployment | Environment | | | Resource Availability | | | Institutional | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Barrier | Reservoir Data: [illegible] | Knowledge of [illegible] | Knowledge of Oil & Definition of Reservoir [illegible] | High Front End Cost | Uncertain Rate of Return | Cost of Injectant | Cost of Injection Facilities | Heavy Oil Market [illegible] | Emission Standards | Fresh Water Demand | Ground Water Contamination | Oil Field Equipment & Drilling Rigs | Skilled & Unskilled Labor | Availability of Injectant | Price Controls (GS) | Pooling & Facility Permits (GS,GN) | Unitization Procedures (GN) | Gravity Differentials (NG) |
| Barrier Importance | 5 | 3 | 4 | 4 | 5 | 3 | NA | NA | NA | 2 | 1 | 1 | 1 | 2 | 2 | NA | 4 | NA |
| Process R&D (FG)? | 3 | 2 | 2 | 3 | 3 | NA | NA | NA | NA | 2 | 1 | NA | NA | 1 | NA | NA | NA | NA |
| Equipment R&D (FG) | NA | 4 | 4 | 2 | 2 | NA | NA | NA | NA | NA | 1 | 2 | NA | NA | NA | NA | NA | NA |
| Injectant R&D (FG) | 3 | NA | NA | 2 | 2 | 4 | NA | NA | NA | 2 | 2 | NA | NA | NA | NA | NA | NA | NA |
| [illegible] (FG) | 3 | 2 | 2 | 2 | 2 | NA | NA | NA | NA | 3 | 1 | NA | NA | 3 | NA | NA | NA | NA |
| Loan Guarantee (F) | 2 | 1 | 1 | 3 | 1 | 1 | NA | NA | NA | 1 | NA | NA | NA | 1 | 1 | NA | NA | NA |
| [illegible] (F) | 4 | 1 | 1 | 4 | 3 | 3 | NA | NA | NA | 1 | NA | 2 | 2 | 2 | 3 | NA | NA | NA |
| [illegible] Provisions (F) | 3 | 1 | 1 | 3 | 4 | 3 | NA | NA | NA | 1 | NA | 2 | 2 | 2 | 4 | NA | NA | NA |
| Injectant Subsidy? (F) | NA | NA | NA | [illegible] | 3 | 5 | NA | NA | NA | NA | NA | NA | NA | 3 | 2 | NA | NA | NA |
| Investment Tax Credit? (F) | 1 | NA | NA | 2 | 1 | 1 | NA | NA | NA | NA | NA | 3 | NA | NA | 2 | NA | NA | NA |
| Injectant Financing? (F) | 1 | NA | NA | 3 | 2 | 3 | NA | NA | NA | NA | NA | NA | NA | 4 | 2 | NA | NA | NA |
| [illegible] Standards (FGA) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| [illegible] Permits (FGA) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| [illegible] (FG) | 1 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 4 | NA |
| [illegible] (F) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

# DISCUSSION GUIDE

I. Introduction

A. Topic and Purpose of discussion

B. Discussion format

C. Background of participants

1. Organization identity
2. Role of organization in technology
3. Individual's role

II. Current State of the Energy Technology

A. What is the current state of the art?

B. To what extent has the technology advanced over the years?

C. What have been the characteristics of this advancement?

D. What will be the net effect on energy output in short-term? Long-term?

III. Commercialization

A. Is the technology understood and far enough along in its development that it can be commercially implemented?

B. Is industry physically and psychologically ready to accept and implement the technology?

C. What are the likely markets for the technology: Consumer? Governmental? Industrial?

D. Are these markets physically and psychologically ready to accept and utilize the technology?

E. Are any of the following barriers to commercialization What are they? How are they barriers? How important are they?

1. Technological barriers
2. Economic barriers
3. Social barriers
4. Political barriers
5. Environmental barriers

F. Do any of the following present themselves as opportunities or facilitators of commercialization? What are they? How are they opportunities? How important are they?

1. Technological factors
2. Economic factors
3. Social factors
4. Political factors
5. Environmental factors

G. What, if any, information should be provided to insustry and the public to enhance the acceptability of the technology? In what form should it be conveyed? Who should provide the information?

H. Financial considerations

1. What are the estimated costs associated with the commercialization of the technology?
2. What are the sources for these funds? Why these sources?

IV. Impacts

A. What if any, impact will there be on the following as a result of commercialization?

1. Physical environment
2. Social structures
3. Political structures
4. Economic structures
5. Labor market

B. How important are these impacts?

V. Role of the Federal Government in commercialization of the Technology?

A. Should the government exercise a role?

B. What role is desired or necessary?

1. Provide findings?
2. Favorable legislation?
3. Provide knowledge?
4. Provide equipment, materials and facilities?
5. Other?

C. What departments and agencies should be involved?

VI. Presentation of and Reaction to DOE Thinking

A. (Present concept statements to participants)

B. General reactions

C. Are these plans realistic/feasible given the:

1. Current state of technology
2. Realities of the market place
3. Realities of social, economic, political structures?

D. (Focus on specific aspects of the concept statement. Included here:)

1. Has DOE realized all of the opportunities and barriers? Are there others? How important is each?
2. Has DOE presented all of the possible solutions to the barriers? Are there others? What is the relative likelihood of success of each solution?
3. Is DOE's time schedule realistic/feasible?

VII. Summary

(The discussion will be reviewed with the participants in order to develop "bottom line" statements about each critical issue).