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Improvements are needed in the Federal enhanced oil and gas recovery research, development, and demonstration program. Findings/Conclusions: Advanced methods to recover currently nonrecoverable oil and gas could contribute to reducing United States dependence on imported energy resources. Commercialization of many of these techniques will require more technology development. Other obstacles, primarily economic, also stand in the way of commercialization. The Energy Research and Development Administration has a risk-sharing cooperative demonstration program to stimulate industry commercialization of advanced recovery technologies. However, the program has not been based on adequate planning and has been moving along at a slow pace. Although the agency is attempting to improve the program, it is unlikely to have a major effect on increasing domestic oil and gas supplies before the late 1980s or early 1990s. Recommendations: The Administrator of the Energy Research and Development Administration should give continued and increased emphasis to developing and putting into operation a management plan for enhanced gas recovery. The plan should focus on developing a balanced research program to include laboratory research, demonstration tests, and the gathering of geological data on the types of deposits the agency plans to test. The Administrator should also reassess annually the Federal role and level of effort in enhanced oil and gas recovery research and development in the light of increased oil and gas prices and industry's willingness to promote new technology. (Author/SC)

# REPORT TO THE CONGRESS



*BY THE COMPTROLLER GENERAL  
OF THE UNITED STATES*

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## Improvements Needed in The Federal Enhanced Oil And Gas Recovery Research, Development, And Demonstration Program

Energy Research and Development Administration

Advanced methods to recover currently non-recoverable oil and gas could contribute to reducing this Nation's dependence on imported energy. Commercialization of many of these techniques will require more technology development. Other obstacles--primarily economic--also stand in the way of commercialization.

The Energy Research and Development Administration has a risk-sharing cooperative demonstration program to stimulate industry commercialization of advanced recovery technologies. However, the program has not been based on adequate planning and has been moving along at a slow pace. Although the agency is attempting to improve the program, it is unlikely to have a major effect on increasing domestic oil and gas supplies before the late 1980s or early 1990s.



COMPTROLLER GENERAL OF THE UNITED STATES  
WASHINGTON, D.C. 20548

B-178205

To the President of the Senate and the  
Speaker of the House of Representatives

This report discusses the improvements needed in the Federal enhanced oil and gas recovery research, development, and demonstration program.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We are sending copies of this report to the Director, Office of Management and Budget, and to the Administrator, Energy Research and Development Administration.

*James A. Atack*

Comptroller General  
of the United States

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**ABBREVIATIONS**

ERDA	Energy Research and Development Administration
FEA	Federal Energy Administration
FPC	Federal Power Commission
GAO	General Accounting Office

D I G E S T

About 425 billion barrels of crude oil have been discovered in the United States. However, over two-thirds of these resources (290 billion barrels) are not economically recoverable at current prices with the conventional technologies now used. Likewise more than a quadrillion cubic feet of natural gas may exist in the Rocky Mountain and Appalachia areas. This gas is not commercially producible with current extraction technology. (See p. 1.)

The Energy Research and Development Administration has an enhanced oil and gas recovery program. The term "enhanced recovery" has a distinctly different meaning for the production of oil as contrasted to the production of gas. Enhanced recovery of oil refers, for the most part, to increasing output from producing reservoirs. Enhanced gas recovery generally refers to the production of gas from areas where commercial production has not previously been possible. (See pp. 1 and 2.)

The program itself is not intended to produce large quantities of commercial oil and gas, but is supposed to stimulate industry to commercialize enhanced recovery processes by

- accelerating, through cooperative cost-sharing contracts, industry's development of enhanced recovery technologies;
- evaluating the technical and economic feasibility of enhanced recovery technologies; and
- making publicly available the results of its research and development efforts.

As of mid-September 1976, the Energy Research and Development Administration had initiated

27 oil and gas demonstration tests to assess the technical and economic feasibility of commercial-scale enhanced recovery. The total estimated cost of these tests is approximately \$122 million with the Energy Research and Development Administration and private industry participants contributing about \$46 million and about \$76 million, respectively. (See pp. 9 and 10.)

In 1975 the Energy Research and Development Administration established goals of increasing commercial oil production by 1.4 million barrels a day and commercial gas production by 8.2 billion cubic feet a day through enhanced recovery processes by 1985. The 1985 production goals were recently reduced to 500,000 barrels of oil a day and 3 billion cubic feet of gas a day. (See p. 11.)

Although GAO directed its review specifically at the effectiveness of the Energy Research and Development Administration's management of its enhanced recovery program, it recognizes that other factors will affect the development of enhanced recovery technologies. For example, increases in oil and gas prices could stimulate industry research and development and reduce the need for a Federal enhanced recovery research and development effort. (See pp. 13, 15, 21, and 22.)

#### DEMONSTRATION SCHEDULES LACK TIMELINESS

In 1975 the Energy Research and Development Administration developed a startup schedule for 103 oil recovery demonstration tests which were thought to be needed to attain the agency's 1985 oil production goals. The agency also plans 94 natural gas recovery demonstration tests to achieve its 1985 gas production goals. These oil and gas recovery demonstration tests are intended to provide industry with technical and economic data needed for assessing the feasibility of implementing enhanced recovery on a commercial scale. (See pp. 11 and 13.)

The Energy Research and Development Administration's schedules for developing enhanced

oil and gas recovery techniques are unlikely to stimulate enough industry production to reach the agency's 1985 goals because the schedules call for most tests to start during the last 3 years of the 7-year period 1974-80.

Since field demonstrations of the most promising oil recovery methods require 4 to 5 years to complete, most of the technical and economic data needed to prove the commercial feasibility of the technologies will not be available until the 1982-85 period. Production from field-wide commercial applications cannot be expected for another 4 to 5 years after the technical and economic data from these tests are available. Therefore, the current Energy Research and Development Administration demonstration schedule cannot be expected to result in considerable commercial oil production increases before the late 1980s or early 1990s. (See p. 12.)

Enhanced gas recovery technology is not as advanced as enhanced oil recovery technology, and the Energy Research and Development Administration's program is proceeding slowly under the current schedule. As a result, although the time between successful demonstration of enhanced gas recovery methods and substantial gas production using these methods is shorter, it is likely that enhanced gas recovery technologies would not make a considerable contribution to the Nation's gas supply before the late 1980s. (See pp. 13 and 15.)

#### LACK OF AN EFFECTIVE MANAGEMENT PLAN

The Energy Research and Development Administration has not had an effective program management plan for enhanced oil and gas recovery which would result in the most rapid and effective means for increasing domestic petroleum supplies. (See p. 17.)

Recovery methods which prove successful in one oil reservoir may not be productive in others because reservoir characteristics vary. Therefore, to show that these processes can be applied on a widespread commercial basis, demonstrations of their technical and economic



feasibility must be performed in many different types of fields. (See p. 12.)

GAO found that before attempting to implement a field demonstration oil test program, the Energy Research and Development Administration did not identify those reservoirs with the characteristics which could best demonstrate enhanced oil recovery applications. (See p. 17.)

Agency officials could not provide any documentation showing why 94 field demonstration tests of enhanced gas recovery were needed or how the scheduling was derived for these tests. The officials were uncertain of how many projects were necessary to develop enhanced gas recovery technologies. (See p. 17.)

If the Energy Research and Development Administration's oil and gas enhanced recovery program is to contribute considerably to developing these potential energy sources, a well-defined program management plan is essential. A properly developed management plan can provide greater assurance of obtaining projects which make the best contribution toward developing and demonstrating enhanced recovery technology. Furthermore, effectively implementing such a plan and periodically evaluating program results can provide a basis for reassessing the Federal role and the appropriateness of the level of Federal funding given enhanced recovery as higher oil and gas prices provide greater incentive for industry's development of these technologies. (See p. 18.)

Agency officials told GAO that, pursuant to an Office of Management and Budget request, they are now developing a management plan for the enhanced oil recovery program. In developing the plan, the agency is attempting to, among other things, identify major oil reservoirs and assess the best enhanced recovery methods to use on each and better define what the Federal role should be in achieving enhanced oil and gas recovery objectives. The agency intends to include in its program management plan:

- The priority of targets for enhanced recovery testing
- The sequence of tests and cost.
- A system of disseminating technical information.
- A system for measuring the program's effect on production.
- A plan for assessing the environmental consequences of such a program.

Its officials also said they started developing a similar type of management plan for enhanced gas recovery in December 1976. GAO believes these are important steps for an effective enhanced oil and gas recovery program. (See pp. 18 and 19.)

#### FURTHER CONSTRAINTS TO COMMERCIALIZATION

Several factors are constraining industry from demonstrating and commercializing enhanced recovery technology, including:

- The lack of known long-term oil and gas prices against which to calculate economics.
- The large capital investments required.
- The unproven and risky nature of many enhanced recovery techniques.
- Uncertainty as to the future availability of needed recovery materials for the enhanced oil recovery processes. (See p. 21.)

These constraints could slow commercialization of enhanced oil and gas recovery and could interact to make the Energy Research Development Administration's revised goals of increased oil and gas production even more difficult to achieve. (See p. 24.)

## RECOMMENDATIONS

GAO recommends that the Administrator of the Energy Research and Development Administration:

- Give continued and increased emphasis to developing and putting into operation a management plan for enhanced gas recovery. The plan should focus on developing a balanced research program to include laboratory research, demonstration tests, and the gathering of geological data on the types of deposits the agency plans to test. The plan should also define the number of demonstration tests that will be necessary to commercialize enhanced gas recovery technologies as soon as possible.
- Reassess annually the Federal role and level of effort in enhanced oil and gas recovery research and development in the light of increased oil and gas prices and industry's willingness to promote new technology. (See p. 19.)

## AGENCY COMMENTS

The Energy Research and Development Administration did not comment on GAO's recommendations. The agency expressed concern that this report had a negative rather than an objective tone and that it failed to present an adequate discussion of the agency's position on the issues in question. Basic differences exist concerning the effectiveness of the agency's program.

The Federal Energy Administration also reviewed a draft of this report and generally agreed with its findings. (See p. 20.)

## CHAPTER 1

### INTRODUCTION

About 425 billion barrels of crude oil have been discovered in the United States. However, over two-thirds of these already found resources (290 billion barrels) are not economically recoverable at current prices with the conventional technologies now used. Also, vast quantities of natural gas in certain areas of the United States are not commercially producible with current drilling techniques. About 600 trillion cubic feet of such gas may be locked in tight, low permeability formations in deep Rocky Mountain basins. It has also been estimated that as much as 500 to 600 trillion cubic feet of gas may be locked in the Devonian shale formations of Appalachia. The Energy Research and Development Administration (ERDA) is conducting research aimed at developing and demonstrating enhanced recovery techniques to recover this oil and gas.

Today the Nation depends on oil and natural gas to supply over 75 percent of its energy. Although demand for crude oil continues to grow, domestic production has dropped from a peak of 9.6 million barrels a day in 1970 to a current level of 8.2 million barrels a day. Oil imports which provided 23 percent of U.S. oil consumption in 1970 now provide 40 percent. Natural gas production has fallen from a peak of 22.6 trillion cubic feet in 1973 to 20.1 trillion cubic feet in 1975. The result has been forced curtailments in gas usage. Despite these shortfalls in domestic supply, oil and gas will remain important energy sources into the early part of the next century.

ERDA has implemented programs to develop alternative sources of energy, such as solar, oil shale, and geothermal, to help meet our future energy needs. Although these alternative sources hold promise for supplying a portion of the Nation's future energy needs, considerable contributions from these sources are not expected in the near term (1985). Successful development of enhanced recovery technologies offers the potential for increasing our energy supplies and helping reduce our dependence on foreign imports.

#### ENHANCED RECOVERY--WHAT IS IT?

The term "enhanced recovery" has a distinctly different meaning for the production of oil as contrasted to its meaning in the production of gas. Enhanced recovery of oil refers, for the most part, to increasing the production from producing reservoirs. Enhanced gas recovery generally

refers to the production of gas from areas where commercial production has not previously been possible.

## Oil

Oil is not found in large pools or lakes, rather it is found trapped inside the tiny pores of sedimentary rocks, such as limestone or sandstone. Normally when a well is drilled into oil-saturated rock, the natural underground pressures will drive a portion of the oil out of the rock to the well bore where it can be recovered. The process by which oil is produced from these natural pressures is identified as "primary recovery." On the average, only about 15 to 20 percent of a field's oil is produced by natural pressures.

In many oil fields the natural pressures are not sufficient to move the oil. They have diminished over time to a point where the well is no longer productive. By supplementing the natural pressures, additional oil can be recovered. Currently, the most widespread method of extracting oil after natural pressures have diminished is waterflooding; that is, water is pumped into the oil-bearing rock to flood out some of the oil that would not be recovered through natural forces. This process is known as secondary recovery. Although effective, waterflooding can only increase the yield of a well to about 35 percent.

The oil industry has developed much experimental technology for the enhanced recovery of oil beyond the "secondary" level; however, only a few basic methods have been sufficiently advanced by industry to warrant further study for commercial application. The combined production attributed to all the new enhanced recovery technology is less than 250,000 barrels of oil a day and most of this is from steam injection in California. Some of the more promising enhanced recovery techniques which the industry and ERDA have identified include:

- Micellar polymer flooding--The injection of a detergent (micellar fluid) designed to sweep through the reservoir washing oil from the rock grains as it moves. A second substance (polymer) is injected behind the detergent to move it slowly and steadily through the reservoir. (See illustration on p. 4.)
- Hydrocarbon miscible flooding--The injection of solvents, such as kerosene or dry cleaning fluids, to clean the oil from rock. The solvents are driven by gas pressure which pushes the oil to the producing wells. (See illustration on p. 4.)

--Carbon dioxide injection--The use of carbon dioxide (CO<sub>2</sub>) under sufficiently high pressure so it can change the characteristics of the oil so that it will flow. (See illustration on p. 4.)

--Thermal recovery--In some cases oil is so thick that it can neither be pumped out of the ground nor dissolved out of the rocks. Thermal recovery involves heating the oil within the reservoir, thus thinning it and allowing it to flow toward the producing well. (See illustration on p. 5.)

After applying these techniques it takes several years to determine their technical and economic feasibility. Commercial application and production will take several years more.

A wide range of estimates has been made of how much oil can be obtained by using these techniques. These estimates range from 15 to 110 billion barrels. ERDA estimates that 40 to 60 billion barrels could be produced using enhanced recovery techniques.

## Gas

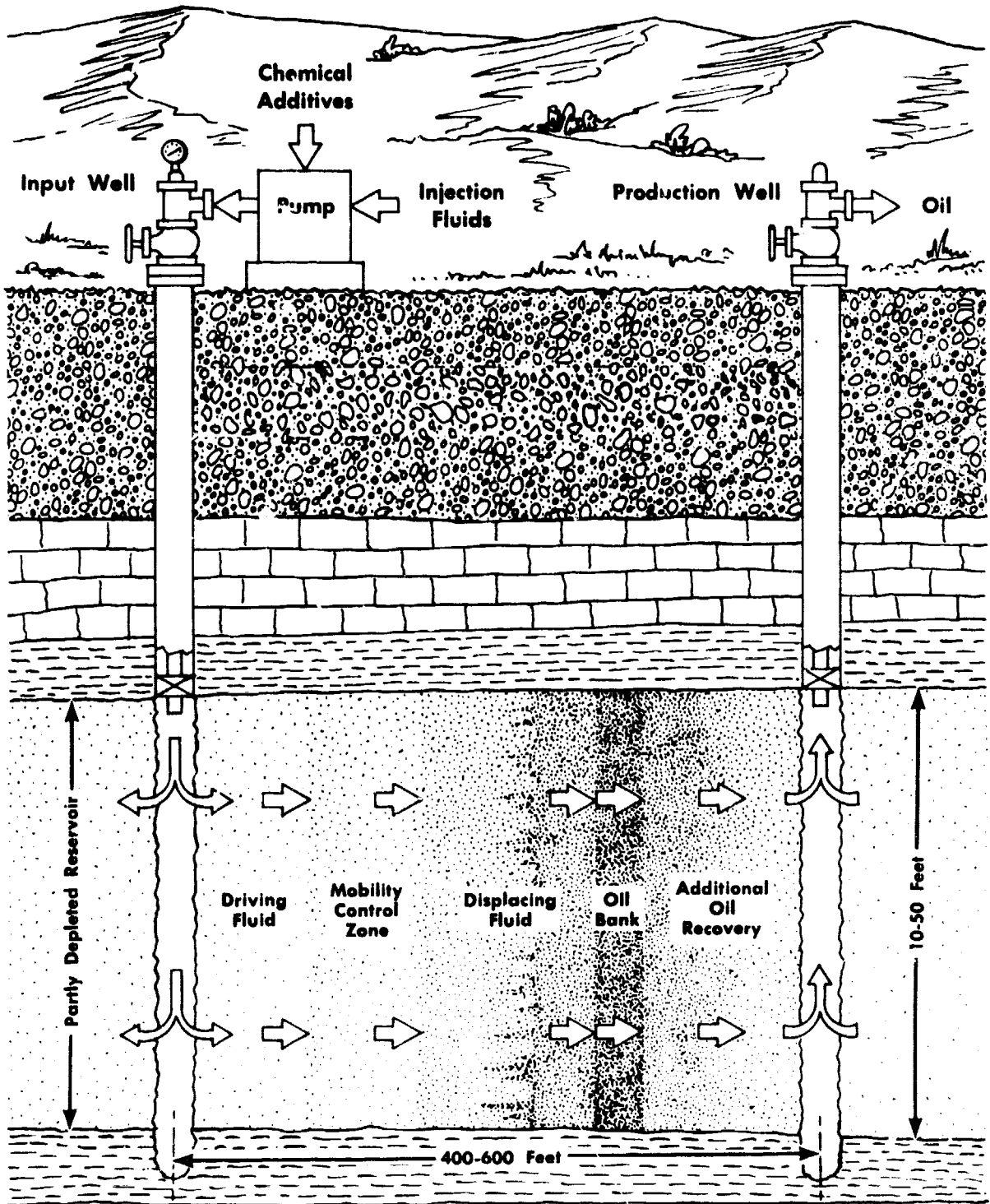
The technology involved in the enhanced recovery of natural gas is quite different than that for the production of oil. The objective of enhanced gas recovery is to expand and extend natural fractures in formations holding gas, causing the gas to flow more rapidly without the need to drill additional wells. Methods of enhanced gas recovery include explosive and hydraulic fracturing and drilling deviated wells.

--Hydraulic fracturing--A fluid containing a "propping" agent, such as sand, is pumped into the well at high pressures. This pressure produces larger and extended fractures, increasing the area from which gas may be recovered. The "propping" agent keeps the fractures open. (See illustration on p. 6.)

--Explosive fracturing--Chemicals, such as nitroglycerin, are placed at the bottom of a well, displaced into fractures, and detonated to stimulate production. (See illustration on p. 7.)

--Deviated wells--Wells are drilled at an angle to increase production by intersecting a maximum number of fractures in gas formations. These "deviated" wells can also be stimulated by hydraulic or explosive fracturing. (See illustration on p. 8.)

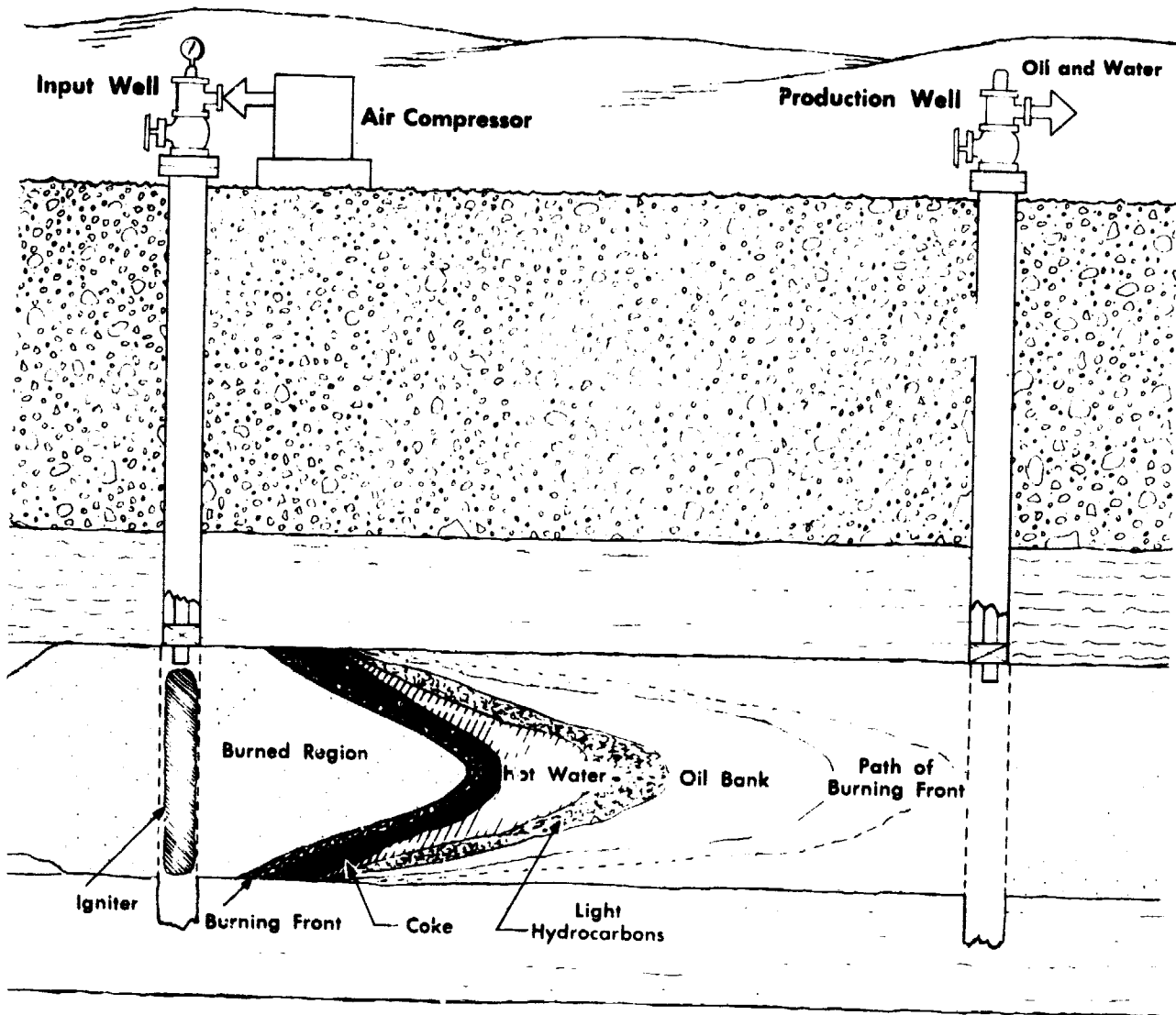
# ENHANCED RECOVERY THROUGH FLUID DISPLACEMENT METHODS



THIS PICTURE IS REPRESENTATIVE OF CARBON DIOXIDE, MICELLAR-POLYMER, AND HYDROCARBON MISCIBLE RECOVERY TECHNIQUES.

SOURCE: MODIFIED VERSION ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION ILLUSTRATION

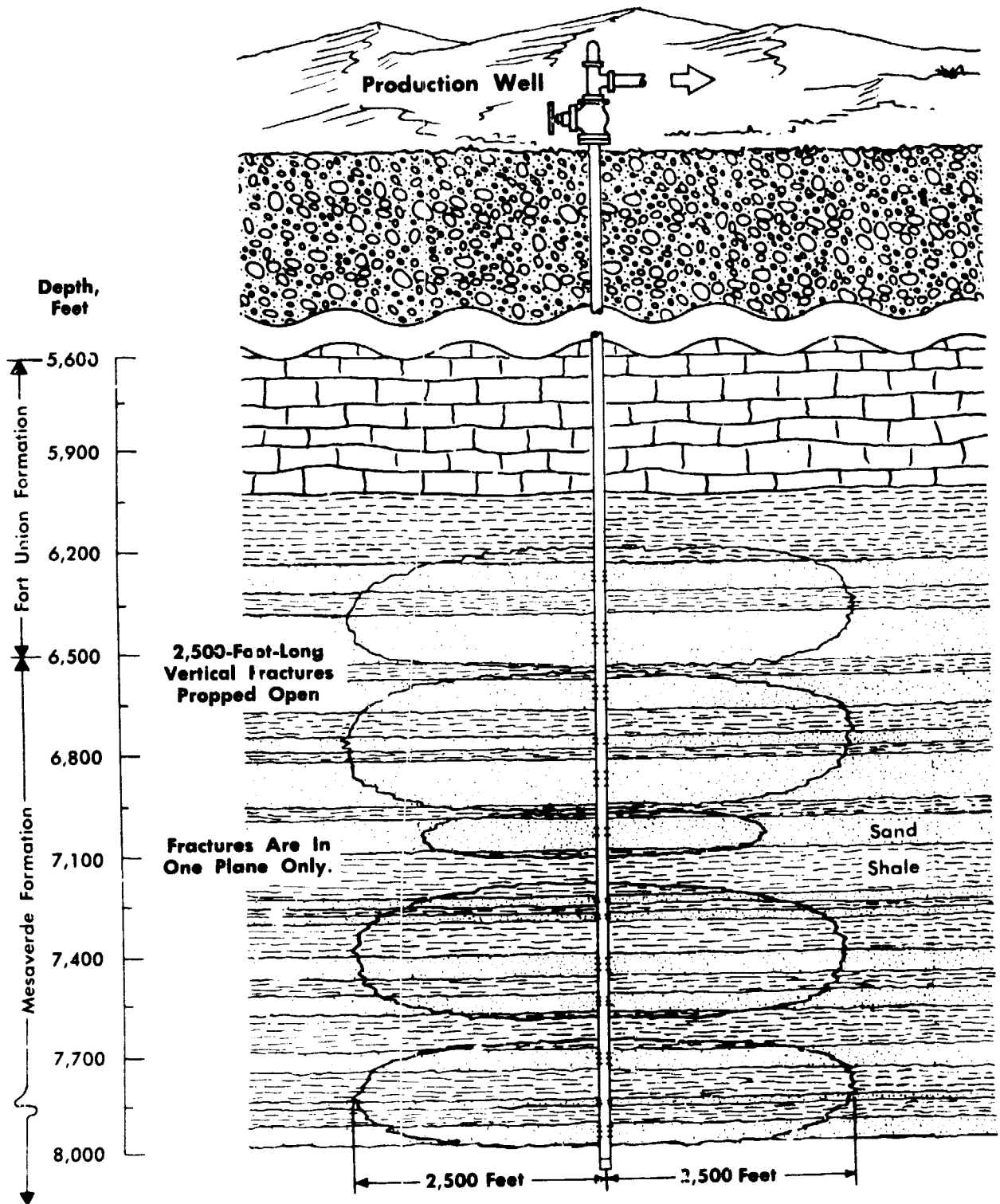
# THERMAL RECOVERY



SOURCE: ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

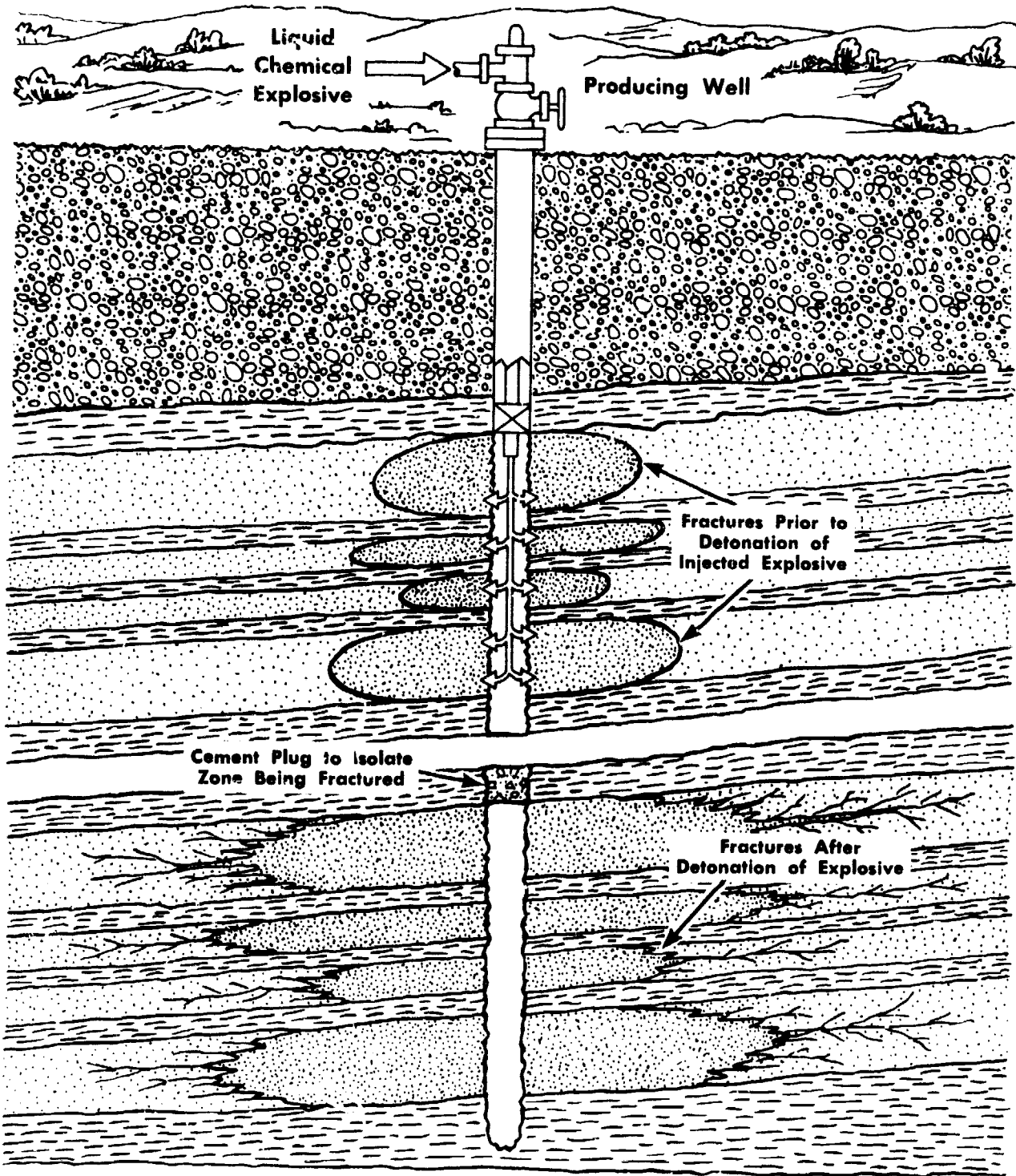


# PRODUCTION STIMULATION BY MASSIVE HYDRAULIC FRACTURING



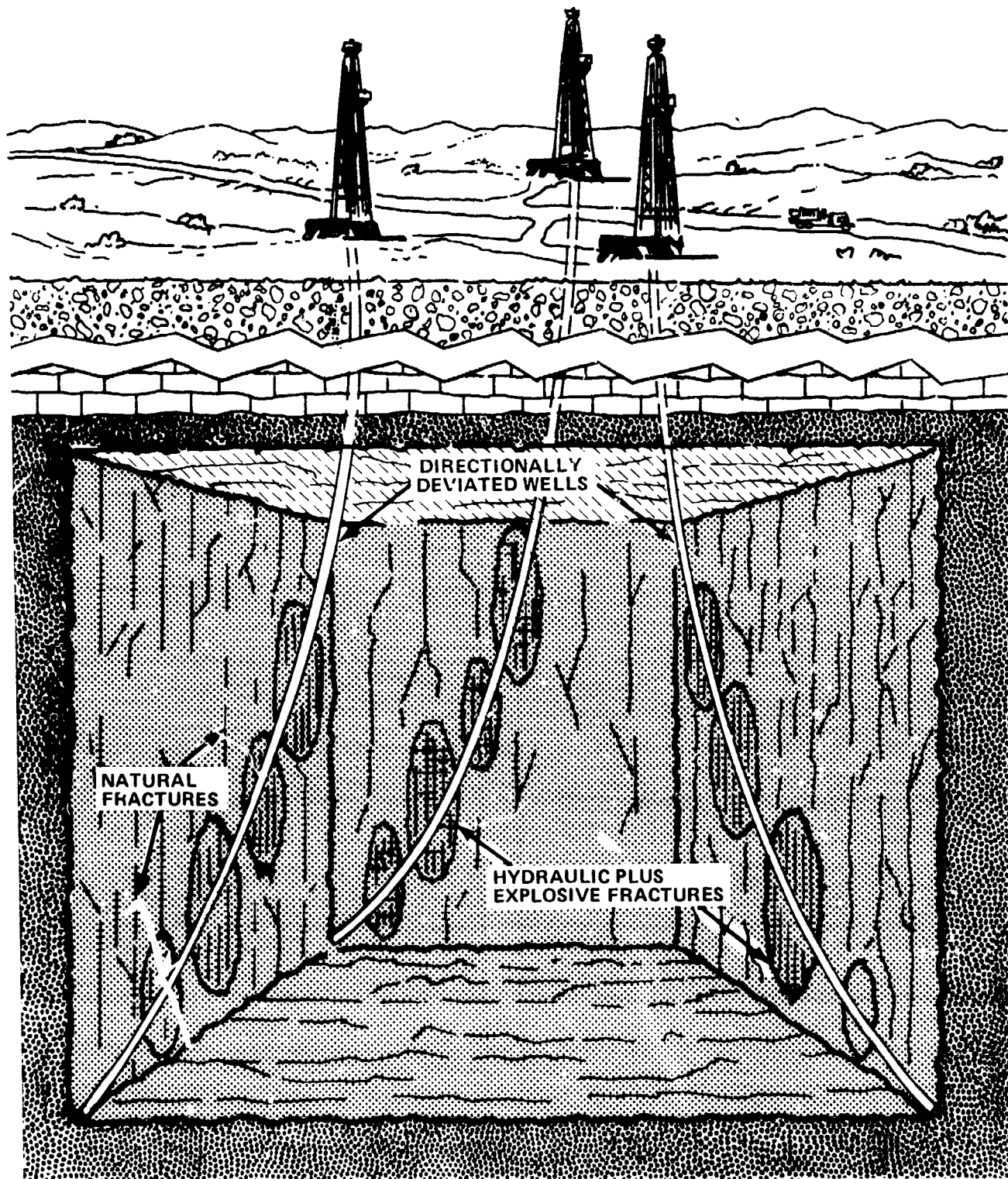
SOURCE: ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

# CHEMICAL EXPLOSIVE FRACTURING



SOURCE: ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

# DIRECTIONALLY DEVIATED WELLS STIMULATED BY HYDRAULIC PLUS EXPLOSIVE FRACTURING



SOURCE: ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

ERDA estimates that as much as 300 trillion cubic feet of gas could be produced using these techniques.

FEDERAL COST-SHARING PROGRAM  
FOR ENHANCED RECOVERY

The Federal Nonnuclear Energy Research and Development Act of 1974 (Public Law 93-577) enacted on December 31, 1974, states that

"It is the policy of the Congress to develop on an urgent basis the technological capabilities to support the broadest range of energy policy options through conservation and use of domestic resources \* \* \*."

The purpose of the act is

"\* \* \* to establish and vigorously conduct a comprehensive national program of basic and applied research and development, including but not limited to demonstrations of practical applications, of all potentially beneficial energy sources and utilization technologies, within the Energy Research and Development Administration."

A specific requirement of the act is to demonstrate new and improved methods for extracting petroleum resources, including the enhanced recovery of oil and gas.

In pursuing these objectives, ERDA is implementing an enhanced oil and gas recovery program, building on an earlier Department of the Interior program. The program itself is not intended to produce large quantities of commercial oil and gas. Rather, the program is supposed to stimulate industry to commercialize enhanced recovery processes by

- accelerating, through cooperative cost-sharing contracts, industry's development of enhanced recovery technologies;
- evaluating the technical and economic feasibility of enhanced recovery technologies; and
- making publicly available the results of its research and development efforts.

When the cost-sharing program has proven an enhanced recovery technique in a full-scale demonstration, industry is expected to utilize it and to assume all costs for commercial development.

Under the program, ERDA has a schedule for entering into cooperative arrangements with private firms to make 103 oil and 94 gas enhanced recovery demonstration tests. ERDA's general policy requires the industry participants to contribute at least 50 percent of the project cost. ERDA expects these tests to be conducted over a 7-year period--1974 through 1980, at a cost of about \$368 million to the Federal Government. As of mid-September 1976, ERDA had initiated 27 oil and gas demonstration tests. The total estimated cost of these tests is approximately \$122 million with ERDA and private industry participants contributing about \$46 million and about \$76 million, respectively. (See app. IV.)

## CHAPTER 2

### ERDA'S ENHANCED OIL AND GAS

#### RECOVERY SCHEDULES LACK TIMELINESS

In 1975 ERDA established goals of increasing commercial oil production by 1.4 million barrels a day and commercial gas production by 8.2 billion cubic feet a day through enhanced recovery processes by 1985. The 1985 production goals were recently reduced to 500,000 barrels of oil a day and 3 billion cubic feet of gas a day. However, ERDA's schedules for developing enhanced oil and gas recovery techniques are unlikely to stimulate enough production by industry to reach the agency's 1985 production goals.

#### ENHANCED OIL RECOVERY SCHEDULE

In 1975 ERDA developed a startup schedule for 103 oil recovery demonstration tests which were thought to be needed to attain the agency's 1985 oil production goals. These tests are intended to provide industry with technical and economic data needed for assessing the feasibility of implementing enhanced recovery on a commercial scale. This schedule was based primarily on a study made in 1973 by the Gulf Universities Research Consortium for the Atomic Energy Commission. <sup>1/</sup> The consortium reported that a consensus of experts from 22 oil companies predicted that about 91 projects utilizing the 4 most promising enhanced oil recovery methods would be needed in a large percentage of the major producing domestic fields before widespread commercial implementation could be expected. The consortium believed that a large number of projects were needed to confidently predict production from enhanced recovery methods. The consortium concluded that about 1.2 million barrels a day could be produced by 1985 if the 91 field tests were started by 1974 and if reasonable wellhead price increases accompanied development of field test data. The report did not provide estimates of the price level required for the technologies' commercial application.

ERDA implemented a 7-year schedule for awarding contracts extending from 1974-80. ERDA's schedule calls for most tests to be started during the last 3 years of the

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<sup>1/</sup> Planning Criteria Relative to a National Research, Development, Testing, and Evaluation Program Directed to the Enhanced Recovery of Crude Oil and Natural Gas, Gulf Universities Research Consortium, November 30, 1973.

7-year period. Of the 103 enhanced oil recovery demonstration tests, 65 are not scheduled to begin until fiscal years 1978 through 1980. ERDA officials told us that a revised schedule will be prepared as part of a new management plan which they are developing. This new plan is discussed on page 18.

Although considerable research and field testing has been done by industry, present knowledge is not adequate to make reasonable estimates of the probable amounts of oil to be recovered from a given reservoir through enhanced recovery techniques. Recovery methods which prove successful in one reservoir may not be productive in others because of variations in reservoir characteristics, such as permeability, porosity, and viscosity. Therefore, to show that these processes can be applied on a widespread commercial basis, demonstrations of their technical and economic feasibility must be performed in many different types of fields.

The period in which the field demonstration tests are completed is vitally important because the test results are to provide the basis for assessing commercial applications. The most promising enhanced oil recovery methods that ERDA expects to develop require several years between field demonstrations, commercial applications, and production. The most promising field demonstration methods require 4 to 5 years to complete.

Since most tests are scheduled to start during the last 3 years of the 7-year period from 1974 through 1980, most of the technical and economic data needed to prove the technologies' commercial feasibility will not be available until the 1982-85 period. Production from field-wide commercial applications cannot be expected for another 4 to 5 years after the technical and economic data from these tests are available. Therefore, the current ERDA demonstration schedule cannot be expected to result in considerable commercial production before the late 1980s or early 1990s. In addition, the micellar-polymer method requires vast chemical quantities for widespread commercial use. The decision to build the required chemical plants is not expected until a viable market is established. The plants' construction is expected to require an additional 2 to 3 years between decision to build and full capacity production.

The Federal Energy Administration (FEA) has been studying the potential of enhanced recovery and has concluded that it can play an important role in aiding the Nation's energy supply. In 1975 FEA suggested that ERDA accelerate its plan for implementing field demonstration tests by increasing the number of tests during the early years of program implementation, thereby compressing the time frame in which test

results would be available for assessing commercial applications. The cost of ERDA's plan and the accelerated plan FEA suggested generally would be the same. Whereas ERDA's plan requires greater funding in the program's later years, FEA's plan requires higher funding during the program's earlier years.

ERDA concurred, in principle, with FEA's proposal. However, ERDA's Administrator felt that further consideration would have to be given to its organizational capabilities, the time implicit in compliance with all the required reviews and competitive proposal procedures, and to the constraints due to limited availability of the surfactant chemicals used for micellar and improved waterflooding. A comparison of ERDA's schedule and FEA's suggested schedule is shown in figure 1.

#### NATURAL GAS RECOVERY SCHEDULE

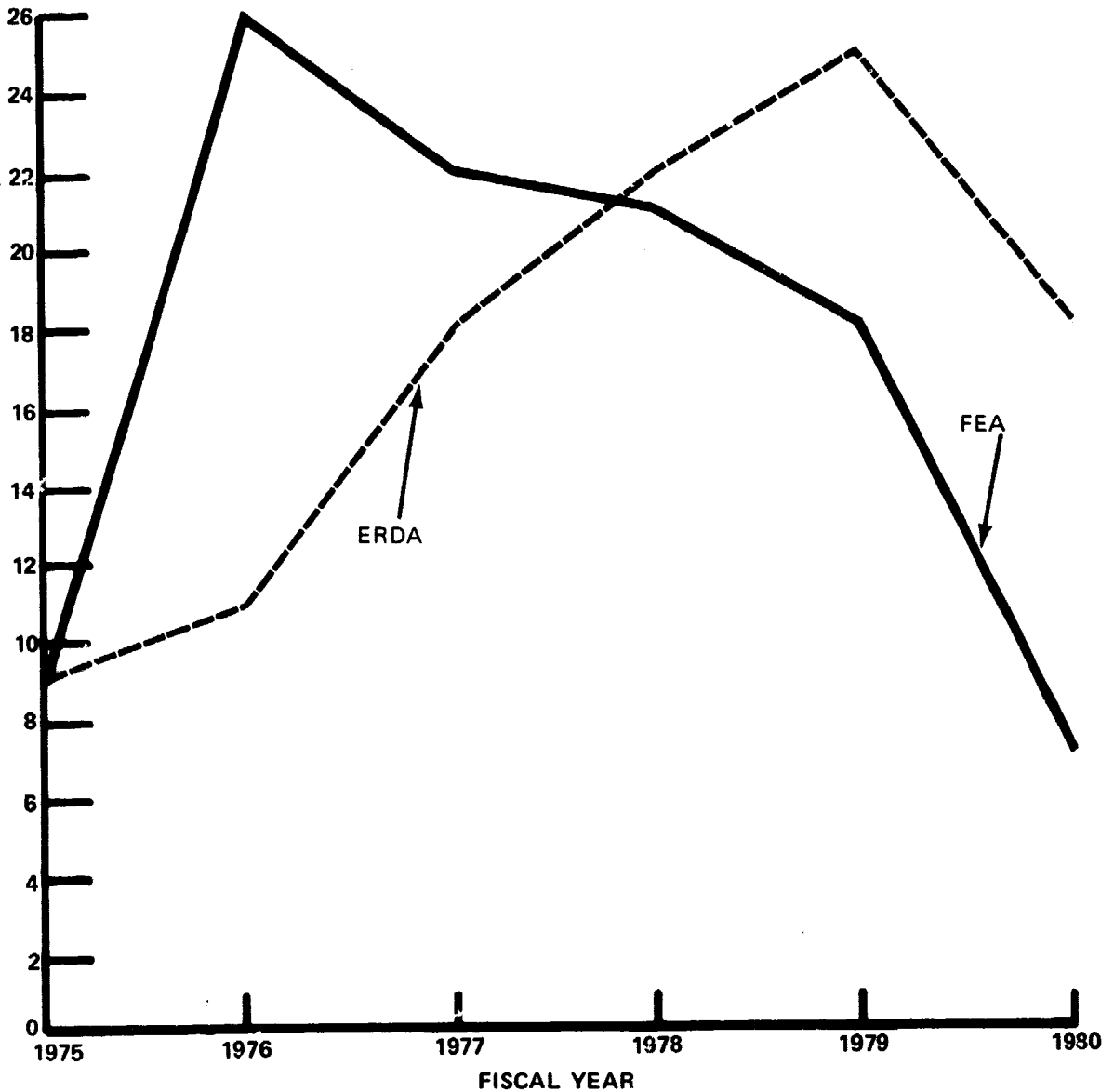
ERDA implemented a schedule for 94 field demonstrations covering the 7-year period 1974-80 to achieve its 1985 production goals. As with oil, these tests are intended to provide industry with technical and economic data needed for assessing the feasibility of implementing enhanced recovery on a commercial scale. Of the 94 tests, 15 were scheduled to begin in fiscal years 1974 through 1976, with the remaining 79 scheduled for fiscal years 1977-80.

The period between field demonstrations and commercial production of natural gas is less than that of enhanced oil recovery. Field tests can be completed in a relatively short period. However, enhanced natural gas recovery technology is not as far advanced as oil recovery technology. Industry officials stated that more research is needed for natural gas recovery processes. ERDA and industry officials said one of the major reasons for this has been historically low wellhead prices (less than 22 cents a thousand cubic feet until 1974) which provided little incentive for developing advanced technology in this area.

Effective July 27, 1976, the Federal Power Commission (FPC) increased the wellhead ceiling prices for interstate natural gas from 52 cents a thousand cubic feet (Mcf) to \$1.42 an Mcf for gas from wells started on or after January 1, 1975, and 93 cents an Mcf for gas from wells started in 1973 and 1974. FPC prescribed that the ceiling price of post-1974 gas could be increased 1 cent an Mcf each quarter starting October 1, 1976. FPC also prescribed that the ceiling price of 1973-74 gas could be increased 1 cent an Mcf annually beginning January 1, 1977. These rate increases



FIGURE 1  
**ERDA'S ENHANCED OIL RECOVERY FIELD DEMONSTRATION  
 SCHEDULE COMPARED TO FEA'S PROPOSED SCHEDULE  
 (BY FISCAL YEAR)**



NOTE: NUMBERS INDICATE PROJECTS PROPOSED DURING EACH FISCAL YEAR;  
 NUMBERS FOR 1976 INCLUDE PROJECTS PLANNED DURING TRANSITION  
 QUARTER BETWEEN FISCAL YEARS 1976 AND 1977

are currently being contested in court and may change. The affect any price increases will have on industry research and development is not yet known, but they are likely to provide additional incentive for industry to develop advanced recovery technologies.

However, because of the slow pace of the Energy Research and Development Administration's enhanced gas recovery demonstration schedule and the lack of fundamental recovery technology, it is likely that enhanced gas recovery technologies would not make a considerable contribution to the Nation's gas supply before the late 1980s.

A few of ERDA's enhanced gas recovery tests have recently been completed; however, the results have been disappointing because little additional gas has been produced. Not enough is known about gas recovery technology and the gas deposits in the areas being tested to adequately evaluate the test results. Therefore, the reasons for the lack of significant production during these tests are generally unknown. Whether the lack of production increases is due to ineffective stimulation techniques, or whether there are inadequate amounts of gas available at the test sites remain unresolved. Industry officials told us that ERDA should implement a rapid and balanced gas recovery research program if gas production is to be increased in the near term. According to them, such a program should include laboratory research, demonstration projects, and the gathering of geological data on the types of gas deposits ERDA is testing.

ERDA has begun a \$4.9 million project in cooperation with the U.S. Geological Survey to gather geological data on gas deposits in the Devonian shale formations of Appalachia. ERDA also plans to award \$18 million in contracts to universities and State and private research groups over the next 5 years to characterize the gas resource targets in order to identify the areas with the most potential for enhanced recovery. ERDA officials told us the results of this effort should provide a basis for better determining the location of future demonstration tests.

## CONCLUSIONS

ERDA's schedules for developing enhanced oil and gas recovery techniques are unlikely to stimulate enough industry production to reach the agency's 1985 oil and gas production goals because the schedules call for most tests to start during the last 3 years of the 7-year period 1974-80.

Since field demonstrations of the most promising oil recovery methods require 4 to 5 years to complete, most of the

technical and economic data needed to prove the technologies' commercial feasibility will not be available until the 1982 to 1985 time frame. Production from field-wide commercial applications cannot be expected for another 4 to 5 years after the technical and economic data from these tests is available. Therefore, the current ERDA demonstration schedule cannot be expected to result in considerable commercial oil production increases before the late 1980s or early 1990s.

Enhanced gas recovery technology is not as advanced as enhanced oil recovery technology, and the Energy Research and Development Administration's program is proceeding slowly under the current schedule. As a result, although the time between successful demonstration of enhanced gas recovery methods and substantial gas production using these methods is shorter, it is likely that enhanced gas recovery technologies would not make a considerable contribution to the Nation's gas supply before the late 1980s.

### CHAPTER 3

#### NEED FOR AN EFFECTIVE MANAGEMENT PLAN AND IMPROVED PROGRAM IMPLEMENTATION METHODS

ERDA's efforts to develop and demonstrate enhanced recovery technologies have been hampered by the lack of an effective program management plan. Adequate consideration has not been given to demonstrating these technologies in the most desirable test fields.

#### LACK OF AN EFFECTIVE MANAGEMENT PLAN

According to the Office of Management and Budget, ERDA has not had an effective program management plan for enhanced oil and gas recovery. The Office of Management and Budget's major criticism is that ERDA has not adequately identified those ingredients essential to a successful enhanced recovery program which would result in the most rapid and effective means for increasing domestic petroleum supplies.

Before attempting to implement a field demonstration oil test program, ERDA did not identify those reservoirs with the characteristics which could best demonstrate enhanced oil recovery applications. Without this information, ERDA was unable to specify project requirements in sufficient detail in its requests for proposals to ensure that it would undertake demonstration tests that made the optimum contribution to developing and demonstrating enhanced oil recovery. ERDA officials agreed that their project specifications were too general. According to them, a management plan now under development should enable ERDA to better specify in its requests for proposals the ranges of reservoir and fluid characteristics required for each test.

Furthermore, ERDA officials could not provide any documentation showing why 94 field demonstration tests of enhanced gas recovery were needed or how the scheduling was derived for these tests. They indicated that the schedule stemmed from earlier Department of the Interior planning exercises made before the program was transferred to ERDA in January 1975. ERDA officials were uncertain of how many projects were necessary to develop enhanced gas recovery technologies.

A properly developed management plan can provide greater assurance of obtaining projects which make the best contribution toward developing and demonstrating enhanced recovery technology. Furthermore, effectively implementing such a plan and periodically evaluating program results can provide

a basis for reassessing the Federal role and the appropriateness of the level of Federal funding given enhanced recovery as higher oil and gas prices provide greater incentive for industry's development of these technologies.

#### ERDA DEVELOPING A PLAN

ERDA officials told us that, pursuant to an Office of Management and Budget request, they are now developing an enhanced oil recovery program management plan. Areas of study which are currently underway include:

- Identifying major oil reservoirs and the assessment of the best enhanced recovery methods to use on each.
- Assessing the production potential of these major oil reservoirs using enhanced recovery techniques.
- Assessing industry's willingness and/or ability to invest in enhanced recovery projects of different type.
- Developing estimates of how much oil would be produced at various price levels, both with and without a Federal research and development program.
- Defining better what the Federal role should be in achieving enhanced oil and gas recovery objectives.

From these studies and subsequent analyses ERDA intends to develop a program management plan which will include:

- The priority of targets for enhanced recovery testing.
- The sequence of tests and cost.
- A system of disseminating technical information.
- A system for measuring the program's effect on production.
- A plan for assessing the environmental consequences of such a program.

ERDA officials told us they started developing a similar management plan for enhanced gas recovery in December 1976.

#### CONCLUSIONS

If ERDA's oil and gas enhanced recovery program is to contribute considerably to developing these potential energy

sources, a well-defined program management plan is essential. A properly developed management plan can provide greater assurance of obtaining projects which make the best contribution toward developing and demonstrating enhanced recovery technology. Furthermore, effectively implementing such a plan and periodically evaluating program results can provide a basis for reassessing the Federal role and the appropriateness of the level of Federal funding given enhanced recovery as higher oil and gas prices provide greater incentive for industry's development of these technologies.

ERDA's preparation of an enhanced oil recovery management plan is an important step for an effective enhanced recovery program and, if developed along the lines currently proposed by ERDA, should contribute to an improved program.

Field demonstrations in those reservoirs, to be identified by ERDA in its management plan, having the characteristics which could best demonstrate the technical and economic feasibility of widespread commercial applications, would result in a more effective and timely demonstration program.

In December 1976 ERDA started developing a management plan for enhanced gas recovery. We believe this is an important step in developing an effective enhanced gas recovery program.

#### RECOMMENDATIONS

We recommend that the Administrator of ERDA:

- Give continued and increased emphasis to developing and putting into operation a management plan for enhanced gas recovery. The plan should focus on developing a balanced research program to include laboratory research, demonstration tests, and the gathering of geological data on the types of deposits the agency plans to test. The plan should also define the number of field demonstration tests that will be necessary to commercialize enhanced gas recovery technologies as soon as possible.
- Reassess annually the Federal role and level of effort in enhanced oil and gas recovery research and development in the light of increased oil and gas prices and industry's willingness to promote new technology.

## AGENCY COMMENTS

The Energy Research and Development Administration did not comment on our recommendations. The agency expressed concern that this report had a negative rather than an objective tone and that it failed to present an adequate discussion of the agency's position on the issues in question. Basic differences exist concerning the effectiveness of the agency's program. (See apps. I and II.)

The Federal Energy Administration also reviewed a draft of this report and generally agreed with its findings. (See app. III.)

CHAPTER 4  
PROBLEMS WHICH MAY AFFECT  
COMMERCIALIZATION OF ENHANCED  
RECOVERY TECHNIQUES

Government and industry agree that enhanced recovery processes could help increase this Nation's domestic energy supply. However, the time frame in which widespread commercial applications of enhanced recovery techniques might be made and the rate at which these resources will become available is quite uncertain.

Several factors are constraining industry from demonstrating and commercializing enhanced recovery technology. These include:

- The lack of known long-term oil and gas prices against which to calculate economics.
- The large capital investments required.
- The unproven and risky nature of many enhanced recovery techniques.
- Uncertainty as to the future availability of needed recovery materials for the enhanced oil recovery processes.

PRICING

According to industry officials, low oil and gas prices have historically been major constraints to development and commercialization of enhanced recovery. The price levels necessary to produce considerable amounts of oil and gas through enhanced recovery operations are not yet well defined. The costs of these techniques will require prices above those presently paid for domestic production.

Oil

The composite price of domestic oil is about \$8 a barrel. Current Organization of Petroleum Exporting Countries (OPEC) prices are about \$13 a barrel. Lewin Associates, Incorporated, recently completed a study for FEA which included an analysis of the potential for enhanced recovery in California, Texas, and Louisiana. The study showed that, of the 43.3 billion barrels of oil technically recoverable through enhanced recovery in these States, 30.5 billion barrels



could be economically recoverable at a price of \$11.28 a barrel under the most optimistic conditions. Of these same resources, Lewin Associates estimated that only 5.2 billion barrels would be economically recoverable at \$5.25 a barrel. It concluded that price strongly affects the quantity of oil to be produced from enhanced recovery techniques.

Some Federal action has been taken to provide additional price incentives for enhanced oil recovery. A recent act (90 Stat. 1125) extending the life of FEA has provided for somewhat greater flexibility in allowing higher regulated prices for oil that is difficult to produce. In this regard, the act requires that early consideration be given to providing additional price incentives for bona fide enhanced recovery techniques.

Our review focused on the management of ERDA's enhanced recovery program. We recognize that increases in the price of oil could stimulate industry research and development and reduce the need for a Federal research and development program in enhanced oil recovery. We did not examine the affect that price increases would have on the need for a Federal enhanced recovery program. However, we plan to consider this question in future work.

### Gas

As discussed on pages 13 and 15, FPC increased the regulated wellhead price ceilings for interstate natural gas, effective July 27, 1976, from 52 cents a thousand cubic feet (Mcf) to \$1.42 an Mcf for wells started on or after January 1, 1975, and 93 cents an Mcf for wells started in 1973 and 1974. FPC prescribed that the ceiling price of post-1974 gas could increase 1 cent an Mcf each quarter starting October 1, 1976, and that the ceiling price of 1973-74 gas could increase 1 cent annually beginning January 1, 1977. The American Gas Association recently estimated that the cost of producing large quantities of gas using enhanced recovery techniques could range from \$1.50 to \$2.50 an Mcf.

### CAPITAL REQUIREMENTS

Enhanced recovery operations require capital investments far in excess of those required using conventional recovery techniques. The major cost increase for enhanced oil recovery using the carbon dioxide or micellar polymer processes stems from the purchase of injection materials (chemicals and fluids), necessary in removing additional oil from the reservoir. The Lewin Associates study for FEA estimated that \$150 billion would be required to produce 30.5 billion barrels from enhanced recovery processes. Some \$30 billion

would be required for field development and equipment and an additional \$120 billion for injection chemicals and fluids.

Not only are enhanced recovery operations more costly than conventional recovery processes, but much of these costs are incurred long before production starts. Chemicals which are injected in 1976 are not expected to produce oil until about 1980. The pace at which the fluids move through the reservoir cannot be accelerated; therefore, repayment of capital investment will be slower than that of using conventional recovery techniques.

### RISK ASSESSMENT

The adequate assessment of risk is considered to be an unavoidable prerequisite to commercializing enhanced recovery processes. Industry officials told us Government participation is necessary in demonstrating and assessing these high risk processes. ERDA's position is that the assessment of risk can only be accomplished by completing many field demonstration tests. Although the period required for assessing these processes through field demonstration tests will directly affect implementing commercial-scale ventures, ERDA, as of mid-September 1976, had only initiated 16 enhanced oil recovery field demonstration tests and 11 natural gas tests. (See app. IV.)

### RECOVERY MATERIALS

The enhanced recovery methods ERDA expects to produce the most oil involve the injection of chemicals and fluids into the reservoirs to remove the oil still in place.

Industry officials told us that shortages of these enhanced recovery materials could impede commercializing enhanced recovery technologies. According to a recent Gulf Universities Research Consortium study--based on information obtained from oil and chemical companies--for ERDA, about 3.5 billion pounds of chemicals would be needed annually to maintain production of one-half million barrels of oil a day from the micellar polymer process. Most of the current production of these chemicals is committed to other commercial uses. The study estimated the capital investment required to construct needed additional capacity would be about \$1.2 billion. Present chemical production capacity is now considered sufficient to support the field demonstration program. However, commercial application of the processes cannot be made until additional capacity becomes available.

The anticipated increase in chemical demands will require constructing several large chemical plants. However,

ERDA's studies indicate that this expansion will not occur until a viable enhanced recovery market has been established. This can only be accomplished through completing a series of field demonstration tests. ERDA recognizes that a shortage of chemical supplies must be overcome before widespread commercial applications can be made. Also it is recognized that at least 2 to 3 years must be allowed for new chemical plant construction once the decision to build has been made.

Another consideration is the energy intensiveness of the chemicals used in enhanced recovery. Some of the chemicals used in enhanced oil recovery contain large amounts of oil. In addition, energy is required to build and operate the plants which produce the chemicals. The energy intensiveness of chemicals used in enhanced oil recovery will partially offset the energy obtained from these wells. In some cases this offset may be considerable and could be an important consideration in commercializing the processes.

#### CONCLUSIONS

ERDA considers enhanced recovery to be one of the most effective near-term methods for increasing domestic energy supplies. ERDA's present program, however, does not provide for maximizing the development of these resources in the near term. The assessment of risk has progressed slowly and commercial applications of enhanced recovery techniques are not expected until such an assessment is completed. Delays in commercial applications are further compounded by possible shortages of injection materials, plus high capital investment.

Price levels necessary to provide enhanced recovery resources have not been firmly identified; however, pricing is a primary determinant in assessing commercial applications. Adequate price levels against which economics could be calculated are essential for establishing industry confidence.

These constraints could slow commercialization of enhanced oil and gas recovery and could interact to make ERDA's revised goals of increased oil and gas production even more difficult to achieve.

## CHAPTER 5

### SCOPE OF REVIEW

We directed our review at the management of ERDA's enhanced oil and gas recovery program. We interviewed officials at the following locations.

- ERDA Headquarters, Washington, D.C.
- Bartlesville Energy Research Center, Bartlesville, Oklahoma.
- Federal Energy Administration Headquarters, Washington, D.C.
- Gulf Universities Research Consortium, Houston, Texas.
- University of Tulsa, Tulsa, Oklahoma.
- Cities Service Oil Company, Wichita, Kansas.
- Phillips Petroleum Company, Bartlesville, Oklahoma.
- Kewanee Oil Company, Tulsa, Oklahoma.
- Amoco Production Company, Tulsa, Oklahoma.
- Shell Oil Company, Houston, Texas.
- Penn Grade Crude Oil Association, Bradford, Pennsylvania.
- Guyan Oil Company, Parkersburg, West Virginia.
- CER Geonuclear Corporation, Las Vegas, Nevada.
- Columbia Gas System Service Corporation, Columbus, Ohio.
- El Paso Natural Gas Company, El Paso, Texas.
- Physics International Company, San Leandro, California.
- Kentucky-West Virginia Gas Company, Prestonburg, Kentucky.
- Mobil Oil Corporation, Dallas, Texas.

--Continental Oil Company, Houston, Texas.

--Gulf Oil Corporation, Houston, Texas.

--Oil and Gas Journal, Tulsa, Oklahoma.

AGENCY COMMENTS ANDGAO EVALUATION

In a letter dated September 14, 1976, ERDA commented on a draft of this report. Presented below is the text of the agency's comments, along with our evaluation.

ERDA COMMENT

"Dear Mr. Canfield:

"Thank you for the opportunity to comment on the draft report entitled 'Enhanced Oil and Gas Recovery--Federal Effort Moving Slowly.'

"We have reviewed the draft with members of your staff and we understand that a number of changes and clarifications which we suggested will be made. There are, however, several additional changes which we would like to see made in order that the report may become a more objective, meaningful document for the Congress.

"In addition to being somewhat dated, in general, we find that the report has a negative rather than an objective tone and fails to present an adequate discussion of ERDA's positions on the issues in question. Even the title seems to reflect this tone, and may bias the reader from the outset. We would suggest a more objective title such as 'An Evaluation of ERDA's Enhanced Oil and Gas Recovery Program.' Indeed, the report discusses only ERDA's program, but does not include other parts of the 'Federal Effort,' such as the regulatory program.

"Frequent comments are made about the need for enhanced oil and gas recovery management plans, but the report does not recognize that both programs (oil and gas) started with program plans. These have since evolved along with the state of knowledge and industry attitudes.

"Industry opinions are cited in numerous places. It is important to recognize that the views of industry concerning the state of enhanced oil recovery technology, its applicability, and the costs of tertiary oil have changed considerably over

the past few years. It would be in order for GAO to obtain a current industry opinion."

### GAO EVALUATION

Our report is current and not dated. We initiated the review in August 1975, and our draft report submitted to ERDA reflects information obtained from the Federal Government and industry sources through July 1976. Although the views of industry concerning the state of enhanced oil recovery technology, its applicability, and the costs of tertiary oil may have changed considerably over the past few years, as stated by ERDA, most of our discussions with industry on these matters have all taken place within the past year.

We have revised the report to show that the number of ERDA-enhanced oil and gas projects has increased from 15 in our draft report to 27 as of August 1976 with the Federal commitment to the projects increasing from about \$23 million to about \$47 million.

As part of the Energy Reorganization Act of 1974, the Bureau of Mines (BOM) enhanced recovery program was transferred to ERDA in January 1975. Shortly after the reorganization, ERDA published "A National Plan for Energy Research, Development, and Demonstration: Creating Energy Choices for the Future" (June 1975) which set a goal of increasing commercial oil production by 1.4 million barrels a day and commercial gas production by 8.2 billion cubic feet a day through enhanced recovery processes. However, ERDA did not develop a plan to meet these highly optimistic goals or to increase the recovery of oil and gas at the earliest possible date using enhanced techniques. Rather, ERDA awarded contracts to interested and qualified firms expressing a desire to participate in the BOM program. In fact, most of ERDA's contracts awarded during 1975 were initiated by BOM. ERDA recognized that the achievement of its June 1975 goals was not possible and reduced these goals to 500,000 barrels a day and 3 billion cubic feet a day by 1985. In addition, ERDA is currently reexamining these revised production goals.

This report attempts to put in perspective the fact that ERDA has had to drastically reduce the production goals it initially set for enhanced oil and gas recovery. Although it would be difficult to predict to what extent ERDA's initial goals could have been achieved, one of the major reasons contributing to reducing the goals was the lack of

a well-defined program relating projects and fields to the established goals.

#### ERDA COMMENT

"The reduction in ERDA's goals for increased national production of oil and gas from enhanced recovery methods reflects a change during the past two years in the attitudes of the petroleum industry, particularly toward enhanced oil recovery. In 1974, the industry felt it had enhanced recovery technology on the shelf, ready to be used if only the price of oil could make these expensive processes profitable. Early ERDA goals reflected this optimistic industry belief. In 1974, large increases in oil prices provided the impetus to invest in field applications of advanced recovery technologies. Only then was it realized that not enough was known about the physics, chemistry and engineering of petroleum reservoirs and their interaction with the injection materials used for enhanced recovery. In mid-1974, the best physical chemists in the larger oil companies were assigned to the enhanced recovery problem and the information gained since then has served to make the industry more cautious in its assessment of these processes and their potential."

#### GAO EVALUATION

This information was available to ERDA when it established its initial production goals in June 1975. As early as 1973, a study the Gulf Universities Research Consortium made for the Atomic Energy Commission/ERDA pointed out that

"the state of knowledge regarding enhanced methods and their application to varying reservoir characteristics, size, depth, lithology, etc. denies any reasonable estimate of the probable recovery in a specific reservoir. Only large-scale field tests supplemented with highly directed supplemental R&D can overcome this difficulty."

This information, along with other information developed by industry since 1974, which ERDA states has made industry more cautious in its assessment of these processes and their potential should have been reflected in the 1975 goals.



ERDA COMMENT

"It is incorrect to state that ERDA does not have a program management plan for enhanced oil and gas recovery. The enhanced recovery program has been guided by a 1974 (Interior) proposal for a five year plan since its inception and the current and planned projects are a result of that plan. Naturally, as industry attitudes towards enhanced recovery have changed, the Government's role has changed and its program plan has evolved. Our current efforts are aimed at improving the existing plan and grounding it on a firm analytical basis, but the program to date has certainly not been aimless. It has been based on experience and the best information available. As such, it has been the product of an evolutionary process. An improved management plan is expected to be implemented in October 1976. An updated estimate of the number, type and timing of enhanced oil recovery tests is currently being developed and is expected to be a part of this improved management plan."

GAO EVALUATION

In our draft report we did not state that ERDA does not have a program management plan. Rather, we stated that:

"ERDA's efforts to develop and demonstrate enhanced recovery technologies have been hampered by the lack of an effective program management plan."

When the program was transferred from BOM, ERDA did not develop a revised program to meet ERDA's goals or to optimize enhanced recovery.

The Office of Management and Budget has also criticized ERDA for not developing an effective program management plan for enhanced oil and gas recovery. The Office of Management and Budget informed us that ERDA has not adequately identified those ingredients essential to a successful enhanced recovery program which could result in the most rapid and effective methods for increasing domestic petroleum supplies. As a result, the Office of Management and Budget has required ERDA to improve its existing management plan by performing a detailed analysis of the Federal role in enhanced recovery and the proper scope and content of a research and development program. More specifically, ERDA has been requested to (1) provide estimates of the value

of a Federal research and development program in enhanced oil recovery as compared to, and in combination with, other Federal initiatives to encourage commercialization of tertiary recovery technologies and (2) analytically develop a research and development plan for the most effective allocation of ERDA's enhanced oil recovery budget. Pursuant to the Office of Management and Budget's request, ERDA started the same type of study for its enhanced gas recovery program in December 1976.

[See GAO note, p. 35.]

[See GAO note, p. 35.]

#### ERDA COMMENT

"The GAO report cites, in several places, an ERDA schedule for awarding contracts to conduct demonstration tests and criticizes it for planning to start most of the tests during the latter years of a seven year program. It should be noted that what the report refers to is not an ERDA schedule, but three different projections of how different funding distribution, over a five year period, might be reflected in actual field test starts. These projections were reflected in a July 17, 1975, letter from Dr. Seamans to Frank Zarb in response to an accelerated funding schedule suggested by FEA. The ERDA letter clearly indicated that while we concurred with FEA's suggestion in principle, there were a number of factors which ERDA needed to consider before reconciling the exact level of acceleration."

#### GAO EVALUATION

We agree that the 103 field demonstration tests were outlined in a letter to the Administrator of the Federal Energy Administration projecting how different funding distribution over a 5-year period might be reflected in actual field starts. However, this projection/schedule was at that time, and still is, ERDA's basis for carrying out its enhanced oil recovery demonstration tests. ERDA could not provide us with any other document outlining its planned strategy for carrying out its demonstration tests. ERDA officials told us that an updated estimate of the number, type, and timing of enhanced oil recovery tests is currently being developed and is expected to be a part of its improved management plan.

ERDA COMMENT

"ERDA's position is not the result of a lack of understanding of the need for urgency; rather, it is affected by the following factors:

"A. ERDA has constraints on the amount of money it can spend on enhanced recovery projects and on the manpower resources it can call up on to plan, prepare, execute and manage procurements and monitor projects. For the available manpower resources, we believe that the program is moving as fast as possible and, as discussed above, is undergoing reexamination. Development of the improved management plan may require a different mix of people and dollars than the present effort."

GAO EVALUATION

We agree that funding and manpower resources place constraints on what can be accomplished under a particular program. Office of Management and Budget officials indicated to us and to ERDA in budget negotiations that they were not satisfied with ERDA's current approach for managing the enhanced oil and gas recovery programs. As a result, the Office of Management and Budget directed ERDA to develop an improved management plan.

The Office of Management and Budget suggested ERDA's revised management plan include (1) estimates of the value of a Federal research and development program in enhanced oil recovery and (2) an analytically developed research and development plan demonstrating the most effective allocation of ERDA's enhanced oil recovery budget. If ERDA had, at the start of the program, developed a plan with these elements, it would have had a better basis for justifying requests for additional funds to the Office of Management and Budget.

ERDA COMMENT

"B. It must be recognized that the accelerated strategy suggested by the GAO is a much riskier one than ERDA's present plan. The accelerated schedule would force ERDA to plunge into an intensive and expensive effort with a minimum amount of information, understanding and planning. While the early field tests that ERDA is conducting may not achieve commercial production for eight to ten years, they provide very valuable performance data after two or three years, enabling us to plan

for and choose the later projects much more effectively. To accelerate the schedule of projects, we may need to accept proposals in advance of information developed by projects, accept proposals that are inferior to those we have already funded, or force proposals from companies that have not planned and budgeted for such projects. As information from the earlier tests is made available, more companies should be encouraged to plan for and seek joint projects with ERDA."

#### GAO EVALUATION

Risky projects of this nature are directly in line with ERDA's role. ERDA's role, as set forth in "A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future 1976," is as follows:

"Since the development and application of enhanced oil and gas recovery technologies involve high risk and long lead times, the government is providing incentives for industry to accelerate development; the primary responsibility for commercialization, however, lies with industry.

"The present program provides industry incentives through cost-sharing, and thus risk-sharing R&D contracts with industry."

Enhanced recovery appears to have great potential in increasing our domestic energy supplies (40 to 60 billion barrels, according to the latest ERDA estimate) and it may be beneficial to the Nation for the Federal Government to assume some additional risks in this area. Hopefully, the information ERDA is developing for its new management plan will assist ERDA in identifying those reservoirs it needs for its tests and if program acceleration is warranted, allow the agency to do so without accepting inferior proposals.

#### ERDA COMMENT

"It is true that enhanced gas recovery technology is not as far advanced as that of recovering oil. This is due to the fact that up until 1974 the wellhead price for natural gas was under twenty cents per thousand cubic feet (MCF). No incentive was present to develop advanced--and necessarily expensive--technologies to recover such a low-value commodity.

Even today, natural gas price regulation dampens industry interest and creates great economic uncertainties with respect to enhanced gas recovery."

#### GAO EVALUATION

The purpose of this section is to report on the status of ERDA's enhanced gas recovery efforts and to show that the program is not moving along as fast as it should.

We recognize that keeping the wellhead price of natural gas down may hinder research and development and may create economic uncertainties with respect to enhanced gas recovery and have revised the report to show ERDA's concern for the effects of gas pricing on research and development.

#### ERDA COMMENT

"The enhanced gas recovery tests conducted to date should not be called failures. Much very valuable information was learned about displacing chemical explosives in fractures and detonation of the explosives. The success of these tests cannot be measured in terms of gas production, especially considering the quality of the wells made available for the tests."

#### GAO EVALUATION

In our report we do not state that the enhanced gas recovery tests were failures. Instead, we point out that the results have been disappointing because little additional gas had been produced. We also point out that the reasons for the lack of considerable production during these tests are generally unknown. While we agree that some valuable information may have been learned about displacing chemical explosives in fractures and about detonating them, it is nevertheless difficult to measure the worth of the information ERDA may have obtained from these tests.

[See GAO note.]

GAO note: Three comments in ERDA's letter were deleted because of changes to the final report.



UNITED STATES  
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION  
WASHINGTON, D.C. 20545

SEP 14 1976

Mr. Monte Canfield, Jr., Director  
Energy and Minerals Division  
U.S. General Accounting Office  
Washington, DC 20548

Dear Mr. Canfield:

Thank you for the opportunity to comment on the draft report entitled "Enhanced Oil and Gas Recovery -- Federal Effort Moving Slowly."

We have reviewed the draft with members of your staff and we understand that a number of changes and clarifications which we suggested will be made. There are, however, several additional changes which we would like to see made in order that the report may become a more objective, meaningful document for the Congress.

In addition to being somewhat dated, in general, we find that the report has a negative rather than an objective tone and fails to present an adequate discussion of ERDA's positions on the issues in question. Even the title seems to reflect this tone, and may bias the reader from the outset. We would suggest a more objective title such as "An Evaluation of ERDA's Enhanced Oil and Gas Recovery Program." Indeed, the report discusses only ERDA's program, but does not include other parts of the "Federal Effort," such as the regulatory program.

Frequent comments are made about the need for enhanced oil and gas recovery management plans, but the report does not recognize that both programs (oil and gas) started with program plans. These have since evolved along with the state of knowledge and industry attitudes.

Industry opinions are cited in numerous places. It is important to recognize that the views of industry concerning the state of enhanced oil recovery technology, its applicability, and the costs of tertiary oil have changed considerably over the past few years. It would be in order for GAO to obtain a current industry opinion.

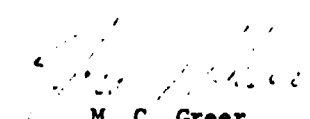


Mr. Monte Canfield, Jr.

- 2 -

Attached are comments on specific remaining issues discussed in the report which we would like to see modified so as to reflect our views. They do not represent the total editorial change necessary to implement the suggested modifications throughout the document.

Sincerely,



M. C. Greer  
Controller

Attachment:  
As stated



ATTACHMENTReduction of 1985 Production Goals

The reduction in ERDA's goals for increased national production of oil and gas from enhanced recovery methods reflects a change during the past two years in the attitudes of the petroleum industry, particularly toward enhanced oil recovery. In 1974, the industry felt it had enhanced recovery technology on the shelf, ready to be used if only the price of oil could make these expensive processes profitable. Early ERDA goals reflected this optimistic industry belief. In 1974, large increases in oil prices provided the impetus to invest in field applications of advanced recovery technologies. Only then was it realized that not enough was known about the physics, chemistry and engineering of petroleum reservoirs and their interaction with the injection materials used for enhanced recovery. In mid-1974, the best physical chemists in the larger oil companies were assigned to the enhanced recovery problem and the information gained since then has served to make the industry more cautious in its assessment of these processes and their potential.

Lack of Management Plan

It is incorrect to state that ERDA does not have a program management plan for enhanced oil and gas recovery. The enhanced recovery program has been guided by a 1974 (Interior) proposal for a five year plan since its inception and the current and planned projects are a result of that plan. Naturally, as industry attitudes towards enhanced recovery have changed, the Government's role has changed and its program plan has evolved. Our current efforts are aimed at improving the existing plan and grounding it on a firm analytical basis, but the program to date has certainly not been aimless. It has been based on experience and the best information available. As such, it has been the product of an evolutionary process. An improved management plan is expected to be implemented in October 1976. An updated estimate of the number, type and timing of enhanced oil recovery tests is currently being developed and is expected to be a part of this improved management plan.

[See GAO note, p. 40.]

[See GAO note, p. 40.]

Demonstration Schedule Lacks Urgency

The GAO report cites, in several places, an ERDA schedule for awarding contracts to conduct demonstration tests and criticizes it for planning to start most of the tests during the latter years of a seven year program. It should be noted that what the report refers to is not an ERDA schedule, but three different projections of how different funding distribution, over a five year period, might be reflected in actual field test starts. These projections were reflected in a July 17, 1975, letter from Dr. Seamans to Frank Zarb in response to an accelerated funding schedule suggested by FEA. The ERDA letter clearly indicated that while we concurred with FEA's suggestion in principle, there were a number of factors which ERDA needed to consider before reconciling the exact level of acceleration.

ERDA's position is not the result of a lack of understanding of the need for urgency; rather, it is affected by the following factors:

A. ERDA has constraints on the amount of money it can spend on enhanced recovery projects and on the manpower resources it can call up on to plan, prepare, execute and manage procurements and monitor projects. For the available manpower resources, we believe that the program is moving as fast as possible and, as discussed above, is undergoing reexamination. Development of the improved management plan may require a different mix of people and dollars than the present effort.

B. It must be recognized that the accelerated strategy suggested by the GAO is a much riskier one than ERDA's present plan. The accelerated schedule would force ERDA to plunge into an intensive

and expensive effort with a minimum amount of information, understanding and planning. While the early field tests that ERDA is conducting may not achieve commercial production for eight to ten years, they provide very valuable performance data after two or three years, enabling us to plan for and choose the later projects much more effectively. To accelerate the schedule of projects, we may need to accept proposals in advance of information developed by projects, accept proposals that are inferior to those we have already funded, or force proposals from companies that have not planned and budgeted for such projects. As information from the earlier tests is made available, more companies should be encouraged to plan for and seek joint projects with ERDA.

Slow Progress in Gas Recovery Technology

A. It is true that enhanced gas recovery technology is not as far advanced as that of recovering oil. This is due to the fact that up until 1974 the wellhead price for natural gas was under twenty cents per thousand cubic feet (MCF). No incentive was present to develop advanced--and necessarily expensive--technologies to recover such a low-value commodity. Even today, natural gas price regulation dampens industry interest and creates great economic uncertainties with respect to enhanced gas recovery.

B. The enhanced gas recovery tests conducted to date should not be called failures. Much very valuable information was learned about displacing chemical explosives in fractures and detonation of the explosives. The success of these tests cannot be measured in terms of gas production, especially considering the quality of the wells made available for the tests.

[See GAO note.]

GAO note: Three comments in ERDA's letter were deleted because of changes to the final report.



FEDERAL ENERGY ADMINISTRATION  
WASHINGTON, D.C. 20461

SEP 15 1976

OFFICE OF THE ASSISTANT ADMINISTRATOR

Mr. Monte Canfield  
Director, Energy and Mineral Division  
General Accounting Office  
Washington, D.C. 20548

Dear Mr. Canfield:

This responds to your letter of August 9, 1976, regarding your report, "Enhanced Oil and Gas Recovery--Federal Effort Moving Slowly." The report has been reviewed, as requested, and comments are attached. Briefly, it is agreed that Enhanced Oil Recovery (EOR) has not contributed very much toward increasing hydrocarbon production. Some of the problems with EOR are discussed in the attached comments. Generally, the EOR technology is old and applications have not been very successful.

If we can be of further assistance, please do not hesitate to contact us.

Sincerely,

  
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Assistant Administrator  
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Enclosure

The GAO report, "Enhanced Oil and Gas Recovery--Federal Effort Moving Slowly," is a critique of the Energy Research and Development Administration (ERDA) effort and contains recommendations for improving ERDA performance.

The enhanced oil recovery contribution to oil production is hardly increasing in spite of Federal efforts as the Government Accounting Office (GAO) points out. The following discussion is offered in consideration of the ERDA program.

#### Enhanced Oil Recovery (EOR)

Industry has been concerned with enhanced oil recovery for most of the present century. The EOR techniques which first proved commercial were waterflooding and, to a lesser degree, gas driving. Vacuum was widely applied to producing wells, however the beneficial effects were due mostly to resulting gas drive.

Combustion in oil reservoirs was attempted early in the century, but the technology was too crude for success. On the other hand, air injection, a form of gas driving, was fairly widely used. Combustion has not been an important EOR technique and is generally thought to have a relatively restricted usage.

Subsequent to World War II, industry undertook an intense EOR research program. Most major oil companies had research programs in thermal, surface active agents, miscible, carbon dioxide, wettability-reversal, and some forms of mobility control for improving oil recovery efficiency. In the 1950's field tests were undertaken in thermal methods (Mobile, Sinclair), miscible (Stanolind, Atlantic, Humble), wettability-reversal (Stanolind) carbon dioxide (ORCO and others), etc. None of these techniques have found wide application. The most successful by far has been steam injection in the heavy oil reservoirs in California. However, outside that State, the technique is rarely used. Most of the other test results were economic failures. The research effort in all techniques is continuing and getting quite sophisticated in all areas. The sophistication normally indicates significant increases in cost for the processes.

The introduction of high molecular weight polymers in the 1960's, particularly polyacrylamide for mobility control, spawned a new wave of tests. Polymers were tried to increase waterflood efficiency with spotty success. Polymer technology was then linked to surfactant technology in hopes of obtaining a synergistic benefit. This technology is still developing, but the expenses are very high without much indication of commensurate reward.

Test of combustion waves, selective plugging, frontal displacement by steam, alcohols, combinations of combustion and water injection, and carbonated waterflooding have been economic failures except in unique cases.

The purpose of this discussion is to indicate that EOR is an oil topic in the oil industry. The patent and technical literature on the subject is vast. The successes of new EOR technology, steam in California and carbon dioxide in Scurry County, Texas, and high pressure miscible gas in Crane County, Texas, were projects started years ago when oil was fourfold less expensive. The processes have had a very minor impact on increased production since the embargo. A significant and essential consideration in the Texas EOR projects was the increased production allowed by the Texas Railroad Commission. Since production is hardly restricted by regulation at present, this incentive is no longer applicable.

The combined production attributed to all the new EOR technology is less than 250,000 barrels of oil per day and most of this is from steam injection in California.

The entry of ERDA into the EOR field was stimulating and helpful. Unfortunately, the projects they had to choose from were pretty well shopworn. The state of the art may have contributed to the contracting problems discussed by GAO. The selection of prospects for support would require a thorough geologic review to assure the lithology, mineralogy, reservoir continuity, structure, etc., was compatible with the proposed process. The particular process would have to be evaluated against prior results and technically evaluated to assure that a reasonable contribution to the oil recovery art would be obtained. Additionally, the bureaucratic contracting process would impose additional delays.

#### Tight Gas Reservoir Stimulation

The same general comments made concerning EOR also apply to stimulation of tight gas reservoirs. Industry has tried many different stimulation techniques including hydraulic fracturing, a variety of chemical explosives, and nuclear explosives. Those which have responded sufficiently to be economically attractive have been developed, but the large volume of gas in the tighter reservoirs to which GAO points are not good candidates.

It is probable that technology to develop these tight gas reservoirs is still in the research stage and the success of such research cannot be determined. In the meantime, it would appear the only course left to ERDA is to push for projects using the old techniques.

### General

A significant problem with government sponsorship of hydrocarbon recovery techniques concerns propriety considerations. Any EOR technique which is successful is a very valuable property and would almost certainly be protected by patents or, less likely, maintained as a trade secret.

The nominal contribution by government, compared to the potential of a successful EOR technique, may not be worthwhile. This would tend to reduce the ERDA opportunities to second-class prospects.

The development of a management plan as requested on page 24 of the report is a difficult task. The determination of the most efficient type of EOR technique to use could be presumptuous at the present level of technology. As a matter of fact, reservoir damage could be incurred which could cost the Nation future reserves recoverable by some new appropriate technique.

The lack of equipment, materials, and supplies as a problem in starting EOR projects is probably an excuse rather than a reason. Short-term shortages may be expected for some items. However, the chemical and equipment industry inherently respond faster than the oil industry. Shortages, other than short-term, are unlikely.

STATUS OF MAJOR ERDA  
FIELD DEMONSTRATION PROJECTS  
AS OF SEPTEMBER 20, 1976

OIL

1. Contractor: Cities Service Oil Company  
Contract Date: June 26, 1974  
Anticipated Completion: October 1978  
Total Project Cost: \$7,098,394  
Government Award: \$3,002,117  
Type Project: Micellar-Polymer Flood

PROJECT STATUS

Prime attention has been given to treating selected wells with an acid solvent and conducting other tests. The preliminary test results were reported to have been encouraging.

2. Contractor: Phillips Petroleum Company  
Contract Date: May 12, 1975  
Anticipated Completion: August 1979  
Total Project Cost: \$9,764,514  
Government Award: \$3,402,042  
Type Project: Micellar-Polymer Flood

PROJECT STATUS

Construction and installation of facilities and equipment is nearing completion. Reservoir evaluation testing is underway and simulations of production and injection rates are being performed.

3. Contractor: Penn Grade Crude Oil Association  
Contract Date: June 30, 1975  
Anticipated Completion: June 30, 1980  
Total Project Cost: \$4,444,000  
Government Award: \$2,222,000  
Type Project: Micellar-Polymer Flood

PROJECT STATUS

Preliminary testing was underway to determine the feasibility of micellar-polymer flooding of low permeability reservoirs. The injection of a biopolymer was begun in October 1975 and continued through February 1976. Test data obtained from these injections were being evaluated for transient fluid flow characteristics.



4. Contractor: Gary Operating Company  
 Contract Date: June 30, 1976  
 Anticipated Completion: June 30, 1981  
 Total Project Cost: \$5,039,000  
 Government Award: \$2,519,500  
 Type Project: Micellar-Polymer Flood

PROJECT STATUS

New Project

5. Contractor: City of Long Beach  
 Contract Date: July 6, 1976  
 Anticipated Completion: December 31, 1980  
 Total Project Cost: \$7,000,000  
 Government Award: \$3,500,000  
 Type Project: Micellar-Polymer Flood

PROJECT STATUS

New Project

6. Contractor: Guyan Oil Company, Inc.  
 Contract Date: September 1, 1975  
 Anticipated Completion: August 31, 1978  
 Total Project Cost: \$3,246,260  
 Government Award: \$1,200,000  
 Type Project: Carbon Dioxide Injection

PROJECT STATUS

Final project design and installation of facilities is expected to take about 12 months. Injection and evaluation phases are expected to require 24 months for a total project life of 3 years.

7. Contractor: Columbia Gas Transmission Corp.  
 Contract Date: June 3, 1976  
 Anticipated Completion: June 1979  
 Total Project Cost: \$1,416,316  
 Government Award: \$ 472,300  
 Type Project: Carbon Dioxide Injection

PROJECT STATUS

This is a new project. Reservoir pressure was raised up to 1,000--1,200 psi before the contract started. Carbon dioxide injection was started in July. Carbon dioxide injection rates are now being balanced to equalize injection volumes.

8. Contractor: Pennzoil Company  
 Contract Date: June 30, 1976  
 Anticipated Completion: July 1981  
 Total Project Cost: \$2,627,500  
 Government Award: \$1,021,450  
 Type Project: Carbon Dioxide Injection

PROJECT STATUS

New Project

9. Contractor: Kewanee Oil Company  
 Contract Date: June 26, 1975  
 Anticipated Completion: May 1979  
 Total Project Cost: \$3,884,890  
 Government Award: \$1,150,752  
 Type Project: Polymer Flood

PROJECT STATUS

Field activity has been directed toward installing equipment and facilities. Preparations were being made for a mini-injectivity chemical test.

10. Contractor: Shell Oil Company  
 Contract Date: June 26, 1975  
 Anticipated Completion: June 30, 1979  
 Total Project Cost: \$7,374,872  
 Government Award: \$2,168,206  
 Type Project: Polymer Flood

PROJECT STATUS

The water injection facilities and the polymer injection facilities were 92 percent completed. The production facilities were in service and tests were being run to establish the accuracy of the test equipment.

11. Contractor: Husky Oil Company  
 Contract Date: January 24, 1975  
 Anticipated Completion: January 23, 1980  
 Total Project Cost: \$6,791,800  
 Government Award: \$2,000,000  
 Type Project: Thermal Recovery

PROJECT STATUS

Development drilling for the project was completed in January 1976. Reservoir and

geological evaluations have been made and steam stimulation of selected test wells has been accomplished. An increase in production of about 30 percent was attributed to the steam stimulation. Production averaged 43 barrels a day from 9 test wells.

12. Contractor: Hanover Petroleum Company  
 Contract Date: January 24, 1975  
 Anticipated Completion: January 23, 1979  
 Total Project Cost: \$3,048,059  
 Government Award: \$ 951,725  
 Type Project: Thermal Recovery

PROJECT STATUS

Several attempts were made to ignite one test well during the period of October 1, 1975, through January 1, 1976. On February 2, 1976, the company decided to abandon the well due to mechanical problems and high injection pressures and selected another well for testing.

13. Contractor: Carmel Energy, Inc.  
 Contract Date: April 1, 1976  
 Anticipated Completion: September 30, 1977  
 Total Project Cost: \$825,534  
 Government Award: \$675,547  
 Type Project: Thermal Recovery

PROJECT STATUS

Construction has commenced on the new Vapor Thermal unit for recovery of heavy oil. Drilling has started on the process wells.

14. Contractor: Getty Oil Company  
 Contract Date: June 25, 1976  
 Anticipated Completion: July 1980  
 Total Project Cost: \$8,700,000  
 Government Award: \$2,000,000  
 Type Project: Thermal Recovery

PROJECT STATUS

New Project

15. Contractor: Cities Service Oil Company  
 Contract Date: June 1, 1976  
 Anticipated Completion: June 30, 1982  
 Total Project Cost: \$8,229,000

Government Award: \$3,102,000  
 Type Project: Thermal Recovery

PROJECT STATUS

New Project

16. Contractor: Chanslor Western Company  
 Contract Date: June 16, 1976  
 Anticipated Completion: June 1983  
 Total Project Cost: \$8,247,000  
 Government Award: \$1,700,000  
 Type Project: Thermal Recovery

PROJECT STATUS

New Project

NATURAL GAS

17. Contractor: CER Geonuclear Corporation  
 Contract Date: June 19, 1974  
 Anticipated Completion: March 1977  
 Total Project Cost: \$3,475,000  
 Government Award: \$1,975,000  
 Type Project: Massive Hydraulic Fracture

PROJECT STATUS

Two massive hydraulic fractures have been completed. Results from these fractures were well below expectations. Plans for third and fourth fracturing phases are being studied.

18. Contractor: Columbia Gas System Service Corp.  
 Contract Date: June 18, 1975  
 Anticipated Completion: December 1977  
 Total Project Cost: \$4,395,000  
 Government Award: \$2,154,155  
 Type Project: Massive Hydraulic Fracture

PROJECT STATUS

In January 1976, ERDA reported that surface ownership complications had delayed access to the planned well site location which required the first of three wells to be relocated. As a result, field activities are 3 months behind schedule. In March 1976, studies to determine the design of stimulation treatments were reportedly in progress.

19. Contractor: Columbia Gas Systems Inc.  
 Contract Date: July 29, 1976  
 Anticipated Completion: February 1979  
 Total Project Cost: \$4,803,715  
 Government Award: \$2,500,000  
 Type Project: Advanced Hydraulic Fracturing

PROJECT STATUS

New Project

20. Contractor: Gas Producing Enterprises, Inc.  
 Contract Date: September 9, 1976  
 Anticipated Completion: April 1978  
 Total Project Cost: \$6,986,000  
 Government Award: \$2,155,000  
 Type Project: Advanced Hydraulic Fracturing

PROJECT STATUS

New Project

21. Contractor: Mobil Oil Corp.  
 Contract Date: August 27, 1976  
 Anticipated Completion: February 1978  
 Total Project Cost: \$6,506,675  
 Government Award: \$2,600,000  
 Type Project: Advanced Hydraulic Fracturing

PROJECT STATUS

New Project

22. Contractor: Pacific Transmission Supply Co.  
 Contract Date: September 13, 1976  
 Anticipated Completion: January 1979  
 Total Project Cost: \$2,395,512  
 Government Award: \$1,098,755  
 Type Project: Advanced Hydraulic Fracturing

PROJECT STATUS

New Project

23. Contractor: Physics International Company  
 Contract Date: May 15, 1975  
 Anticipated Completion: October 14, 1976  
 Total Project Cost: \$381,356  
 Government Award: \$381,356  
 Type Project: Novel Fracturing Technique

PROJECT STATUS

The objective of this project is to develop and evaluate a method of well stimulation that is based on generating a multiple vertical fracture pattern in a gas or oil-bearing reservoir. Five wells were stimulated during the period October 24 through November 4, 1975. Production did not increase in one well and evaluations of the other wells were being performed.

24. Contractor: El Paso Natural Gas Company  
 Contract Date: September 19, 1975  
 Anticipated Completion: October 1978  
 Total Project Cost: \$4,761,000  
 Government Award: \$1,608,000  
 Type Project: Massive Hydraulic Fracture

PROJECT STATUS

The first phase of the project has been completed. During 37 days of testing, 16.2 million cubic feet of natural gas was produced. The contract provides that under certain conditions two additional phases may be performed under supplemental agreements. No decision has been made concerning these additional tests.

25. Contractor: Kentucky-West Virginia Gas Company  
 Contract Date: June 12, 1975  
 Anticipated Completion: October 1979  
 Total Project Cost: \$229,500  
 Government Award: \$169,700  
 Type Project: Directionally Deviated Wells  
 and Inducing Multiple Hydraulic Fractures

PROJECT STATUS

A four-stage hydraulic fracture treatment was conducted on the Company's well No. 7239, Big Sandy Field, Perry County, Kentucky. Four 100-foot zones were treated successfully. Preliminary test results indicated that the reservoir pressure was very good, but that the deliverability was very poor.

26. Contractor: Tally-Frac Corp.  
 Contract Date: June 24, 1974  
 Anticipated Completion: Completed  
 Total Project Cost: \$131,083  
 Government Award: \$131,083  
 Type Project: Chemical Explosive Fracture

PROJECT STATUS

Detonation of 15,000 pounds of liquid explosives was successfully carried out on November 14, 1974. Final production tests on this well showed no improvement in production. A second well was also successfully fractured, however, the well showed no effect from the explosive fracture treatment. A third well was fractured and production was slightly improved over that previously experienced.

27. Contractor: Petroleum Technology Corp.  
 Contract Date: June 24, 1974  
 Anticipated Completion: December 24, 1975  
 Total Project Cost: \$474,000  
 Government Award: \$474,000  
 Type Project: Chemical Explosive Fracture

PROJECT STATUS

Detonation of 20,000 pounds of explosive was successfully conducted in two different wells in West Virginia. A third well in Virginia was detonated with 30,000 pounds of explosive. Production tests show no improvement in the West Virginia wells, and an increase in the production rate of the Virginia well.

PRINCIPAL OFFICIALS  
RESPONSIBLE FOR ADMINISTERING  
ACTIVITIES DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
<u>ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION</u>		
ADMINISTRATOR:		
Robert C. Seamans, Jr.	Jan. 1975	Present
ACTING ASSISTANT ADMINISTRATOR		
FOR FOSSIL ENERGY:		
S. William Gouse, Jr.	Jan. 1975	June 1975
ASSISTANT ADMINISTRATOR FOR		
FOSSIL ENERGY:		
Philip C. White	June 1975	Present