United States General Accounting Office 130438

GAO

Briefing Report to the Chairman, Subcommittee on Environment, Energy, and Natural Resources, Committee on Government Operations House of Representatives

June 1986

ENERGY R & D

Current and Potential Use of Enhanced Oil Recovery

GAO/RCED-86-181BR

UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

RESOURCES, COMMUNITY AND ECONOMIC DEVELOPMENT DIVISION

June 24, 1986

B-214429

The Honorable Mike Synar
Chairman, Subcommittee on Environment, Energy, and Natural Resources
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

In response to your request of March 3, 1986, and as subsequently agreed with your office, this briefing report provides information on (1) crude oil production and consumption in the United States and the role of enhanced oil recovery in production, (2) current enhanced oil recovery activities and future prospects for increased production, (3) the impact of price changes on a major potential enhanced oil recovery resource--stripper wells, and (4) the effects of price changes and the Department of Energy's (DOE) fiscal year 1987 budget proposal on enhanced oil recovery research.

In summary, the information we obtained shows that

--domestic oil reserves are being depleted rapidly;

--enhanced oil recovery can, depending on future oil price levels and continued research, make a major contribution to increasing domestic production; and

--DOE recently proposed a change in its strategy for funding enhanced oil recovery research that does not appear well-founded.

The U.S. economy depends heavily on a continuing supply of crude oil, but current estimated producible domestic oil reserves--28 billion barrels--are being depleted rapidly. As reserves become depleted, their replacement will be costly and require technological advances. Two studies done for DOE in 1984 indicate that enhanced oil recovery could be important for increasing domestic oil supplies. One found that it could make a major contribution at less cost than alternative sources of oil. The other study reported that, with technological advances based on continued research and favorable economic conditions, it could double present producible domestic oil reserves.

DOE recently proposed a change in its strategy for funding enhanced oil recovery research. Currently, DOE supports basic research on enhanced oil recovery at its National Institute for Petroleum and Energy Research facility in Bartlesville, Oklahoma, its laboratories and technology center, and universities. In its fiscal year 1987 budget, DOE proposes to eliminate all direct funding to universities and its laboratories, with funds allocated to the National Institute and for completion of ongoing work at the Morgantown Energy Technology Center. In place of this direct support, DOE proposes to establish, with the oil industry and universities, joint venture pools for applied research and development. The joint venture approach would shift funding away from needed basic research; has little industry or university support; and seems inconsistent with DOE's emphasis on funding long-term, high-risk research. Also, DOE proposes to sell the Bartlesville facility in 1988 and thereafter plans to rely on joint ventures for enhanced oil recovery research.

The information in this report raises questions about whether DOE's proposal for joint venture funding has been considered thoroughly and provides the optimal use of funds available for enhanced oil recovery research. Consequently, as they make their decisions on the optimal use of such funds, DOE's oversight and appropriations committees should closely review with DOE the strategy and justification for its joint venture approach for applied research on enhanced oil recovery.

To gather information for this report, we researched the literature related to crude oil production and consumption, the development of enhanced oil recovery technologies, and the money spent on oil and gas research in the United States and other countries. We interviewed DOE officials in DOE headquarters and at DOE's Bartlesville Project Office to learn about the federal government's ongoing and planned enhanced oil recovery programs, including projected funding through fiscal year 1987. We conducted interviews with oil company officials and consultants experienced in enhanced oil recovery research and oil field applications. We also met with petroleum engineering professors and department heads at universities in Oklahoma, Kansas, and Texas, and conducted telephone interviews with experts at several other universities. Except where noted, the data in this report comes from various federal publications. We did not independently verify the data. The graphics are based on information from the sources identified in this report. In our analysis of DOE's fiscal year 1987 budget proposal, we limited our work to the effects of the proposal on enhanced oil recovery research.

As agreed with your office, we did not obtain agency comments on this report. We did, however, discuss its contents with responsible agency officials during the course of our work and incorporated their comments where appropriate. As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days from the date of issuance.

Sincerely yours,

J. Dexter Peach
Director

C o n t e n t s

ILLUSTRATIONS

ABBREVIATIONS

BBL	barrel
BETC	Bartlesville Energy Technology Center
DOE	Department of Energy
EOR	enhanced oil recovery
GAO	General Accounting Office
IEA	International Energy Agency
IOCC	Interstate Oil Compact Commission
METC	Morgantown Energy Technology Center
NG	natural gas
NGL	natural gas liquids
NIPER	National Institute for Petroleum and Energy Research
NPC	National Petroleum Council
R&D	research and development
TORIS	Tertiary Oil Recovery Information System

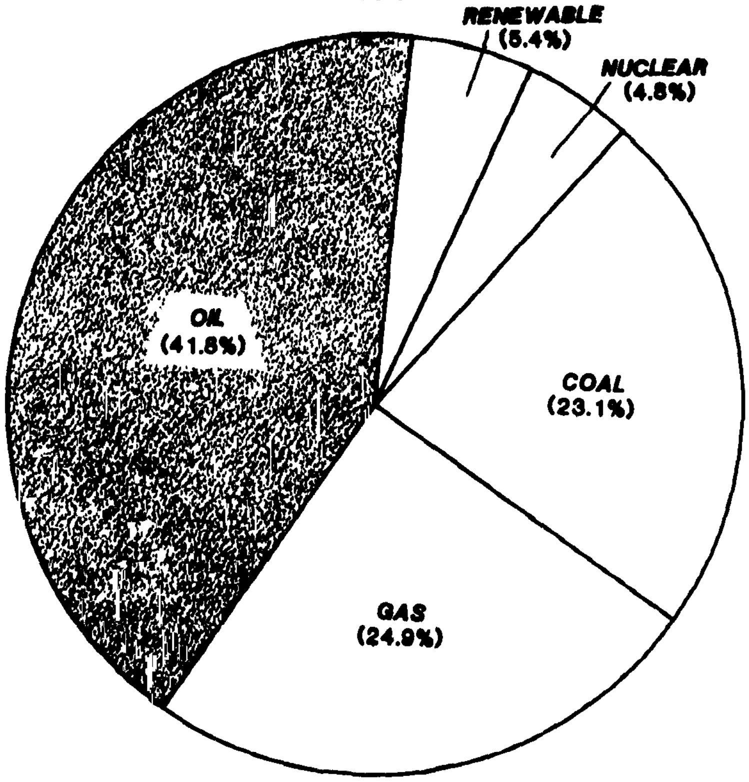
SECTION 1

U.S. CRUDE OIL PRODUCTION AND CONSUMPTION, INCLUDING THE ROLE OF EOR IN PRODUCTION

FIGURE 1.1

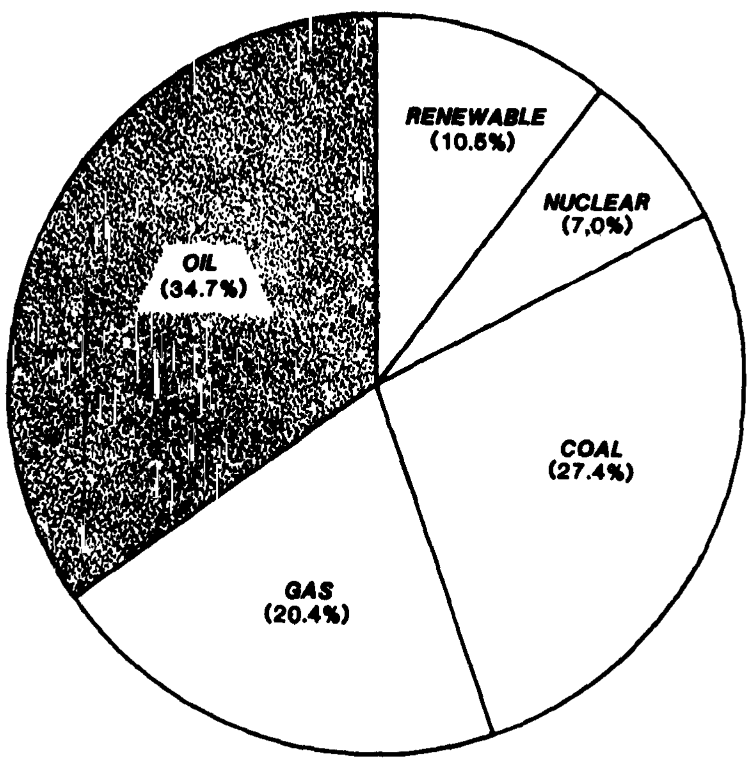
TOTAL PRIMARY ENERGY USAGE BY SOURCE

1984



SOURCE: ENERGY INFORMATION ADMINISTRATION, 1985.

2000



SOURCE: DEPARTMENT OF ENERGY, 1985.

BACKGROUND

Crude oil accounted for 41.8 percent of all primary energy sources used in the United States in 1984. Although the Department of Energy (DOE) has projected that crude oil will account for only 34.7 of all energy sources by the year 2000, it made this estimate before oil prices dropped dramatically in January 1986. (See fig. 1.1.) Lower oil prices could make other energy sources (gas, coal, nuclear, and renewable fuels) less competitive and increase the volume of oil used in this country.

Even without this recent price decline, the nation had depended heavily on oil. Sixty-two percent of the crude oil refined in the United States in 1984 was converted to transportation fuels used primarily for motor vehicles, aircraft, and farm machinery. Twelve percent of the crude oil was refined for residential and commercial uses and for electric utilities. Twenty-six percent was used in industry as a fuel and as a primary ingredient for such things as plastics. Since transportation systems are so highly dependent on oil, the United States will continue to need this energy source well into the foreseeable future. Although heating needs can be met from other energy sources, many other needs, such as the manufacture of plastics, will also continue to rely on oil until other sources become as economical to use.

Given oil's importance to the nation's economy, it is of particular concern that U.S. oil reserves declined from about 39 billion barrels to about 28 billion barrels between 1970 and 1986. Reserves are the oil in reservoirs that can be recovered through known, economically viable means. Furthermore, new discoveries of oil between 1970 and 1983 have averaged about 160 million barrels annually. This figure represents replacement of only about 5 percent of domestic production. The balance of additions to the reserves was through revisions and extensions in previously discovered fields. During this period, exploration efforts have also found proportionately fewer large fields of oil than in the past. DOE states that discovery of major new reserves is unlikely in the continental United States.

With the use of enhanced oil recovery (EOR) techniques, however, the National Petroleum Council (NPC) estimates that the United States could add approximately 15 to 30 billion more barrels to domestic reserves by retrieving the oil that remains in currently known reservoirs after conventional methods have been exhausted.

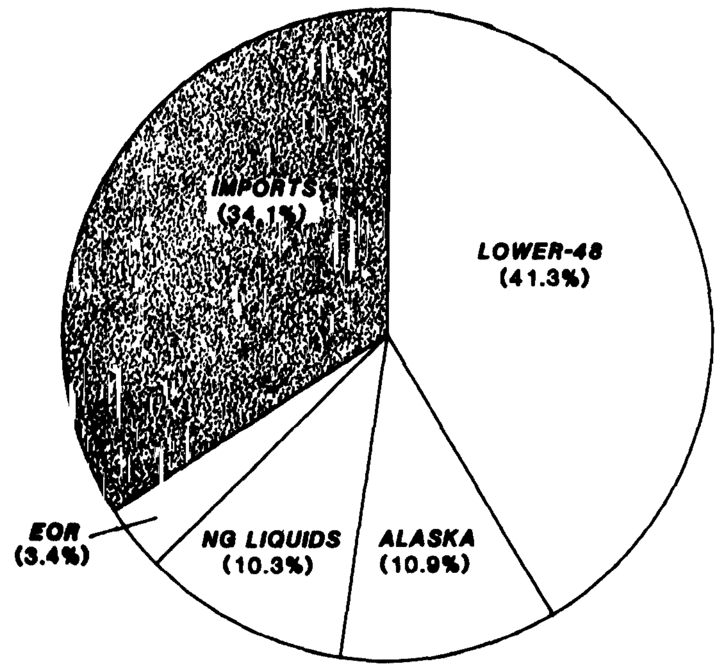
Recovery methods

Oil is extracted from underground reservoirs through primary and secondary recovery methods and through EOR, also known as "tertiary recovery." Primary and secondary recovery methods, which recover, on average, about 32 percent of the original oil-in-place, are limited to those portions of a reservoir where the oil flows relatively freely. Primary methods rely on natural pressure in the reservoir to drive the oil to the production wellbore. Secondary methods employ additional energy, such as water or gas, to drive out the oil. After these methods of recovery have been employed, EOR is used to get out as much additional oil as possible. EOR involves using heat, chemicals, or gases to thin oil, increase oil volume; decrease the pressure holding the oil in reservoir rock; and/or help it flow more easily.

FIGURE 1.2

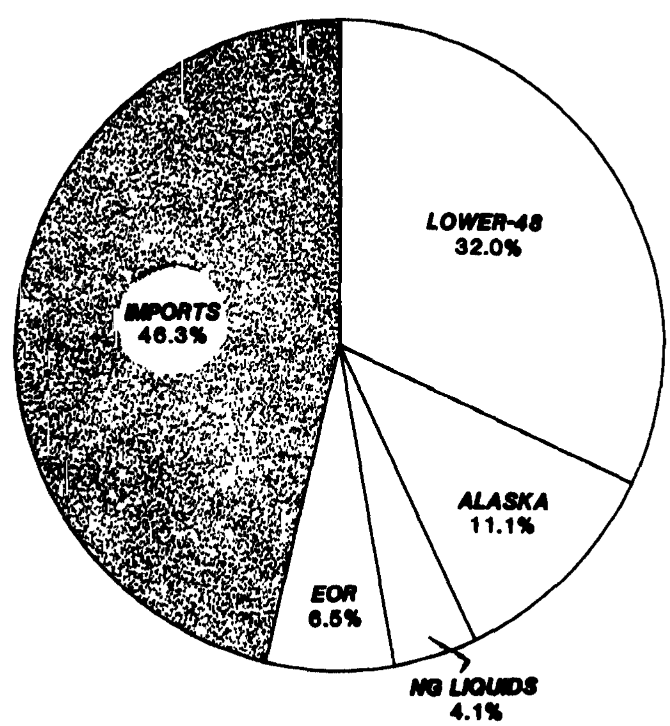
U.S. OIL SUPPLY BY SOURCE

1984



SOURCES: ENERGY INFORMATION ADMINISTRATION, 1985.
OIL AND GAS JOURNAL, 1985.

2000



SOURCE: DEPARTMENT OF ENERGY, 1985.

PETROLEUM IMPORTS

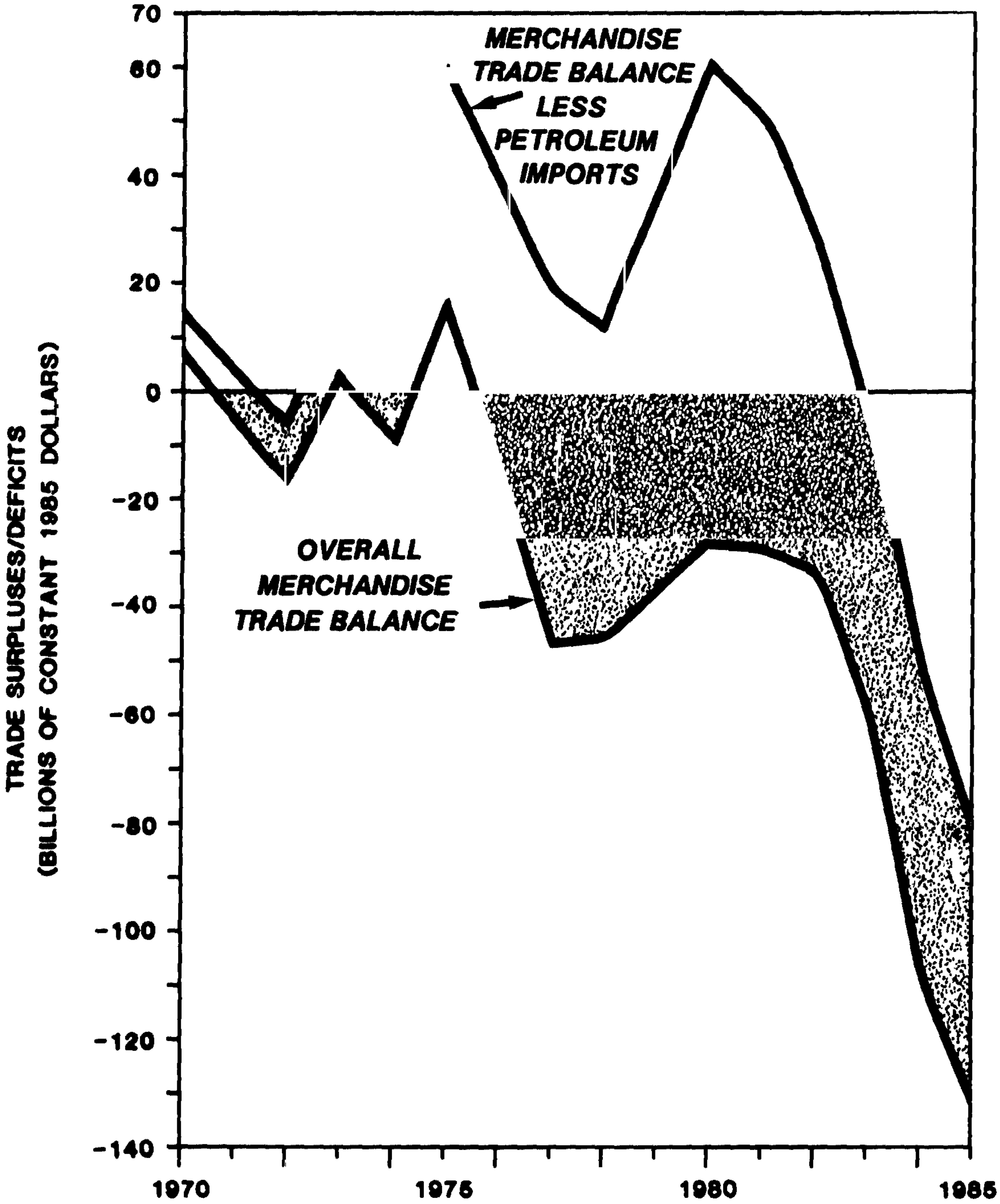
In 1984 the United States consumed a total of 5.7 billion barrels of petroleum, or 15.7 million barrels per day. Of the total consumption, 34.1 percent was imported. A 1984 DOE study projects that by the year 2000 imports will increase to 46.3 percent, with a further increase to 53 percent by 2010, unless production from known domestic reservoirs increases.

According to a 1986 DOE study, these increased imports will be due, in part, to the projected shortfall between future domestic oil production and domestic use of oil. DOE projects that by 1990, the shortfall will increase approximately 3.2 million barrels per day at an oil price of $17 a barrel, and about 3.5 million barrels per day at a price of $30 a barrel by 1995.

Based on DOE's 1984 study, as figure 1.2 indicates, the percentage of the oil supply from EOR is expected to almost double, from 3.4 percent to 6.5 percent, between 1984 and the year 2000. At the same time, however, oil production in Alaska is projected to remain at the 1984 rate of 11 percent for the year 2000, and production in the lower-48 states will decrease.

FIGURE 1.3

U.S. MERCHANDISE TRADE BALANCE WITH AND WITHOUT PETROLEUM IMPORTS



SOURCE: U.S. DEPARTMENT OF COMMERCE, 1985.

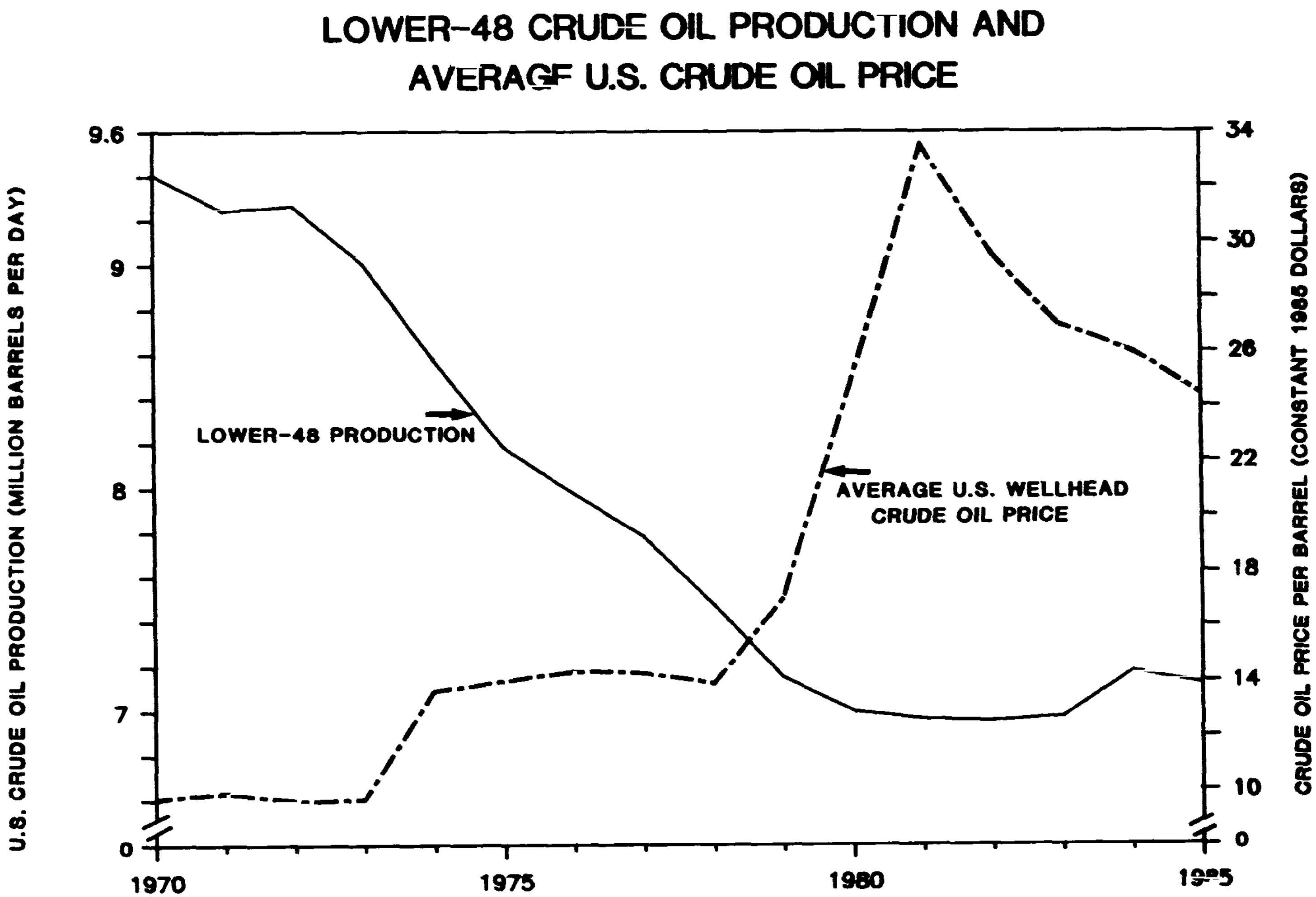
TRADE BALANCE

The increase in oil imports since 1970, coupled with a rapid rise in world oil prices, has exacerbated the U.S international trade balance deficit. As figure 1.3 shows, the U.S. trade balance would have been a large surplus in almost every year since 1970 if tens of billions of dollars had not been spent on petroleum imports. These expenditures occurred even though the total domestic demand for petroleum was only 4 percent greater in 1983 than it was in 1970. During this period, however, oil imports rose by 41 percent and oil prices increased four-fold.

After 1983, even removing oil imports from the overall trade balance computations would not have created a trade balance surplus because other economic factors are also contributing to the deficit. The current reduction in oil prices, however, has reduced the growth rate of that portion of the deficit due to oil imports.

Even so, continued and growing dependence on oil imports means that a significant proportion of the balance-of-trade problem will continue to be oil imports. Lower oil prices will not eliminate the balance-of-trade problem because lower oil prices are likely to result in the purchase of more imported oil over time. (See fig. 4.1.) DOE has projected that imported oil could be as much as 53 percent of demand by the year 2010. Consequently, the volume of imported oil would continue to contribute to any balance-of-trade deficit we may have. Further, as the volume of imported oil increases and the nation becomes more dependent on oil imports, the trade deficit could become worse when prices increase again.

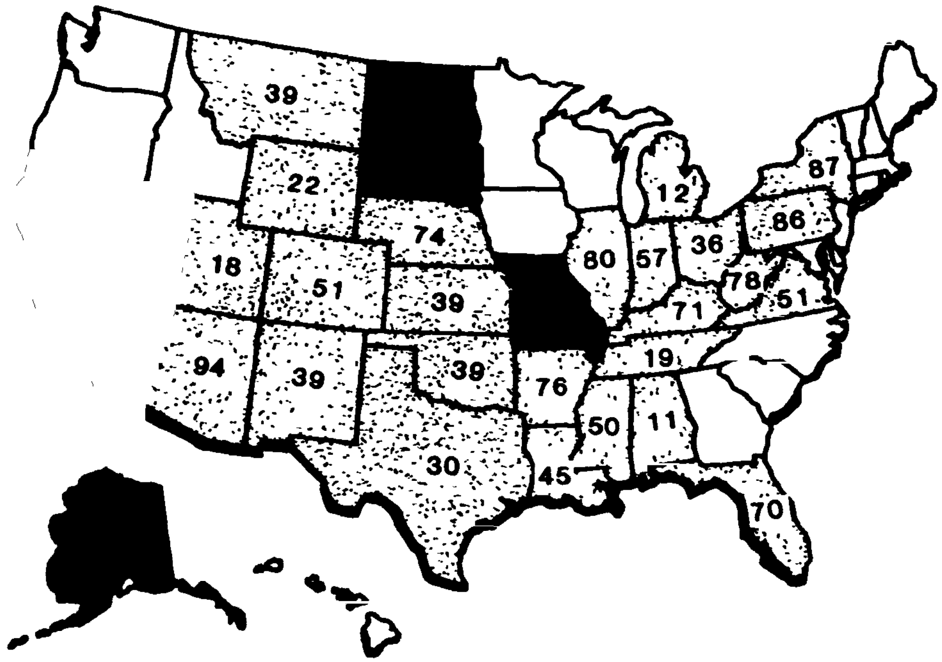
FIGURE 1.4



SOURCES: AMERICAN PETROLEUM INSTITUTE/AMERICAN GAS ASSOCIATION/CANADIAN PETROLEUM ASSOCIATION, 1970–1979.
ENERGY INFORMATION ADMINISTRATION, 1980–1985.

FIGURE 1.5

PRODUCTION DECLINE IN OIL-PRODUCING STATES (% DECLINE FROM EACH STATE'S PEAK YEAR THROUGH 1984)



PRODUCER STATES WITH DECLINING PRODUCTION FROM PEAK YEAR
PRODUCER STATES NOT YET IN PRODUCTION DECLINE

AVERAGE U.S. PRODUCTION DECLINE: 31%

SOURCES: AMERICAN PETROLEUM INSTITUTE, 1984.
ENERGY INFORMATION ADMINISTRATION, 1985.
INDEPENDENT PETROLEUM ASSOCIATION OF AMERICA, 1984.

DECLINES IN DOMESTIC PRODUCTION

Domestic oil production in the lower-48 states declined sharply up to 1979 and has been relatively constant since then. Crude oil production decreased even with the increased oil prices experienced between 1973 and 1981. Falling oil prices even before the 1986 decline have reversed the temporary upturn and flattening in the lower-48 states' production, which occurred in 1983-84 because of the stimulation of production from high-cost marginal wells. Production estimates indicate a future decline that is likely to be greater than that shown in figure 1.4. Under these conditions, marginal wells cease production.

Past oil production has not necessarily correlated with oil prices, although this lack of correlation appears to be changing in the current oil market. In the past, oil production in the lower-48 states dropped from about 9.4 million barrels per day to about 7.1 million barrels per day between 1970 and 1985. During this period, oil prices increased from about $9 per barrel to over $24 per barrel, with a peak price of nearly $33 in 1981. However, as of June 1986, oil prices have dropped to around $13.

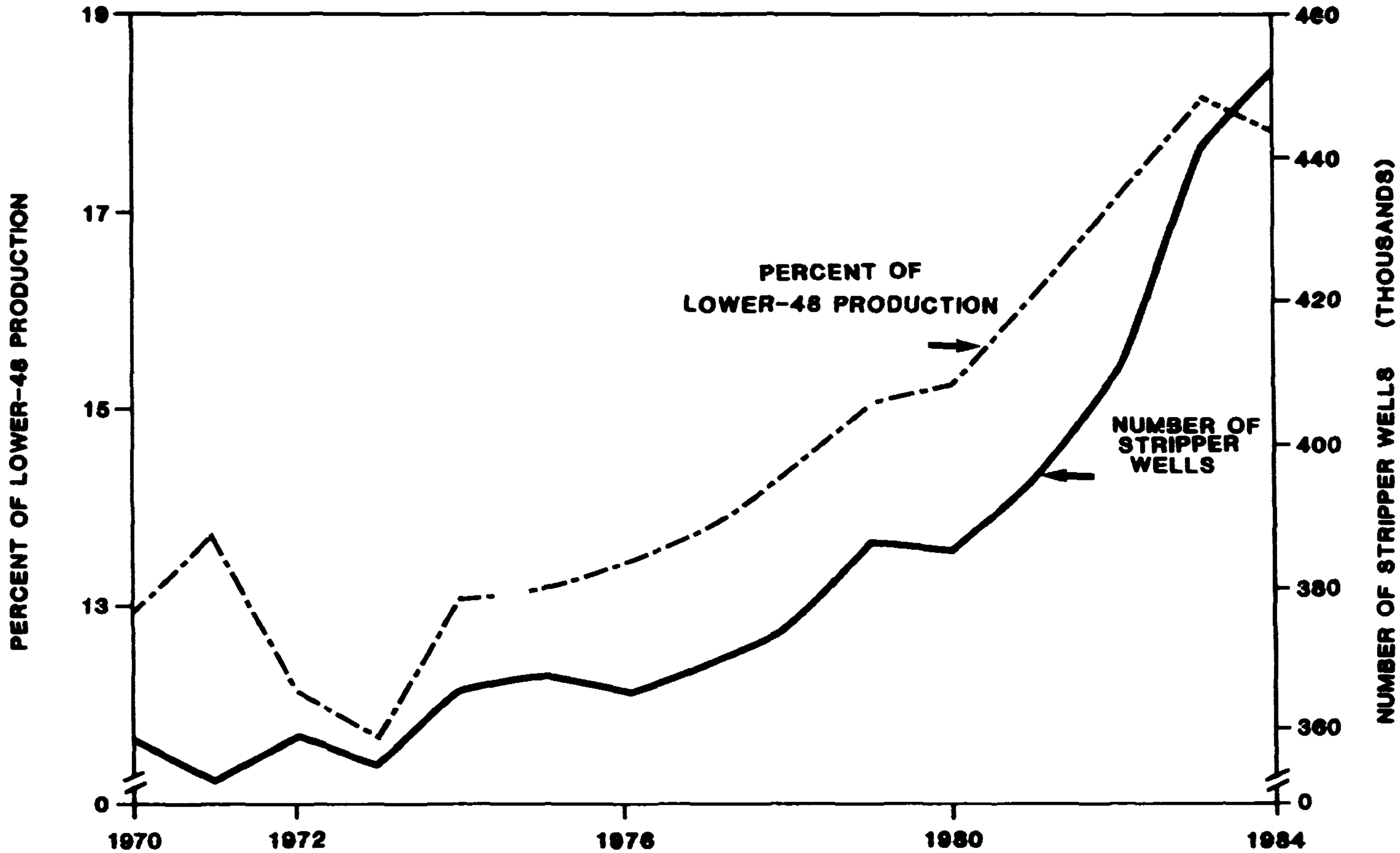
Oil exploration efforts in the United States, however, are highly responsive to oil prices. For example, "wildcat" wells in new fields doubled between 1973 and 1982. A new wildcat field refers to a reservoir in which oil is newly discovered, as opposed to extension wells, which may simply be new oil wells in an already producing oil field. But when oil prices dropped between 1982 and 1983, the number of new wildcat fields declined by 25 percent. Even though price stimulated new discoveries of oil, newly discovered fields contained significantly less oil than such discoveries prior to 1970. For example, in 1970, 27 percent of newly discovered fields contained more than one million barrels of oil. By 1983 this proportion had dropped to 2 percent of all discoveries.

Decline by state

In oil-producing states, the average decline in oil production was 31 percent from each oil-producing state's peak year to December 1984. (See fig. 1.5.) This decline has been steady and predictable, especially in the lower-48 states. With the exception of six states--Alaska, California, Nevada, North and South Dakota, and Missouri--all others have declined from their peak year of production by 11 to 94 percent. Of the six states that have not declined from their peak year, only two --California and Alaska--make a significant contribution to the total U.S. crude oil production. Given the lower oil prices, production is likely to decline even more sharply in the lower-48 states.

FIGURE 1.6

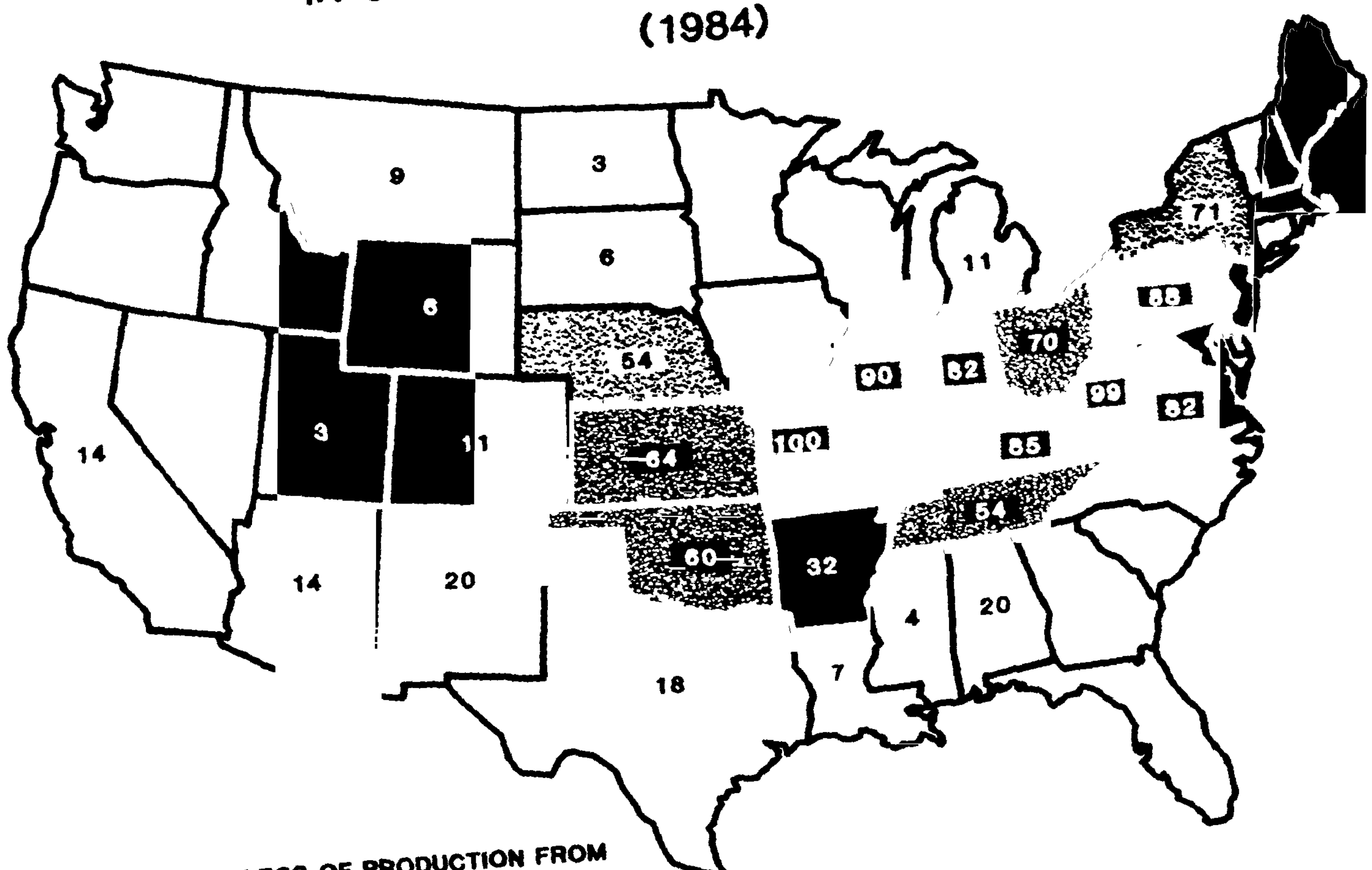
NUMBER OF STRIPPER WELLS AND PERCENT OF U.S. PRODUCTION FROM STRIPPER WELLS



SOURCES: THE RAM GROUP, LIMITED, 1986.
OIL AND GAS JOURNAL DATABASE, 1986.
AMERICAN PETROLEUM INSTITUTE, 1986.

FIGURE 1.7

STRIPPER WELL PERCENT OF TOTAL CRUDE OIL PRODUCTION IN STATES WITH STRIPPER WELLS (1984)



49% OR LESS OF PRODUCTION FROM STRIPPER WELLS

50-75% OF PRODUCTION FROM STRIPPER WELLS

76-100% OF PRODUCTION FROM STRIPPER WELLS

SOURCE: INTERSTATE OIL COMPACT COMMISSION, 1985.

STRIPPER WELLS

Most oil fields in the United States are past their prime and are classified as mature. Because of higher oil prices from 1970 to 1983, however, many mature fields continued to operate that would have otherwise been abandoned. Stripper wells are used to produce oil from many of these fields.[1]

Many of the plugged or abandoned stripper wells will not be used to recover the oil remaining in the reservoir using EOR technologies, unless economic conditions warrant. In 1983 more than 18 percent of lower-48 production came from stripper wells, up from 8 percent in 1973. (See fig. 1.6.) The average production per stripper well was 2.9 barrels per day in 1983, down from 3.4 barrels per day in 1970. Since these stripper wells are in mature fields, they are prime candidates for EOR production. But with decreasing oil prices, these wells are being plugged and abandoned in growing numbers. Plugged wells cannot be used again. Abandoned wells, however, can produce oil using EOR technologies, but only for approximately 1 year after initial abandonment. EOR methods could be used in new wells drilled in fields with plugged or abandoned wells, but because this would require new drilling for production, economic conditions would have to be very favorable to warrant the investment. Further, the oil might migrate over time, and the cost of discovering its new location would have to be factored into a decision to produce using EOR technologies.

Overall stripper well production in the nation has been relatively stable over the past several years, although certain states have declined from their peak production levels. This has occurred because of a vast increase in the number of stripper wells. Many of these wells, however, are nearly ready to be abandoned, especially as oil prices fall faster than the costs of operating the wells.

For 13 of the producing states, more than half of their total production is from stripper wells. In addition, stripper wells make up more than 75 percent of the total production in seven producing states, with one of the seven states accounting for 100 percent of its production from stripper wells. These seven states are clustered in the coal region stretching from Missouri to Pennsylvania. (See fig. 1.7.)

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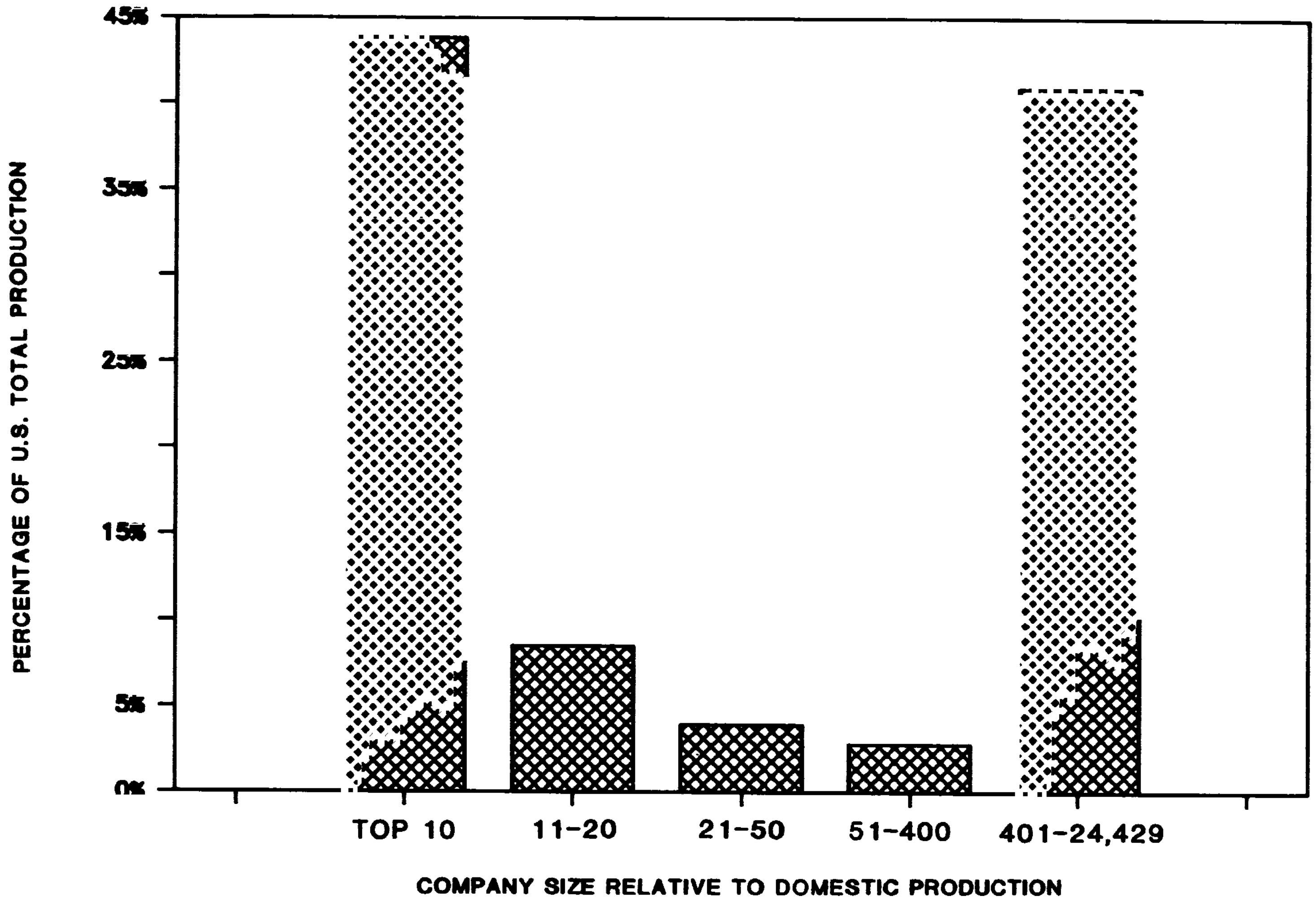
[1] A stripper well is one that produces 10 or fewer barrels per day for at least one year. The well retains the stripper designation for certain tax purposes, however, even if secondary or EOR technology is used after primary production to increase the average daily production above 10 barrels per day.

FIGURE 1.8

DISTRIBUTION OF U.S. 1984 PETROLEUM PRODUCTION BY COMPANY SIZE



SOURCES: OIL AND GAS JOURNAL, 1985.
ENERGY INFORMATION ADMINISTRATION, 1985.

PETROLEUM PRODUCTION BY COMPANY SIZE

More than 24,000 companies in the U.S. produce petroleum, which includes both oil and gas. They vary widely in size and production levels, from the multi-national companies to companies that collect a few barrels per day from a small stripper well operation.

As figure 1.8 shows, the 10 largest companies produce 43.8 percent of all domestic petroleum. At present production levels, this is approximately 3.9 million barrels per day, with most coming from Alaskan fields and the western and southern lower-48 states.

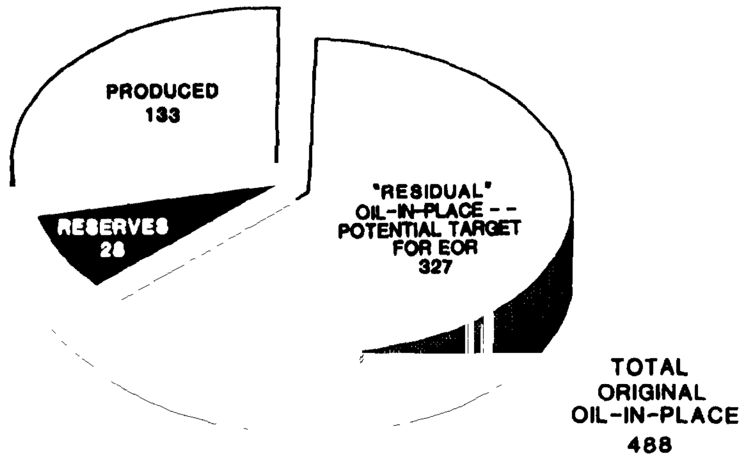
The next 390 largest companies produce about 15.2 percent of the nation's petroleum, or about 1.7 million barrels per day. The remaining companies produce 41.0 percent of the nation's petroleum, or about 3.7 million barrels per day. Therefore, the number of potential candidates for using EOR technology to maintain oil production in maturing fields is quite large.

SECTION 2

CURRENT EOR ACTIVITIES AND FUTURE PROSPECTS FOR INCREASED PRODUCTION

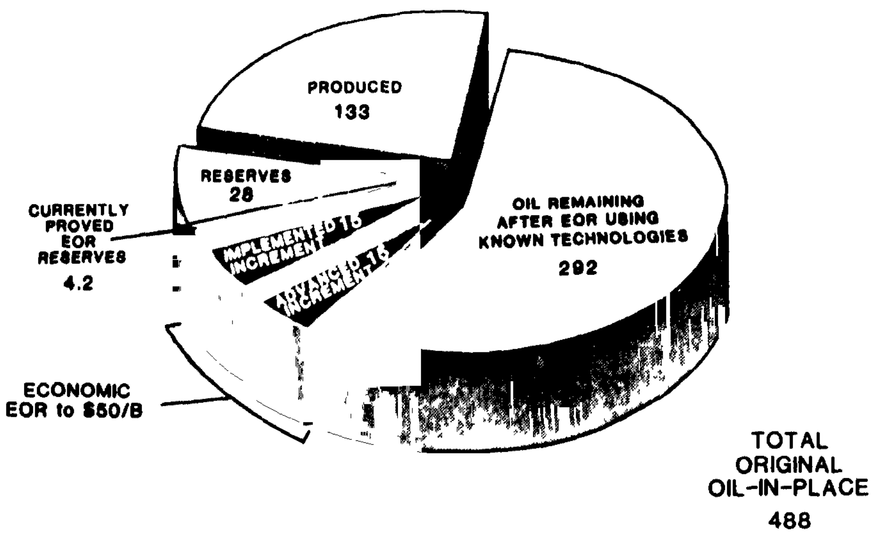
FIGURE 2.1

DOMESTIC RESOURCE AVAILABLE FOR EOR (BILLIONS OF BARRELS)



SOURCES: ENERGY INFORMATION ADMINISTRATION, 1984.
AMERICAN PETROLEUM INSTITUTE/AMERICAN GAS ASSOCIATION/
CANADIAN PETROLEUM ASSOCIATION, 1979.

DISTRIBUTION OF KNOWN U.S. OIL-IN-PLACE AFTER EOR (BILLIONS OF BARRELS)



SOURCES: BARTLESVILLE PROJECT OFFICE, 1985.
NATIONAL PETROLEUM COUNCIL, 1984.
ENERGY INFORMATION ADMINISTRATION, 1984.
AMERICAN PETROLEUM INSTITUTE/AMERICAN GAS ASSOCIATION/
CANADIAN PETROLEUM ASSOCIATION, 1979.

EOR CAN ADD SIGNIFICANTLY TO DOMESTIC OIL RESERVES

Of its estimated 488 billion barrels of original oil-in-place, the United States has produced an estimated 133 billion barrels. Of the remaining 355 billion barrels, 28 billion barrels are known recoverable reserves. (See fig. 2.1.) The remaining 327 billion barrels constitute a potential target for EOR. Every 1 percent of the 327 billion barrels that can be recovered adds over one year of domestic production at current rates of production.

With EOR, the lower-48 states (excluding off-shore reservoirs) can more than double the nation's future domestic crude oil supplies, from 28 billion barrels to 58 billion barrels, according to Enhanced Oil Recovery, a report issued in 1984 by NPC.[2] The study, based on data developed in 1982 and 1983, found that about 30 billion barrels of the 327 billion barrels of potential EOR target oil could be recovered using either implemented or advanced EOR technologies.[3] NPC advised, however, that the potential for EOR depends significantly on a broad spectrum of economic, technological, and policy considerations and constraints.

Cost and technology constraints enter into the study's estimates of the amount of oil that can be recovered using EOR. According to the study, at the market price of approximately $30 per barrel of oil, implemented EOR technologies can recover about 11 billion barrels. Another 13 billion barrels can be recovered through use of advanced technologies at the same price, rising to a total of about 30 billion barrels at the market price of approximately $50 per barrel. Once the R&D work for advanced technologies has been completed, however, the cost of advanced technologies would be less than of implemented technology, in constant dollars. The study concluded that, even after EOR technologies realize their maximum potential, 60 percent of the known U.S. oil will remain unrecovered and can be the target for EOR processes that either have not yet been developed or that require major refinements of present processes.

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[2] NPC is an advisory council to the Secretary of DOE. Its members represent industry, academia, and environmental groups.

[3] Implemented technology means the successful application of existing EOR methods to currently producing fields. Advanced technology means specific technological advances that conceivably would be developed within the 30-year time frame of the NPC's projections. NPC projected that the advanced technology, as it was defined for the study, would become available between 1988 and 1995. All constituents of the defined advanced technology are well defined in laboratory and field experiments.

FUTURE CRUDE OIL REPLACEMENT COSTS

- Additional sources of oil will be needed to sustain domestic production in the future.

- A 1984 study done for DOE ranks additional crude oil sources by lowest to highest production costs as follows:

  --EOR (advanced technology),

  --EOR (implemented technology),

  --Alaska offshore (shelf),

  --deep water offshore in lower-48 states,

  --Alaska offshore (slope), and

  --other hostile and fragile frontier areas.

- EOR is the least costly source for additional oil because

  --the costs of finding oil have already been incurred, and

  --the costs have also been incurred for the production wells that would be used for EOR.

- EOR becomes increasingly cost-effective as R&D improves the technology.

FUTURE CRUDE OIL REPLACEMENT COSTS

As conventional crude oil reserves become depleted, their replacement will be costly and will require technological advances. A study done for DOE in 1984 by Lewin and Associates Inc., entitled Replacement Costs of Domestic Crude Oil, estimated that the costs of replacing crude oil reserves at 1982 production rates would exceed $50 per barrel (in 1983 dollars) by the year 2000. The study concluded, on the basis of production costs for potential additional domestic oil sources, that EOR is the least costly method for obtaining new reserves.

The study rankings, from lowest to highest production costs, are: EOR using advanced technology, EOR using implemented technology, Alaskan offshore oil located on the ocean shelf, deep water offshore oil in the lower-48 states, Alaskan offshore oil located on the ocean slope, and other hostile and fragile frontier areas.

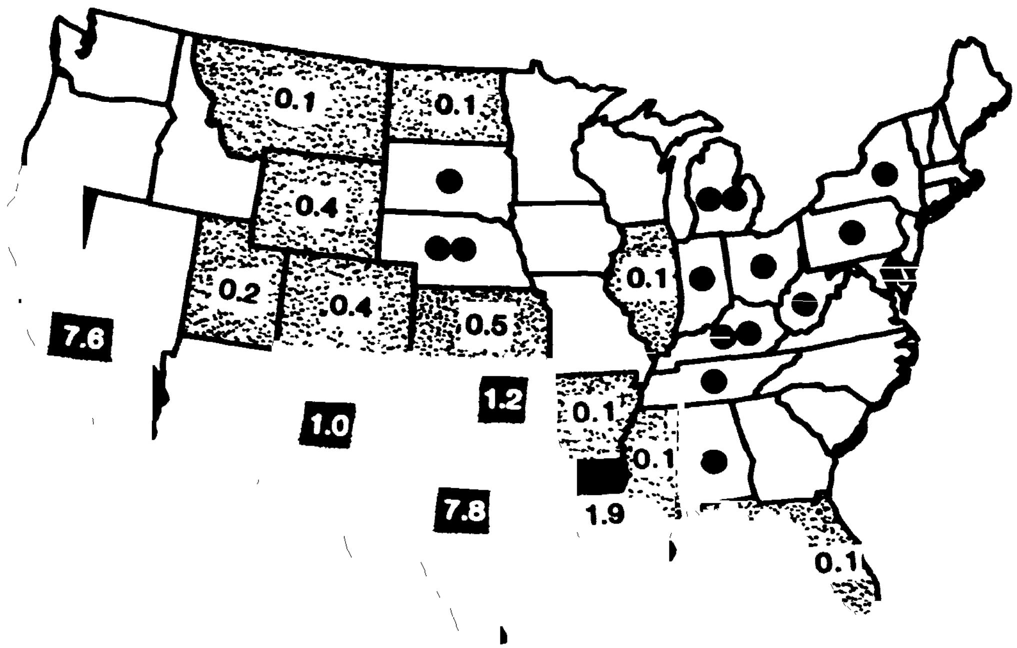
Methods other than EOR have distinct drawbacks. Recent disappointments in Alaskan exploration have shown that predictions about oil discoveries are not always confirmed. In addition, offshore and frontier areas depend on extremely costly and long lead-time exploration and development efforts.

According to the study, EOR, on the other hand, can increase production from known domestic reservoirs at a lower cost and in a more timely fashion than the other sources for replacing domestic reserves. EOR can be applied in known oil fields that have a substantial existing infrastructure, which significantly reduces the cost of this oil. Also, the exploration and development for these oil reservoirs have already occurred, which further lowers the cost of using this technology. The study concluded that starting about 1990, increased use of advanced EOR technologies can provide producible additional reserves at the lowest cost of alternative sources of oil. Advanced technologies are lower cost relative to current implemented technologies because the former are more efficient (i.e., get more barrels out relative to cost).

Finally, with advances in EOR technology, and increasing oil prices, EOR would be increasingly cost-effective. NPC found in its study, however, that advanced EOR technology can only realize its potential with substantial investments in R&D. With such investments, advanced EOR technology will yield the greatest return in additional reserves after the year 1995 of all the known potential recovery methods. In addition to improving tertiary efforts, EOR R&D can help the oil industry better understand reservoir characteristics, potentially enabling it to use less costly primary or secondary recovery methods in reservoirs where these are applicable.

FIGURE 2.2

POTENTIAL EOR RESERVES "IMPLEMENTED" TECHNOLOGY [a] (BILLIONS OF BARRELS)



[a] IMPLEMENTED TECHNOLOGY AT NOMINAL $30/B; EXTRAPOLATED TO INCLUDE RESERVOIRS NOT YET ANALYZED IN DETAIL

● INSUFFICIENT DATA

●● LESS THAN 0.05 BILLION BARRELS

■ GREATER THAN 1 BILLION BARRELS

▒ GREATER THAN 0.1 BILLION BARRELS

TOTAL U.S. POTENTIAL: 22 BILLION BARRELS

SOURCES: INTERSTATE OIL COMPACT COMMISSION, 1984.
ENERGY INFORMATION ADMINISTRATION, 1984.

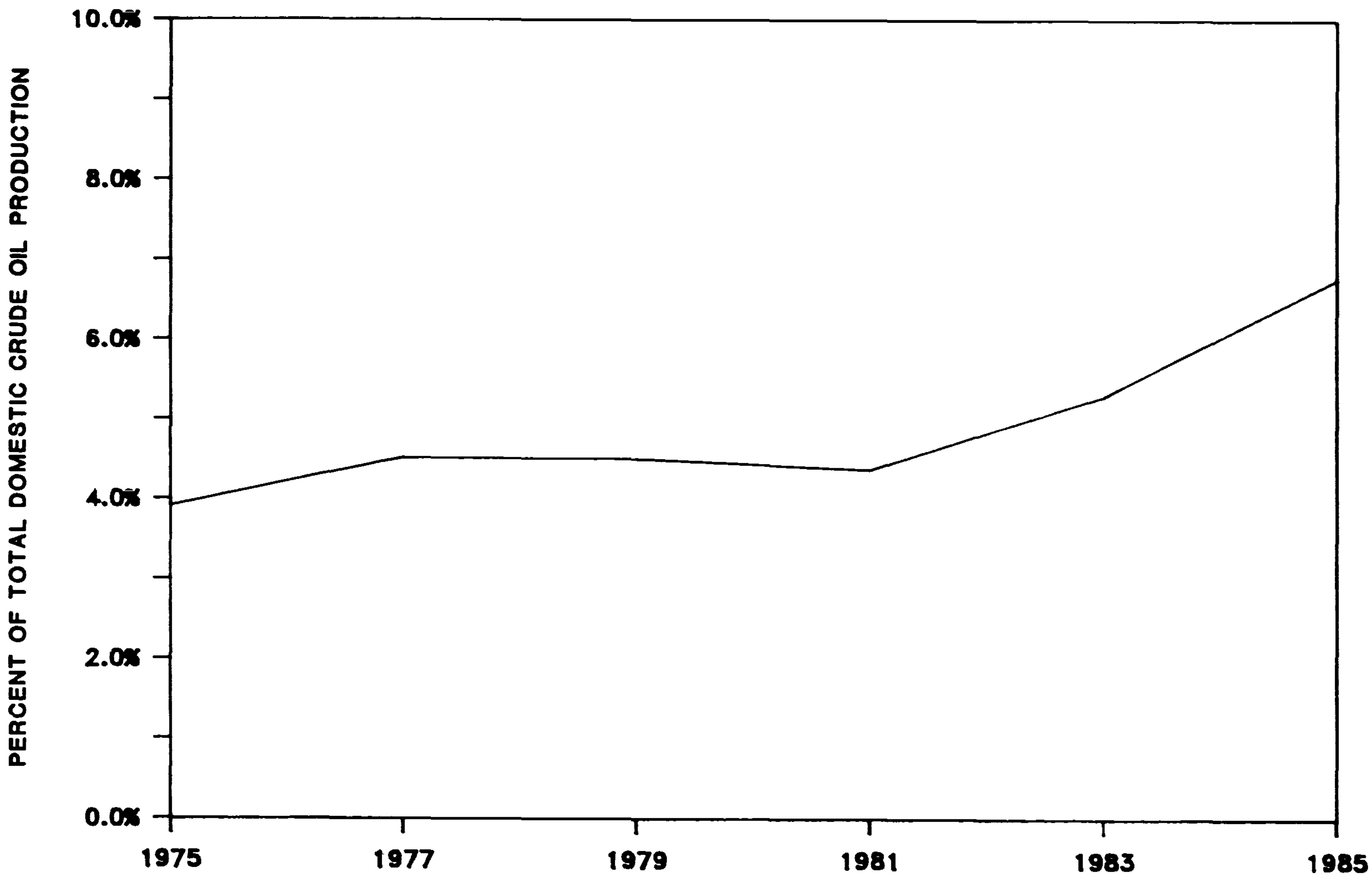
LOCATION OF POTENTIAL EOR RESERVES

Extrapolating from the NPC study, a January 1985 study by the Interstate Oil Compact Commission (IOCC), A Study of the Benefits of Enhanced Oil Recovery for the Oil-Producing States, estimates that EOR could contribute a little over 22 billion barrels of oil reserves using implemented technology. This estimate, which is 7 billion barrels higher than the NPC's, is based on 1984 data, includes more small reservoirs than the earlier study, and more precisely evaluates EOR potential on a state-by-state basis.

The IOCC study found that the 22 billion barrels could be recovered in 19 states, including Alaska. (See fig. 2.2.) Of these 19, 5 in the lower-48 have reserves of about 19.5 billion barrels, which could be produced using current EOR technology. Ten other lower-48 states could add another 2.0 billion barrels, while three more would add only about 70 million barrels. Alaska would add another 500 million barrels. The data for eight states was insufficient for determining how much oil could be added to the reserves. (See fig. 2.2.) Most of these eight states have a high percentage of stripper wells in proportion to total crude oil production, as shown in figure 1.7. Therefore, these eight states also could have great potential for increasing oil reserves with EOR.

FIGURE 2.3

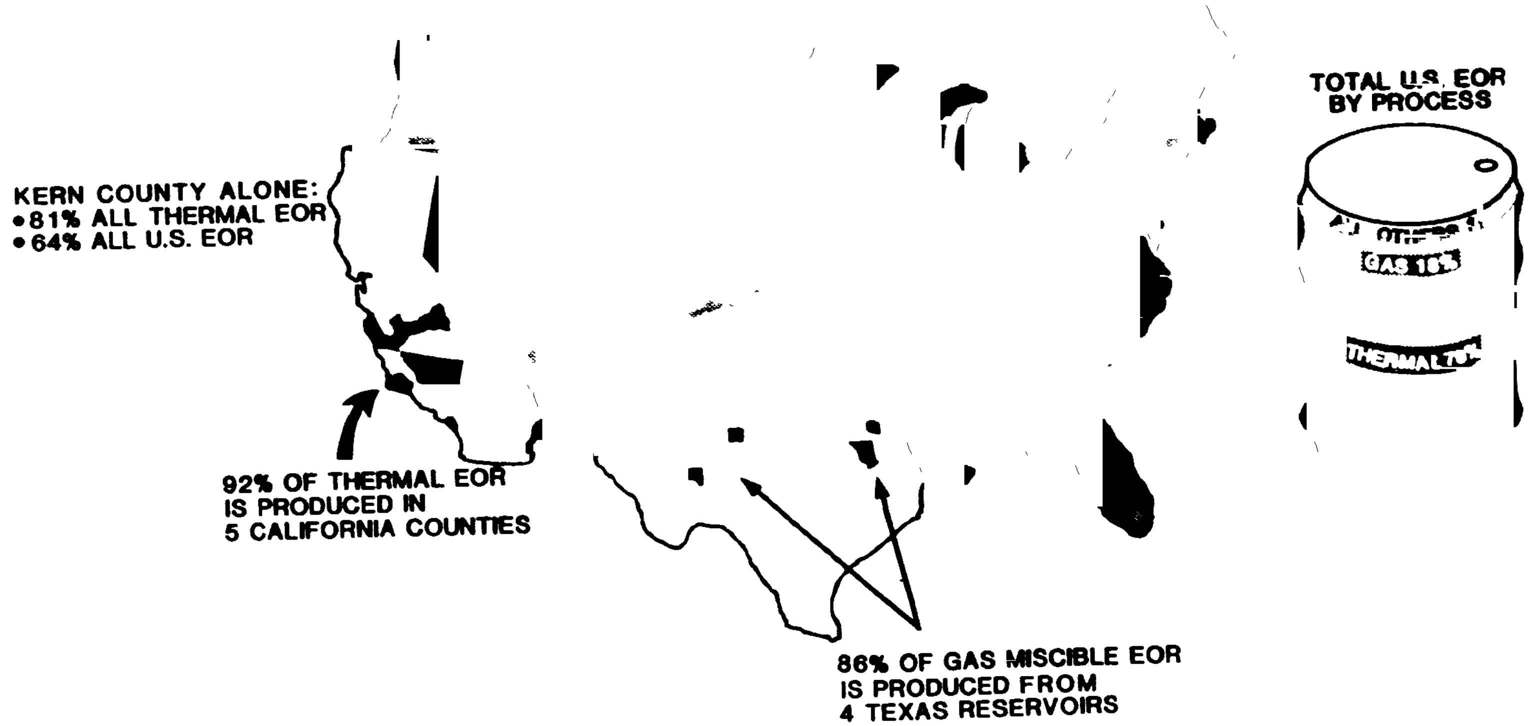
EOR AS PERCENT OF TOTAL U.S. PRODUCTION



SOURCE: OIL AND GAS JOURNAL 1976-86.

FIGURE 2.4

FAVORABLE GEOLOGIC SETTINGS FOR U.S. EOR



SOURCE: OIL AND GAS JOURNAL, 1984.

CURRENT EOR PRODUCTION

Over the past 10 years, EOR production as a percentage of total U.S. production has increased from 3.9 to 6.8 percent. (See fig. 2.3.) This increase has largely occurred in certain areas of Texas and California that have uniquely favorable geologic conditions for currently available EOR techniques. (See fig. 2.4.) In these settings, geologic conditions permit adequate predictability and economic recovery despite the lack of in-depth understanding of the oil reservoir or the processes for producing oil from it. However, most of the residual oil resource lies outside of such favorable geologic settings.

Currently, EOR methods are confined largely to thermal EOR techniques.[4] Of all EOR production, 79 percent is thermal, with 81 percent of thermal EOR occurring in Kern County, California. Most of the oil in reservoirs using thermal techniques is very heavy oil, and less than 10 percent of it can be recovered using primary or secondary extraction methods.

Another EOR technique, known as gas miscible, accounts for 18 percent of EOR production.[5] Four Texas reservoirs account for 86 percent of gas miscible EOR production using carbon dioxide flooding. Carbon dioxide pipelines have been built from underground reservoirs in states adjacent to west Texas fields to increase EOR production in west Texas.

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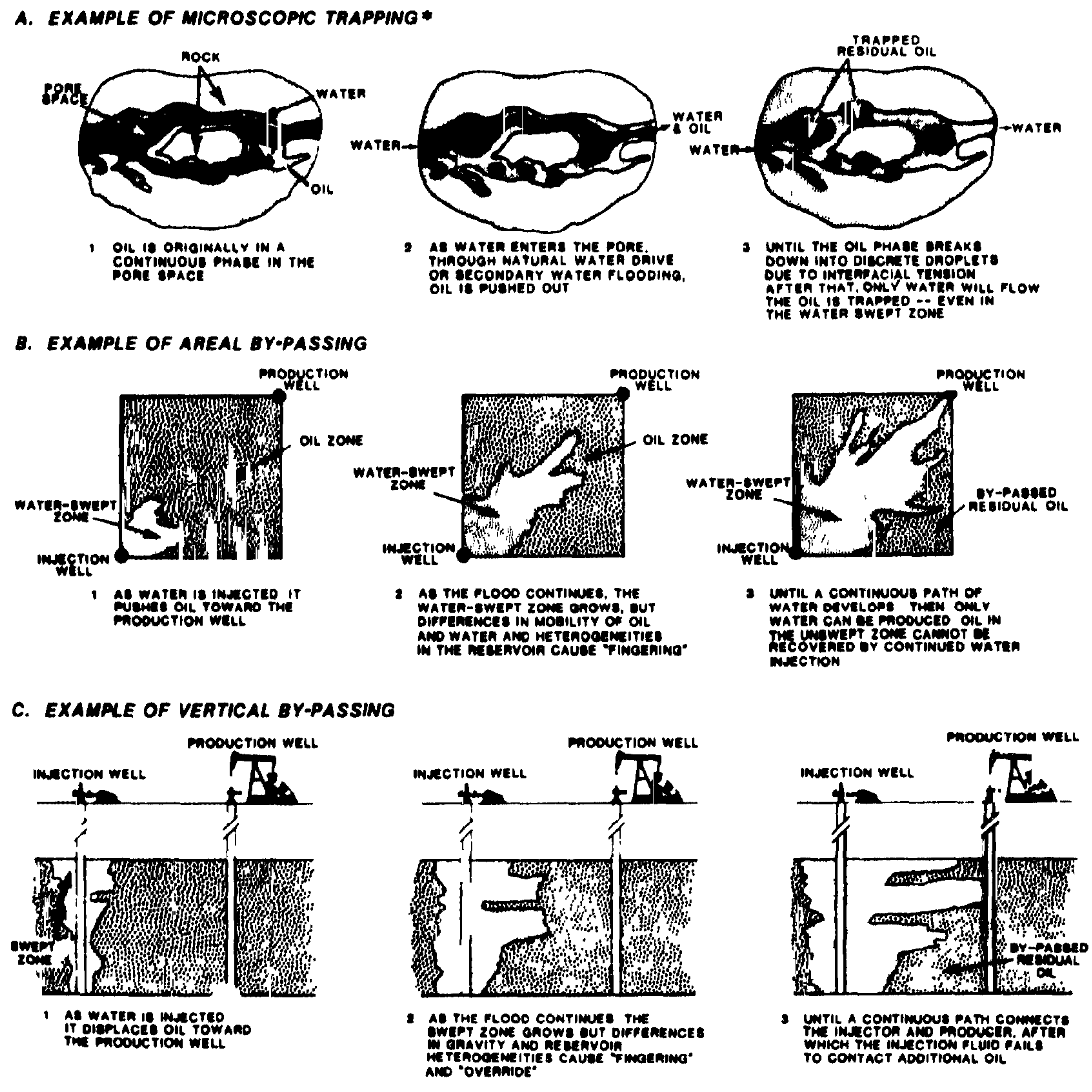
[4] Thermal recovery heats the oil in the ground to make it flow more easily. Steam and <u>in situ</u> combustion processes are the most advanced thermal methods currently in use.

[5] Miscible flooding uses carbon dioxide, nitrogen, or hydrocarbons as miscible solvents for recovering light-weight oils. Carbon dioxide flooding is expected to have more applicability than other miscible process for most fields in the United States other than those highly favorable fields in Texas.

FIGURE 2.5

HOW RESIDUAL OIL IS TRAPPED OR BY-PASSED



*** ILLUSTRATION BASED ON EXXON CONCEPT, 1982.**

SOURCE: DEPARTMENT OF ENERGY, 1983.

EOR's EFFECTIVENESS AND POTENTIAL FOR RECOVERING RESIDUAL OIL

Petroleum experts with whom we spoke said the industry needs a better understanding of the properties and location of the 327 billion barrels of residual oil (fig. 2.1), as well as the technologies for reaching, mobilizing, displacing, or producing this oil. Industry's primary need, they said, is for basic research on reservoir characterization. Research and development in EOR could develop this knowledge, thereby enhancing the U.S. ability to recover residual oil.

Basically, residual oil is oil that remains in a reservoir after conventional primary and secondary recovery. The residual oil is trapped by interfacial tension, lies in zones of the reservoir that cannot be swept by injected fluids, or is too viscous to be produced. (See fig. 2.5.) This is the oil that is usually trapped or by-passed. Further, it is different physically than the oil that was produced by conventional processes and/or is in physical locations that cannot be reached by conventional processes.

Certain EOR processes, such as chemical processes, have not proved as effective in field trials as laboratory tests indicated they would be.[6] However, field trials have been useful in helping to identify what research on reservoirs is needed. DOE currently supports basic research that is aimed at understanding why the residual oil is trapped or by-passed in a reservoir. According to industry experts, basic research on reservoir characterization continues to be needed to more fully understand what takes place in a reservoir so that the residual oil can be recovered.

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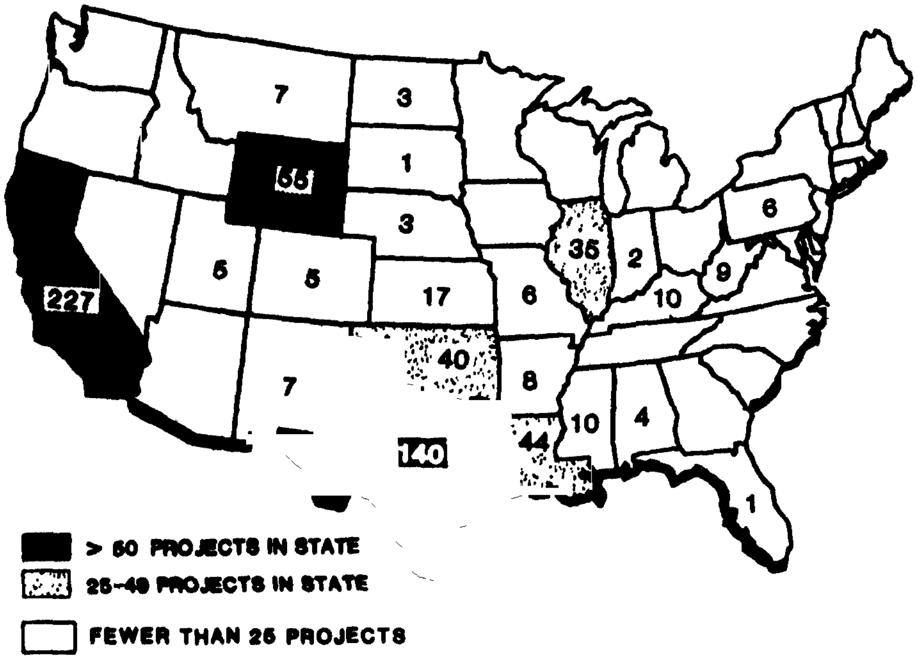
6 Chemical methods include polymer flooding, surfactant (miscellar/polymer, microemulsion) flooding, and alkaline flooding. These methods are broadly characterized by the addition of chemicals to water in order to generate fluid properties or interfacial conditions that are more favorable for oil production.

FIGURE 2.6

LOCATION OF CURRENT EOR PROJECTS[a]



[a] ENTRIES ARE NUMBERS OF PROJECTS.

SOURCE: BARTLESVILLE PROJECT OFFICE, 1984.

CURRENT EOR PROJECTS IN THE U.S.

In order for the oil industry to apply EOR technologies broadly, it must have EOR methods that have been proven to work in reservoirs with different geologic characteristics. Field projects using EOR technologies are therefore necessary to advance research.

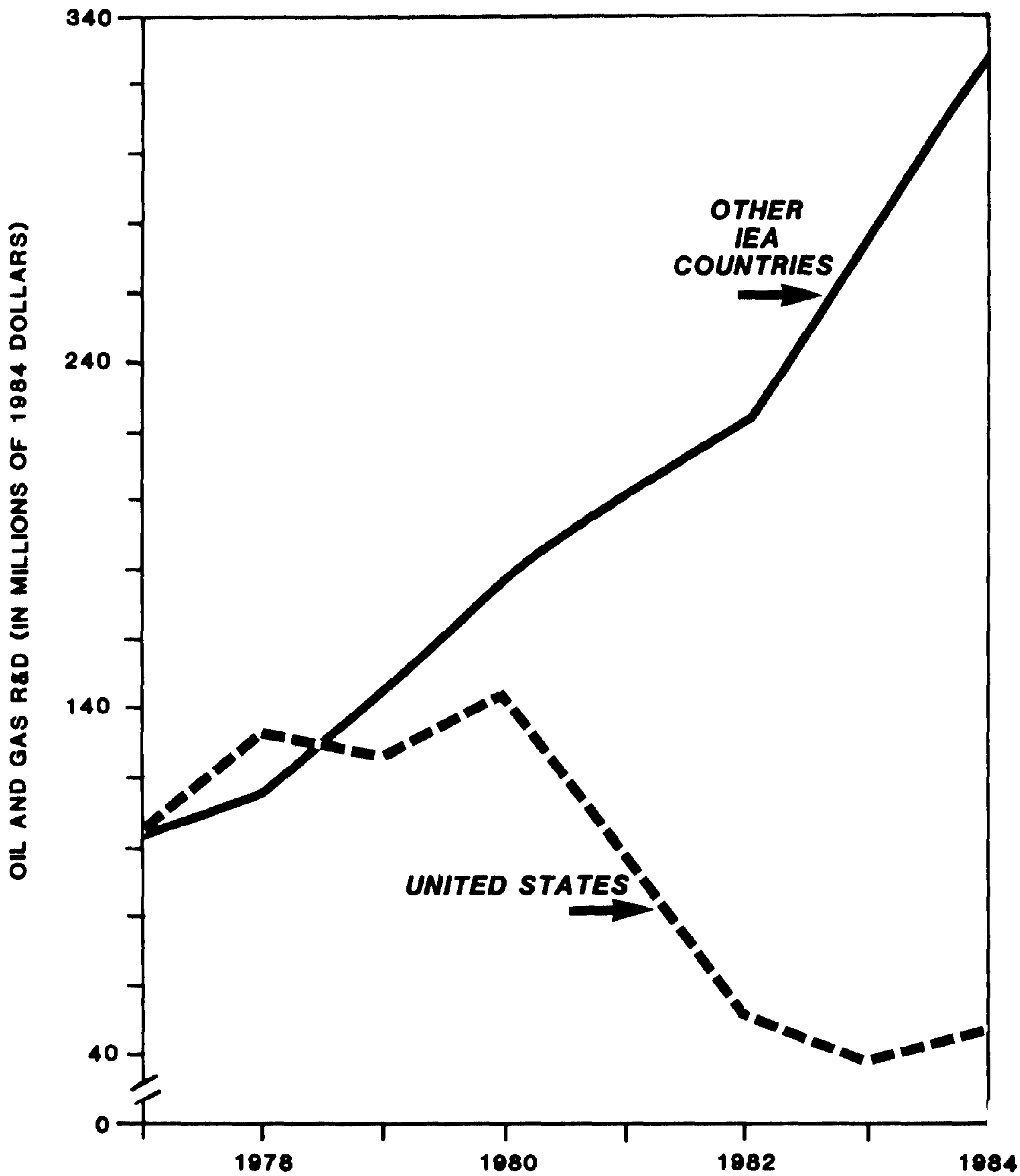
According to DOE data, as of the end of 1984, a total of 645 EOR projects were being conducted in 23 states ranging from California to Florida and from Montana to Texas. (See fig. 2.6.) Of the total, 153 were gas miscible, 219 were chemical, 263 were thermal, and 10 were listed as "other." Most projects, however, are in California and Texas because of the uniquely favorable reservoirs at these locations for proven EOR techniques.

DOE officials told us that another kind of EOR process--microbial--is being tried in some reservoirs for which no current data exists.[7]

[7] Microbial EOR technologies employ animals or plants of microscopic size, such as bacteria, to free the oil in the reservoir and make it flow more easily to the producing well.

FIGURE 2.7

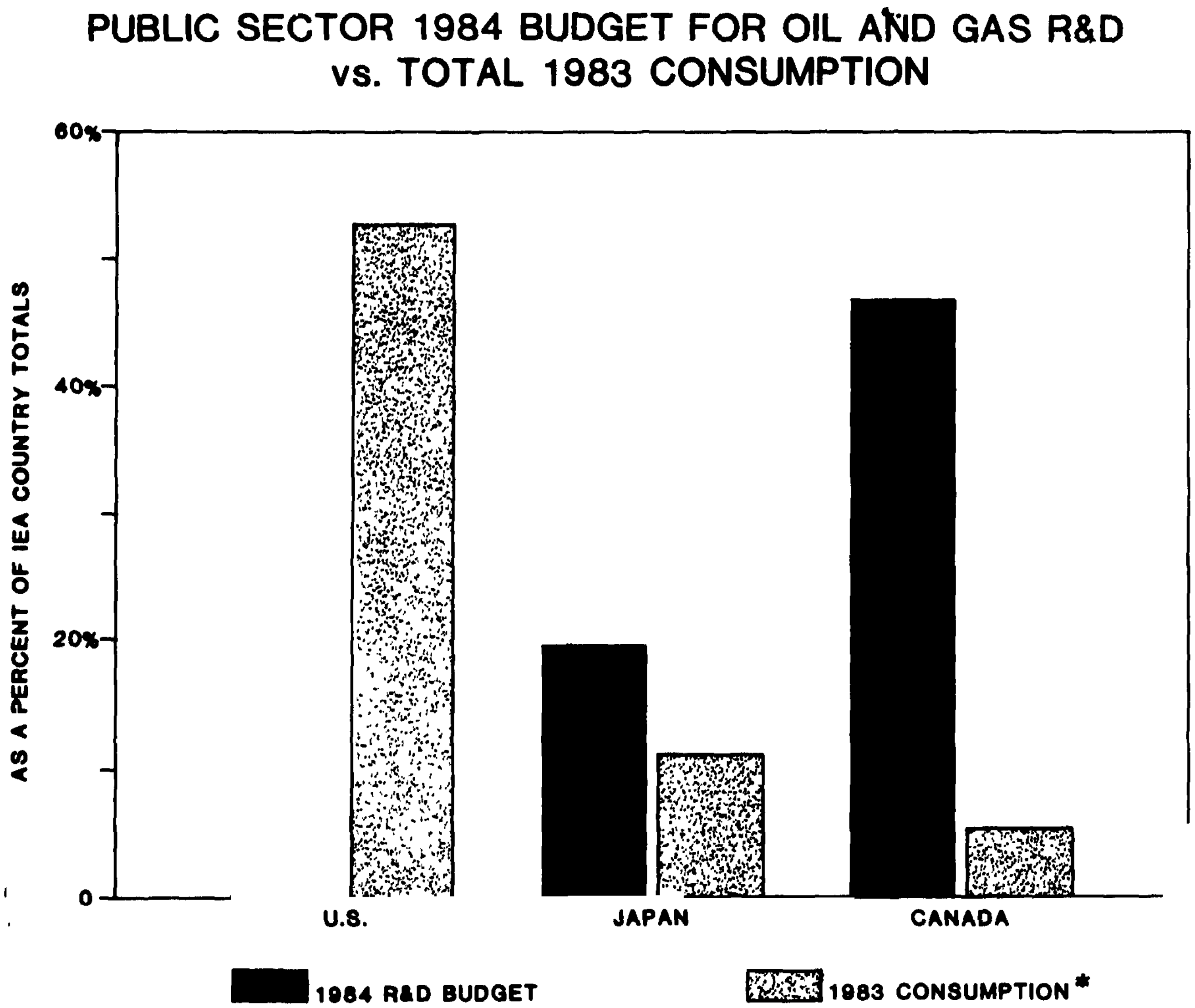
U.S. PUBLIC SECTOR OIL AND GAS R&D vs. OTHER IEA* COUNTRIES



*INTERNATIONAL ENERGY AGENCY (IEA) MEMBER NATIONS.

SOURCE: IEA, 1985.

FIGURE 2.8



* LATEST OFFICIAL DATA AVAILABLE FOR COUNTRIES OTHER THAN U.S
SOURCES: INTERNATIONAL ENERGY AGENCY, 1985.
DEPARTMENT OF ENERGY /ENERGY INFORMATION ADMINISTRATION, 1985

BUDGETS FOR OIL AND GAS R&D

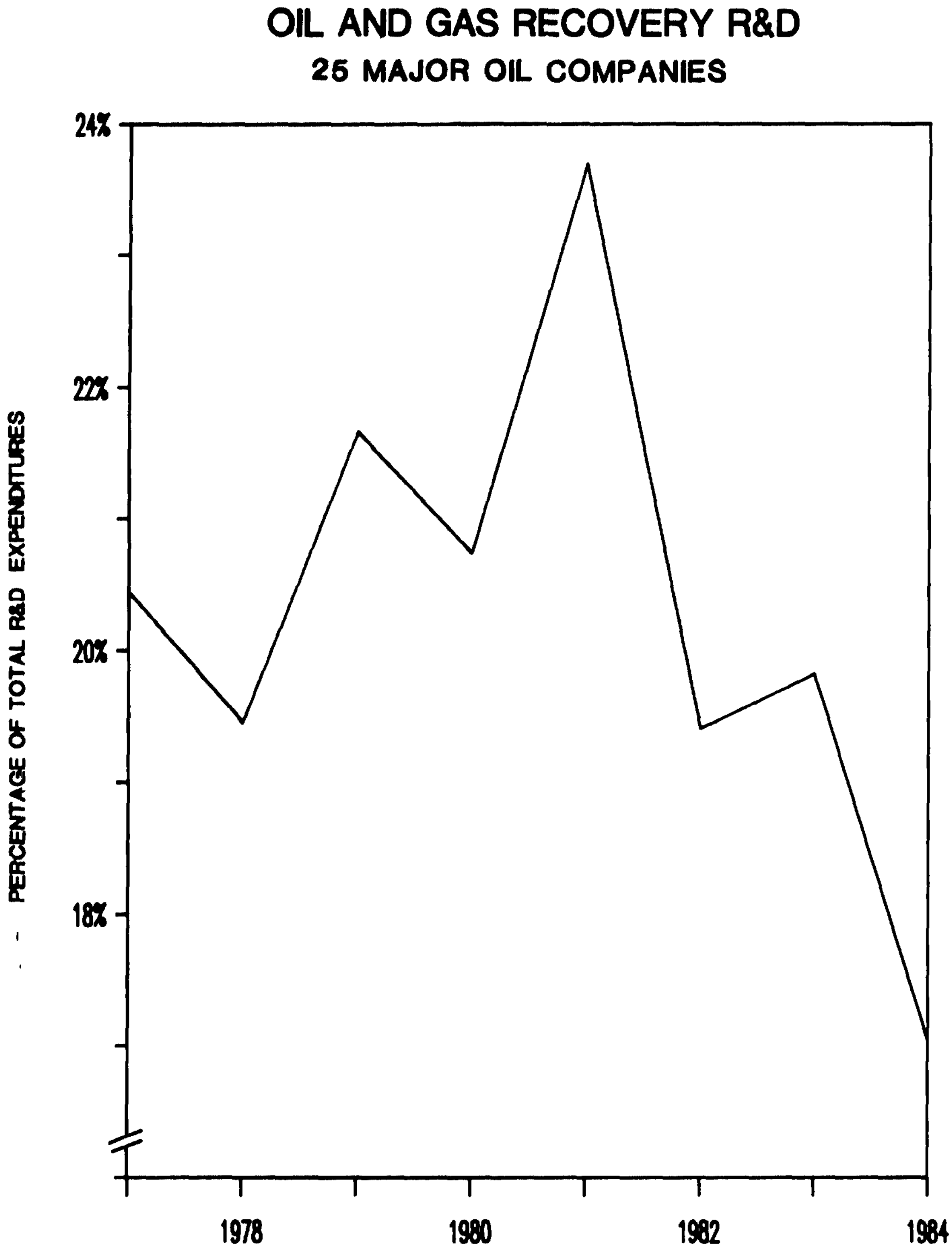
The U.S. government spends considerably less money on oil and gas research than other International Energy Agency (IEA) countries. As figure 2.7 shows, the federal government spent about $45.8 million in 1984, while the other nine countries combined spent about $325.8 million. U.S. oil and gas R&D expenditures, as a percentage of all IEA country oil and gas R&D expenditures between 1977 and 1984, decreased from 50.2 percent to 12.3 percent. The other countries' expenditures increased 214 percent during that same period.

Despite this difference, industry officials and petroleum experts told us that the United States is much further advanced than other countries in EOR technology because U.S. oil companies spend large amounts on EOR R&D and the United States has more mature fields in which EOR technologies have been used than do other countries. (See p. 49.) However, we were also told that if the EOR research budget is eliminated or greatly reduced, other countries could be serious competitors within a few years.

This difference is particularly significant when correlated with oil and gas consumption. (See fig. 2.8.) The differences among the United States, Canada, and Japan, for example, are pronounced. Even though Canada and Japan together consumed less oil and gas than the United States, they budgeted more for oil and gas R&D, including EOR. For example, in 1983 (the latest data available), the United States consumed about 8.5 billion barrels of oil and gas equivalents (about 53 percent of total IEA country consumption); Canada, 860 million barrels (about 5 percent of total IEA country consumption); and Japan, 1.8 billion barrels (about 11 percent of total IEA country consumption). In 1984 the United States spent about $45.8 million on oil and gas R&D, (about 12 percent of total IEA country expenditures); Canada, $174 million (about 47 percent of total IEA country expenditures); and Japan, $73.4 million (about 20 percent of total IEA country expenditures).

Furthermore, Norway, Venezuela, France, Germany, England, Mexico, and Italy are aggressively pursuing EOR research. Norway is funding its research centers by having the major international oil companies pay for EOR research as a condition of drilling for oil.

FIGURE 2.9



SOURCE: ENERGY INFORMATION ADMINISTRATION, 1985.

OIL COMPANIES' R&D ON OIL AND GAS

We could not meaningfully determine the amounts spent by oil companies on specific EOR research because each company uses different research classifications. Instead, we examined oil companies' data on oil and gas recovery R&D expenditures, which are reported to DOE annually and therefore offer consistent trend information.

The data reported to DOE show that between 1977 and 1984, the major 25 oil companies spent over $4.5 billion on oil and gas recovery R&D. However, the percentage spent in this area, as compared with the total spent by these major companies for all R&D decreased from a high of 23.7 percent in 1981 to 17 percent in 1984. (See fig. 2.9.) This percentage drop does not reflect a significant drop in dollar amounts, which held relatively steady over the period. The major companies were devoting more of their research dollars to other areas.

Furthermore, there are growing incentives for oil companies not to spend R&D funds on oil and gas. First, the high cost of producing oil and gas requires high oil prices to warrant the investment in oil R&D. With the drop in oil prices, the companies have less incentive to invest in EOR technology for U.S. fields because they can produce oil less expensively overseas using primary and secondary methods. To illustrate the difference in production, 1984 data show that four times as many wells were drilled in the United States as in the rest of the free world combined, but the rest of the free world's production was 3.5 times higher than the United States'. Consequently, even though the major oil companies continue to spend large amounts of money in the United States because they have major interests in U.S. oil fields, oil company officials told us that there are few places in the United States where any new exploration will be done until oil prices stabilize and companies can plan expenditures on the basis of revenues for at least one year in advance.

Oil industry officials told us that they will be doing little, if any, basic EOR research, and that they will do only applied EOR research in fields where it makes sense economically because of the drop in oil prices and the high initial costs for EOR production. Most of these officials said their companies will not be funding any external research, although in the past they have provided limited support for university-based EOR research.

Independent and small companies

Many independent oil companies have only a few wells or one reservoir from which they produce oil. Generally, their production is small compared with the major companies and with total U.S. production. However, as figure 1.8 shows, these approximately 24,000 companies account for about 41 percent of the U.S. crude oil production. Therefore, their contribution to the domestic oil supply is significant.

Independent companies have never spent much money on EOR research. Although they have been involved in some field tests sponsored by DOE, it was the consensus among those whom we interviewed that these companies would need to have publicly available research and technical expertise in order to use EOR technology.

TABLE 2.1

DOE EOR BUDGET SUMMARY
Fiscal Years 1982-86

	1982	1983	1984	1985	1986[a]
	(thousands)				
Bartlesville Energy Technology Center (BETC)	$ 1,376	$1,426	$ 0	$ 0	$ 0
BETC project management	2,111	2,610	0	0	0
NIPER	0	0	4,728	4,799	3,792
Universities	2,239	2,918	2,598	3,638	2,851
Industry	1,558	555	678	918	1,493
Laboratories	4,100	0	255	432	573
Operations Office (San Francisco)	30	150	83	22	1
Morgantown Energy Technology Center (METC)	100	459	484	632	840
Total [b]	$11,514	$8,118	$8,826	$10,441	$9,550

[a] Estimated as of April 30, 1986.

[b] Totals for FY84-86 do not include funds supporting DOE EOR project management staff. Including these funds, the totals for each of the years would be about $12 million.

DOE EXPENDITURES FOR EOR RESEARCH

DOE has spent approximately $12 million in each of the past 3 years for EOR research. (See table 2.1.) These funds have supported a data base, experiments at the National Institute for Petroleum and Energy Research (NIPER) at Bartlesville, Oklahoma, university-based research, and research at DOE's laboratories and a technology center.

DOE's Bartlesville project office manages the federal EOR projects and maintains the national Tertiary Oil Recovery Information System (TORIS). TORIS is the key data base for understanding what the U.S. residual oil resources are and how current and future technologies can put those resources into production. Using TORIS, DOE can quantify the production implications of alternative EOR R&D strategies. The data base is also used to develop estimates of the total EOR contribution for use in policymaking on domestic oil supplies, forecasting domestic production, and setting priorities among EOR R&D alternatives.

The Illinois Institute of Technology Research Institute runs the NIPER laboratory under contract to DOE. This laboratory is the only fully integrated thermodynamics laboratory in the United States. Research in petroleum thermodynamics provides data that is useful to industry in such areas as designing oil refinery processes. NIPER also conducts research, under DOE's direction, on liquid fuels, including EOR. DOE's contract with NIPER includes annual base level funding of about $5 million for 5 years and an additional level of funding over the same period, decreasing from $4 million to zero in the last year. This financial support is not restricted to EOR research. DOE's fiscal year 1986 budget covered the third year of the NIPER contract.

Universities have received a total of more than $14 million in EOR research grants for basic R&D from DOE over the past 5 years. Funding has supported research on reservoirs that contain light and heavy oils and on advanced process technology (microbial EOR). The focus of this work was to understand the geology of reservoirs and how the oil moves through the reservoirs using various EOR processes.

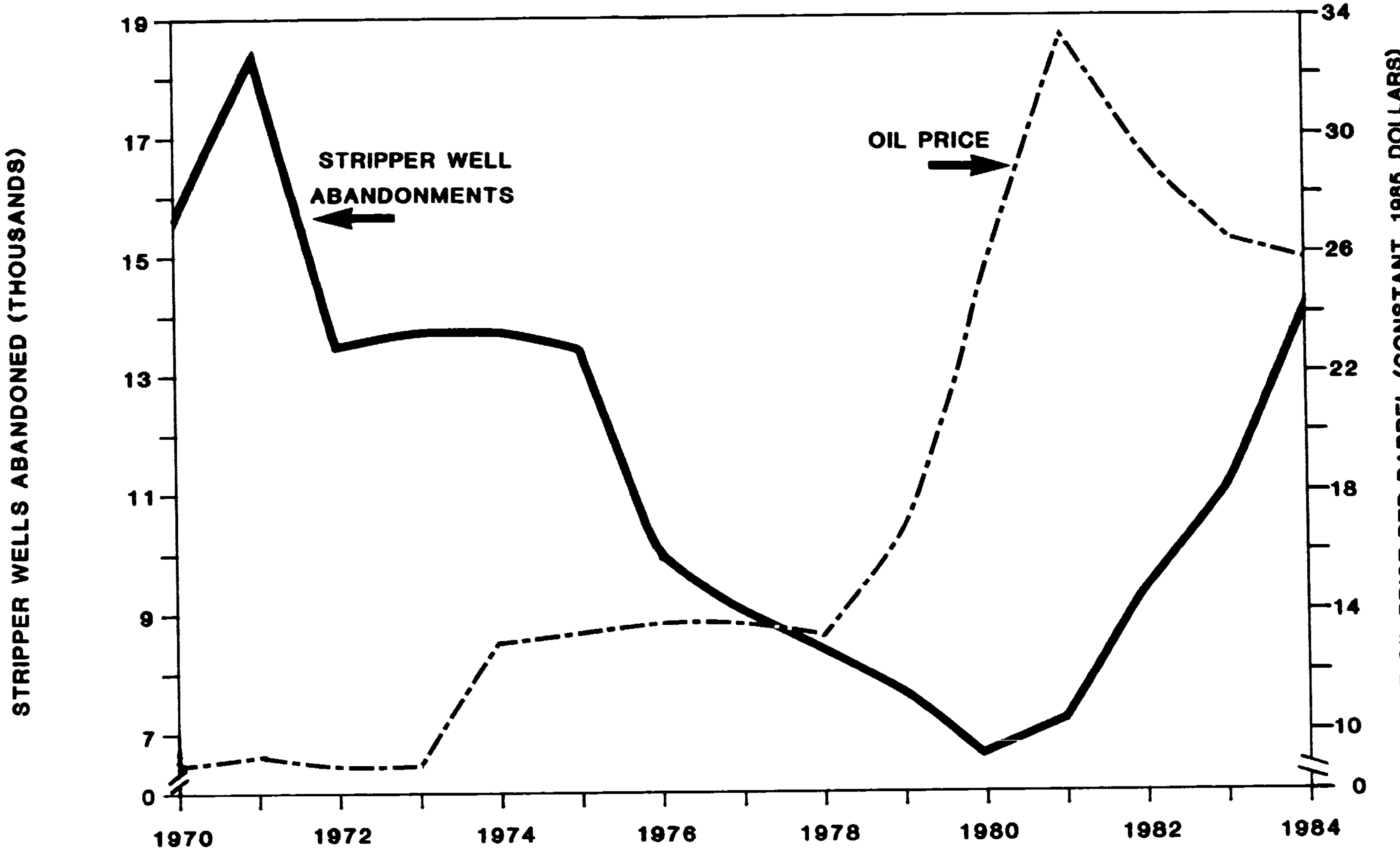
In previous years, DOE also has funded EOR field trials. In the field, many of the processes tested did not perform as well as laboratory tests indicated they would. These laboratory tests, however, were in applied rather than basic research, and lacked information on what occurs in the reservoir when EOR technology is used. The DOE EOR program is currently directed toward basic high-risk, long-term research on reservoir characterization.

SECTION 3

IMPACT OF PRICE CHANGES ON A MAJOR POTENTIAL EOR RESOURCE--STRIPPER WELLS

FIGURE 3.1

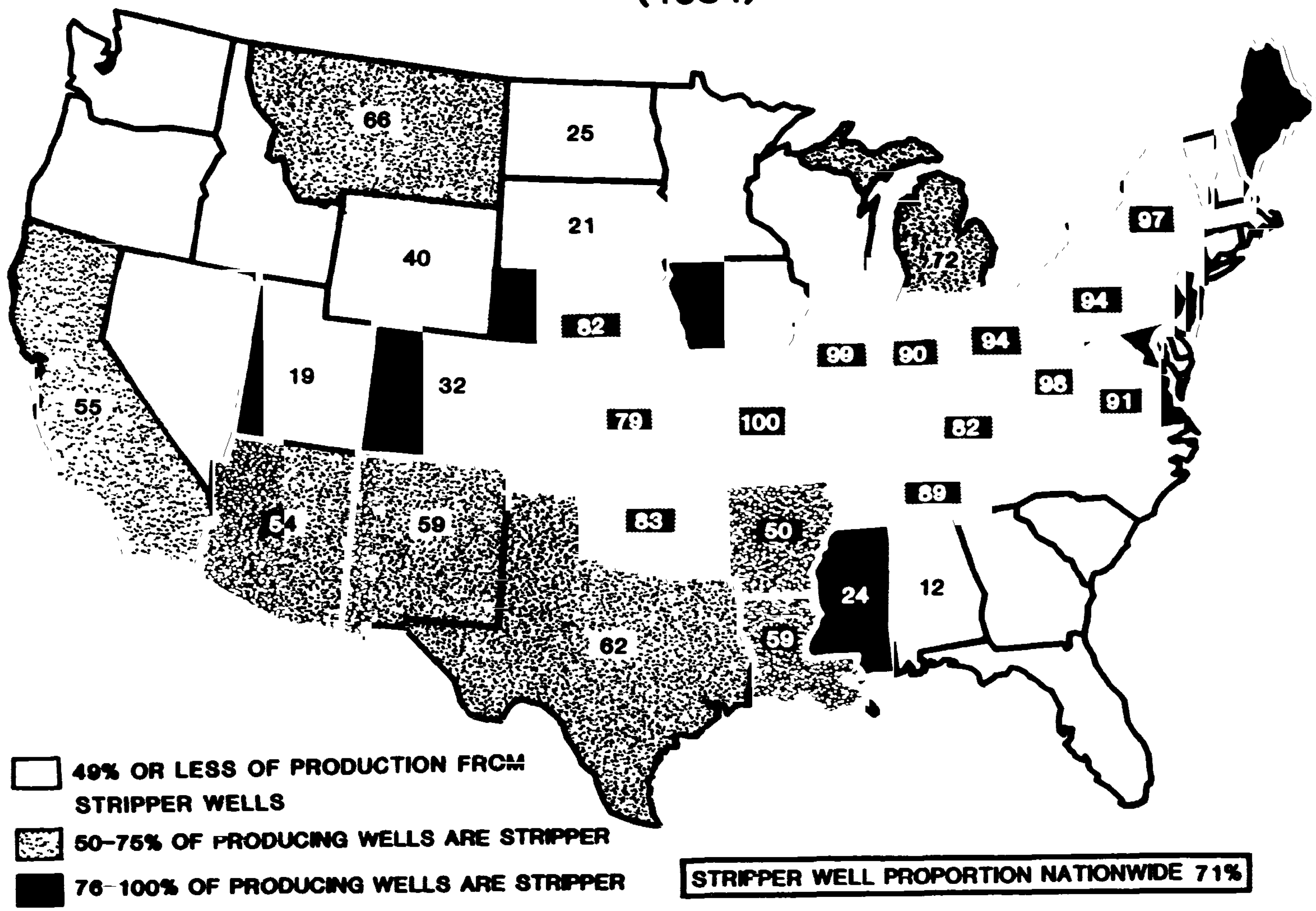
U.S. STRIPPER WELL ABANDONMENTS vs. OIL PRICE



SOURCES: THE RAM GROUP, LIMITED, 1986.
AMERICAN PETROLEUM INSTITUTE, 1986.
OIL AND GAS JOURNAL DATABASE, 1986.

FIGURE 3.2

STRIPPER WELL PERCENT OF TOTAL PRODUCING WELLS IN STATES WITH STRIPPER WELLS (1984)



SOURCE: INTERSTATE OIL COMPACT COMMISSION, 1985.

OIL PRICES, STRIPPERS WELLS, AND PRODUCING STATES

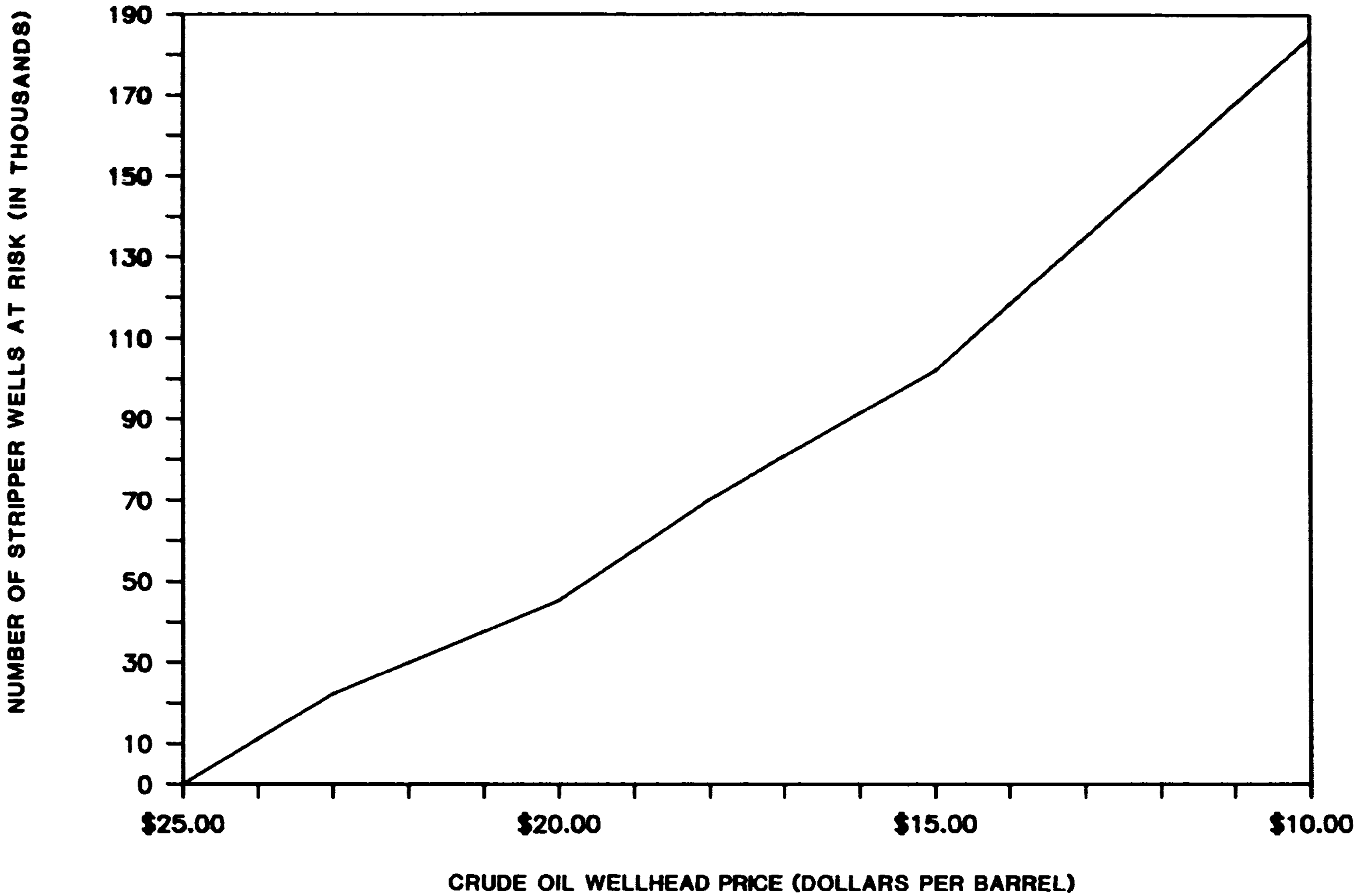
Historically, stripper well production has been very sensitive to changes in oil prices, increasing as prices rise and falling as they decline. These fluctuations affect both the domestic oil supply and revenues in states that rely heavily on stripper well production. In figure 3.1, for example, when the oil price was $9.19 per barrel in 1971 (in 1985 constant dollars), 18,421 stripper wells were abandoned. In 1981 when the oil price was $33.44 per barrel, 7,215 stripper wells were abandoned. By 1984 these numbers had changed to $25.75 and 14,170, respectively. The 1986 drop in oil prices is similarly affecting stripper wells, but current data is not available to indicate how many wells are affected.

Twenty-one producing states in the lower-48 get at least 50 percent of their production from stripper wells. For 13 states, this proportion is greater than 75 percent. (See fig. 3.2.)

As the number of operating stripper wells declines with the drop in oil prices, the affected states are experiencing a drop in revenues from cutbacks in petroleum production and the loss of production taxes and increased unemployment. Even before the most recent drop in oil prices, the 1982-83 price drop caused an average decline of 15 percent in employment in the producing states. In many states, the loss of jobs was significant as oil producing companies shifted from labor-intensive exploration and development activities to the production of existing reserves. Many of those who became unemployed are part of the EOR infrastructure and will probably be unavailable to operate and maintain future EOR projects.

FIGURE 3.3

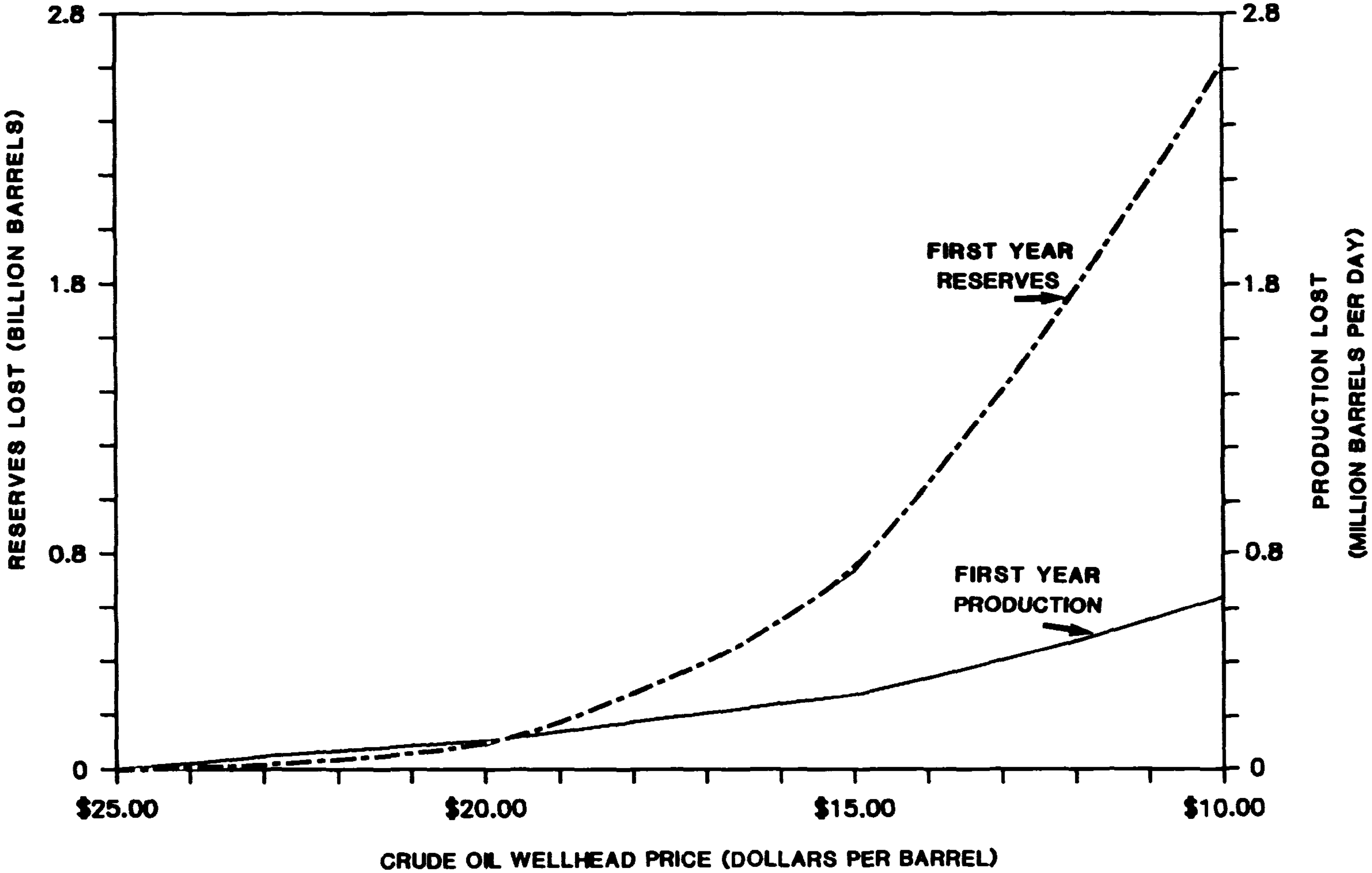
STRIPPER WELLS AT RISK OF ABANDONMENT AT VARIOUS OIL PRICE LEVELS



SOURCE: THE RAM GROUP, LIMITED, 1986.

FIGURE 3.4

STRIPPER WELL PRODUCTION AND RESERVES AT RISK OF LOSS AT VARIOUS OIL PRICE LEVELS



SOURCE: THE RAM GROUP, LIMITED, 1986.

PREDICTED EFFECTS OF STRIPPER WELL ABANDONMENTS

Decreasing crude oil prices affect the number of stripper wells that will continue producing. A May 1986 study conducted by the RAM Group, Ltd. for the IOCC, Costs and Benefits of Stripper Well Tax Credits, examined the impact of decreasing crude oil prices on stripper wells and projected how many stripper wells are at risk of being lost at various prices. The study further projected how much crude oil production would be lost if those stripper wells stopped production.

Number of wells at risk

The RAM Group, Ltd. study found that oil at $10 per barrel would mean 184,547 stripper wells would be abandoned; at $15, 101,956 wells; and at $20, 45,390 wells. (See fig. 3.3.)

Industry officials told us that wells are not abandoned as soon as the price of oil drops, but shortly thereafter. The projected loss of wells is not absolute, but rather contingent upon how marginal the well's production is (production vs. price of oil) and other factors, such as tax considerations.

Production and reserves at risk

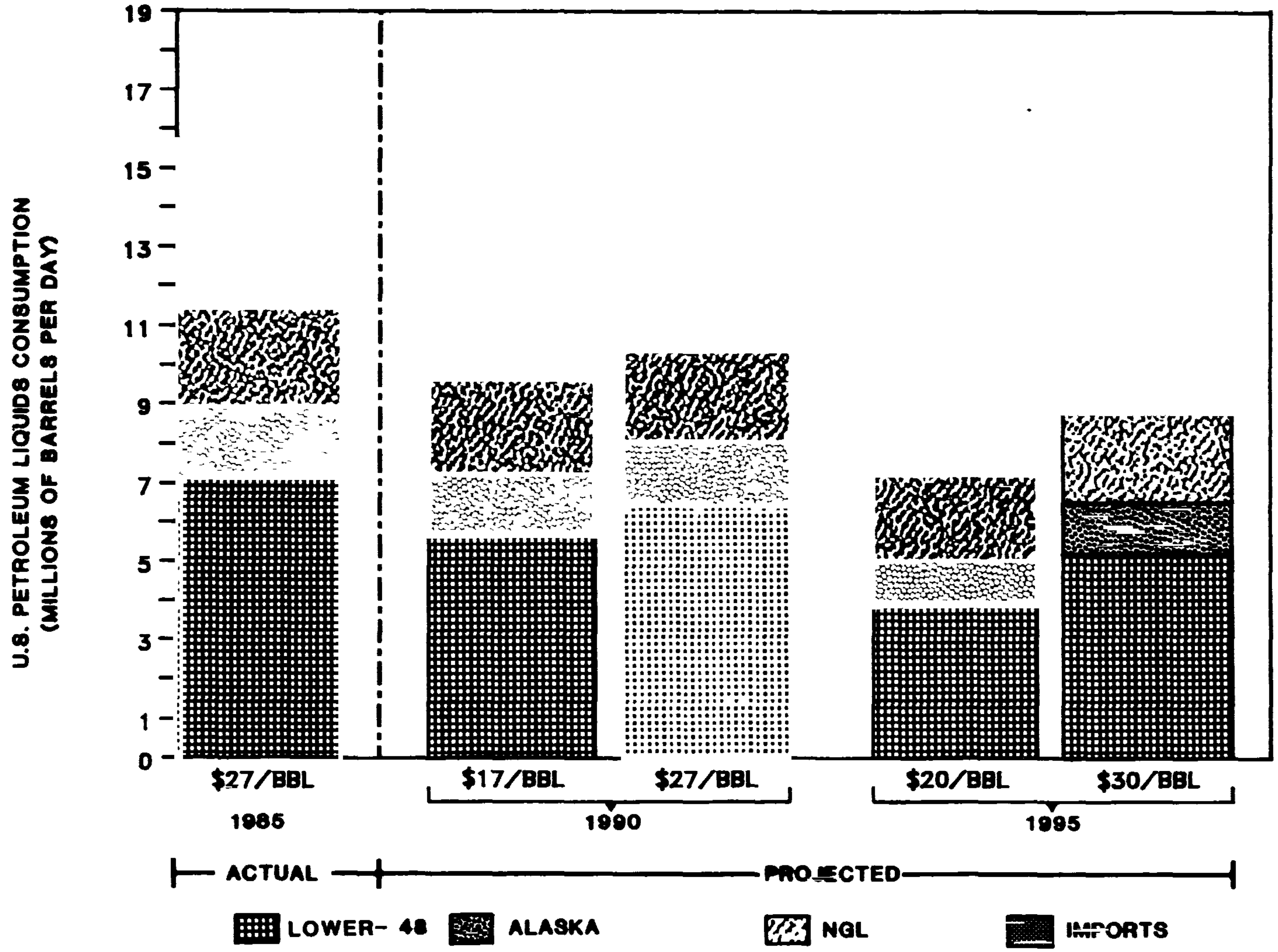
The RAM Group, Ltd. study also predicted how various oil prices would affect stripper well production and reserves. It found that in the first year if prices drop to $10 per barrel, .638 million barrels per day might be lost to production; at $15, .277 million barrels per day; and at $20, about .107 million barrels per day. For reserves, the study found that at $10 per barrel, the reserves at risk in the first year of loss would be 2.611 billion barrels; at $15, .734 billion barrels; and at $20, .093 billion barrels. (See fig. 3.4.)

SECTION 4

EFFECTS OF PRICE CHANGES AND DOE's FISCAL YEAR 1987 BUDGET PROPOSAL ON EOR RESEARCH

FIGURE 4.1

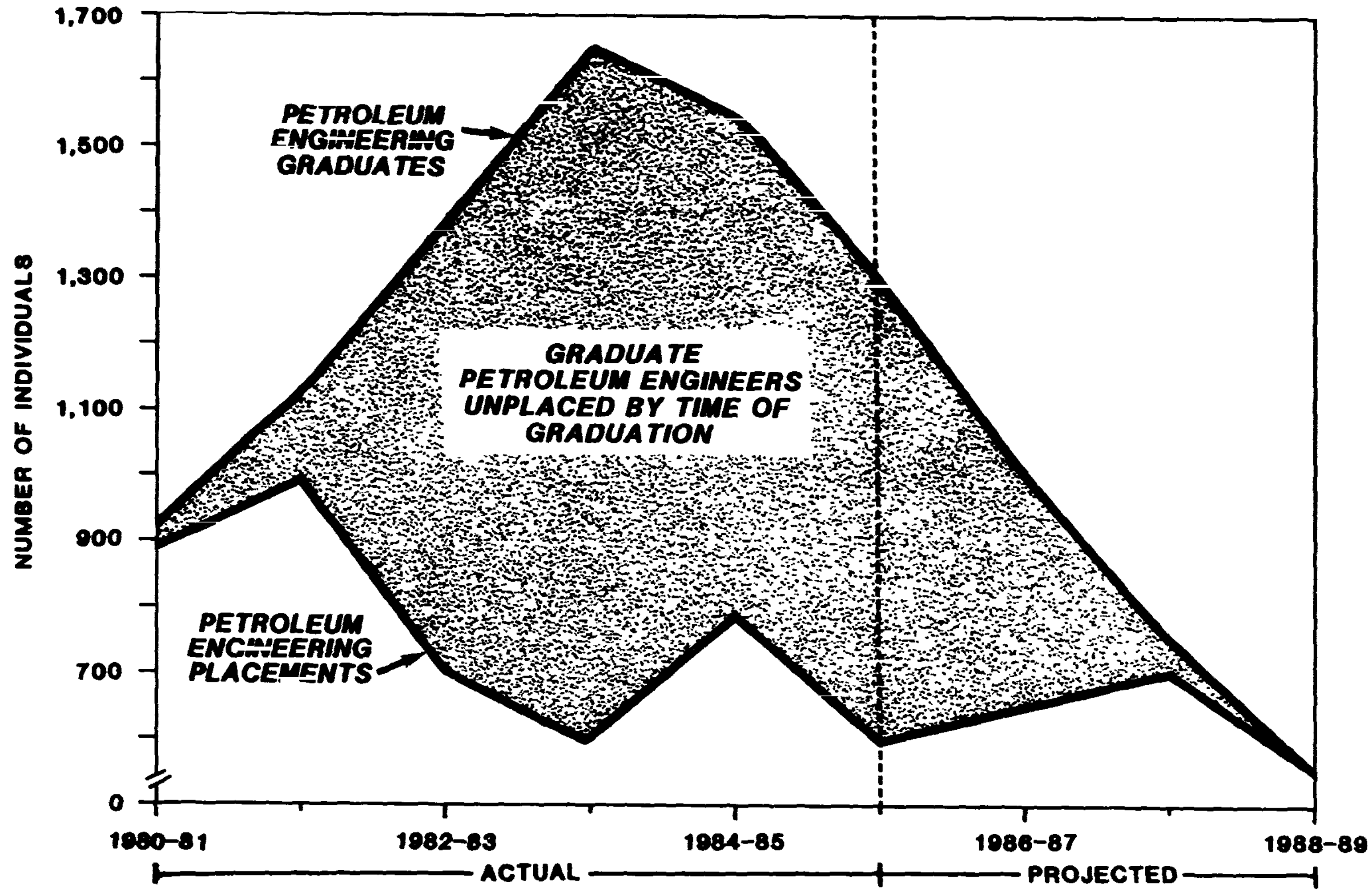
IMPACT OF OIL PRICES ON PETROLEUM LIQUIDS SUPPLY SOURCES



SOURCE: ENERGY INFORMATION ADMINISTRATION, 1985.

FIGURE 4.2

U.S. PETROLEUM ENGINEERING GRADUATES vs. JOB PLACEMENTS



SOURCE: JOURNAL OF PETROLEUM TECHNOLOGY, MARCH 1986.

EFFECTS OF CHANGES IN OIL PRICES

Using econometric models, DOE has examined the effects of changes in oil prices on demand and consumption at various prices per barrel and at different periods of time.

DOE predicts that as prices rise from current levels, the United States will import more oil. However, less oil will be imported and consumed if prices rise rapidly. For example, if oil was $30 per barrel in 1995, total consumption would be 16.6 million barrels per day, with imports accounting for 7.8 million barrels. At $20 per barrel in 1995, total consumption would be 18.15 million barrels per day, but imports would account for 10.97 million barrels. (See fig. 4.1.)

Although there is a great deal of uncertainty as to what future oil prices will be, virtually all industry experts with whom we spoke believe that prices will rise in the next 2 to 5 years. Most expected the price increase to be in the $18-to $22-per barrel range in about 3 years. If these expectations are realized, the United States will be importing significantly more oil in a few years, using DOE's projections of consumption at various price levels.

EOR consequences

With the drop in oil prices, oil companies and the universities have cut back on EOR research. The oil companies are curtailing R&D activities, which could erode the personnel base that supports EOR. The curtailments have occurred in several areas. First, company officials told us that their companies are reducing or eliminating much of their funding for EOR research as well as most of the support they provide to universities for R&D. They said that these cutbacks will mean EOR research will be limited to applied research on those fields in which their companies have already invested money for EOR or in those few instances where it makes economic sense for them to do EOR. The officials also told us that their companies have reduced research staffs and even eliminated some research facilities. They were concerned that the loss of experienced EOR engineers and technicians within their companies would create problems when oil prices go back up and EOR would be more profitable.

Further, the rate of new hires of petroleum engineers has declined significantly since oil prices started to fall in late 1982. (See fig. 4.2.) Industry officials were concerned that this will result in a future lack of available petroleum engineers, and more importantly, in graduate students with experience in EOR research.

Both industry officials and faculty at the universities told us that because many undergraduate petroleum engineers cannot get jobs, they are working toward advanced degrees, many specializing in EOR research. However, because universities are experiencing problems in maintaining funding for their EOR research programs as a direct result of dropping oil prices, these students may not be able to finish their degree work in this area and may be a lost resource to EOR research or for EOR applications by oil companies when oil prices rise again. In particular, Louisiana, Texas, Oklahoma, New Mexico, and Wyoming, which derive more than 25 percent of their state taxes from petroleum production, have announced cuts in their support for university-based EOR research as a result of the decline in their petroleum revenues.

TABLE 4.1

DOE'S EOR BUDGET
PROPOSAL FOR FISCAL YEAR 1987[a]
(in millions)

Advanced process technology	$1.8
Enhanced oil recovery	4.5
Total	$6.3[b]

[a] In addition to this funding, DOE is proposing to include EOR under a cooperative applied R&D joint venture program. Total funding for this program would be $12.5 million. It includes EOR, oil shale, underground coal gasification, and unconventional gas research programs. DOE does not know how much of this money will be available for EOR.

[b] These funds are split between NIPER and METC. NIPER is to receive $6 million and METC $300,000.

DOE's 1987 EOR BUDGET PROPOSAL

DOE's proposed budget for fiscal year 1987 would provide $6.3 million in direct funding for EOR research, down from about $12 million in its fiscal 1986 budget. NIPER would receive $6 million to continue long-term, high-risk basic EOR research and METC would receive $300,000 to complete an ongoing basic EOR research project. The proposed budget eliminates all direct funding for university-based research, and would sell the DOE research facility in Bartlesville in fiscal year 1988. DOE plans to fund the TORIS data base system under the NIPER contract.

Under the proposed budget, DOE would not continue to provide funds to any other federal research facility. In addition, international cooperative EOR research done with DOE would not be directly funded under DOE's budget proposal. DOE officials said that existing agreements would continue under the NIPER contract and that the joint venture approach to research funding, as discussed below, could be used to continue this work.

Industry representatives as well as university EOR experts told us they are concerned about the proposed budget's effect on the availability of information on EOR and on basic EOR research. On the proposal to sell the Bartlesville facility, a number of industry and university officials told us that they believed the federal government should maintain its presence in EOR research and that the Bartlesville facility is in a good geographic location, allowing researchers to interact with independent and major companies and academic communities. DOE told us that they would rely on joint ventures to maintain a DOE presence in EOR research after the Bartlesville facility is sold.

With respect to TORIS, we learned that this data base is considered a national tool that government, companies, and researchers need. TORIS is used for activities such as public policy decision-making and modeling capabilities, which are used to examine EOR strategies in differing reservoirs.

The budget proposal with respect to international cooperative research in EOR raised industry and university concerns about whether this research would continue in the long run. Industry and university representatives said that useful information on EOR can be obtained through these agreements, and they would like to see them continued.

DOE proposed reductions in the EOR research program and in three other fossil energy technology areas--oil shale, underground coal gasification, and unconventional gas--in order to provide money for R&D joint venture pools (joint ventures), a new approach to research funding. Joint ventures would be formed with industry and universities to do this research. DOE's primary goal with this approach is to effectively transfer technology from federal and university laboratories to private industry. DOE believes that this approach to applied research and technology development efforts would strengthen U.S. technological competiveness in the world market and advance the nation's ability to produce energy from domestic resources, when needed, at reasonable costs and with acceptable environmental and health and safety consequences. In addition, DOE believes that joint ventures in R&D for these extraction technologies would provide greater leverage for federal dollars and that industry can best determine what R&D is needed. Oil industry representatives told us, however, that their companies would not be willing to participate in joint venture programs because (1) they would rather do applied research on their own and (2) they did not want to accept any restrictions that DOE might impose. University officials also expressed an unwillingness to participate in joint ventures. If no joint venture arrangements were entered into, federal joint venture money would effectively be lost for EOR research.

SECTION 5

SUMMARY AND MATTER FOR CONSIDERATION BY DOE's OVERSIGHT AND APPROPRIATIONS COMMITTEES

SUMMARY

The U.S. economy depends heavily on a continuing supply of crude oil, and this dependence is expected to continue for some time. Current estimated domestic oil reserves are being depleted rapidly as oil fields mature, and fewer barrels of oil reserves are added each year. In addition, the current decline in oil prices has caused the oil industry to curtail oil exploration, reducing even further the potential for increasing oil reserves. As reserves become depleted, their replacement will be costly and require technological advances.

Two studies done for DOE in 1984 indicate that EOR could be an important tool for increasing domestic oil supplies. One study found that EOR could make a major contribution to domestic production at less cost than other alternative sources of oil. The other study reported that, with technological advances based on continued research and favorable economic conditions, EOR could double present producible domestic oil reserves.

DOE recently proposed a change in its strategy for funding EOR research. Currently, DOE supports basic research on EOR through the EOR budget at its Bartlesville Project Office through a cooperative agreement with the Illinois Institute of Technology Research Institute, and at its laboratories and technology center, and universities. However, DOE's fiscal year 1987 budget proposal would eliminate all direct funding to universities and its laboratories, with funds allocated for Bartlesville and METC. In place of this direct support, DOE proposes to establish joint venture pools with the oil industry and universities for applied research and development for four separate programs, including EOR. DOE also proposes to sell the Bartlesville facility in 1988 and thereafter plans to rely on joint ventures for EOR research. DOE believes that this approach would effectively transfer technology from federal and university laboratories to private industry and provide greater leverage for federal research and development dollars. In addition, DOE believes that industry can best determine what research and development is needed.

DOE's joint venture approach for funding EOR research does not appear to be well-founded because: (1) it could shift funding away from needed basic research; (2) there is little industry or university support for joint ventures in EOR; and (3) it seems inconsistent with DOE's emphasis on funding long-term, high-risk research.

Basic research is important to the successful use of EOR. One reason DOE has directed its current program toward basic research has been to find out more about the characteristics of oil reservoirs. In past years, DOE has funded many applied EOR processes that did not perform as well as laboratory tests

indicated they would because little information was available on what occurs in the reservoir when EOR technologies are used. Basic research on oil reservoir characteristics is expected to result in a better understanding of what occurs in the reservoirs when EOR is used.

Under DOE's fiscal year 1987 budget proposal for ending direct funding to universities and selling the Bartlesville facility, basic research at universities and at NIPER could be ended or significantly curtailed. Further, the oil industry is not likely to perform basic research since it engages primarily in applied, rather than basic, research.

Industry officials told us that they are not interested in participating in joint ventures for applied EOR research, even though the recent drop in oil prices is curtailing their research efforts. They said also that they would rather do their own applied research and did not want to accept any restrictions that DOE might impose as part of a joint venture. University officials also expressed an unwillingness to participate in joint ventures.

Finally, DOE's joint venture approach does not appear to be consistent with its stated emphasis of funding long-term, high-risk research, especially since there appears to be a need to do basic research on EOR reservoir characteristics.

MATTER FOR CONSIDERATION

The information in this report raises questions about whether DOE's proposal for joint venture funding has been considered thoroughly and provides the optimal use of such funds available for EOR research. As they make their decisions on the optimal use of EOR funds, DOE's oversight and appropriations committees should closely review with DOE the strategy and justification for its joint venture approach for applied EOR research.

(001779)

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