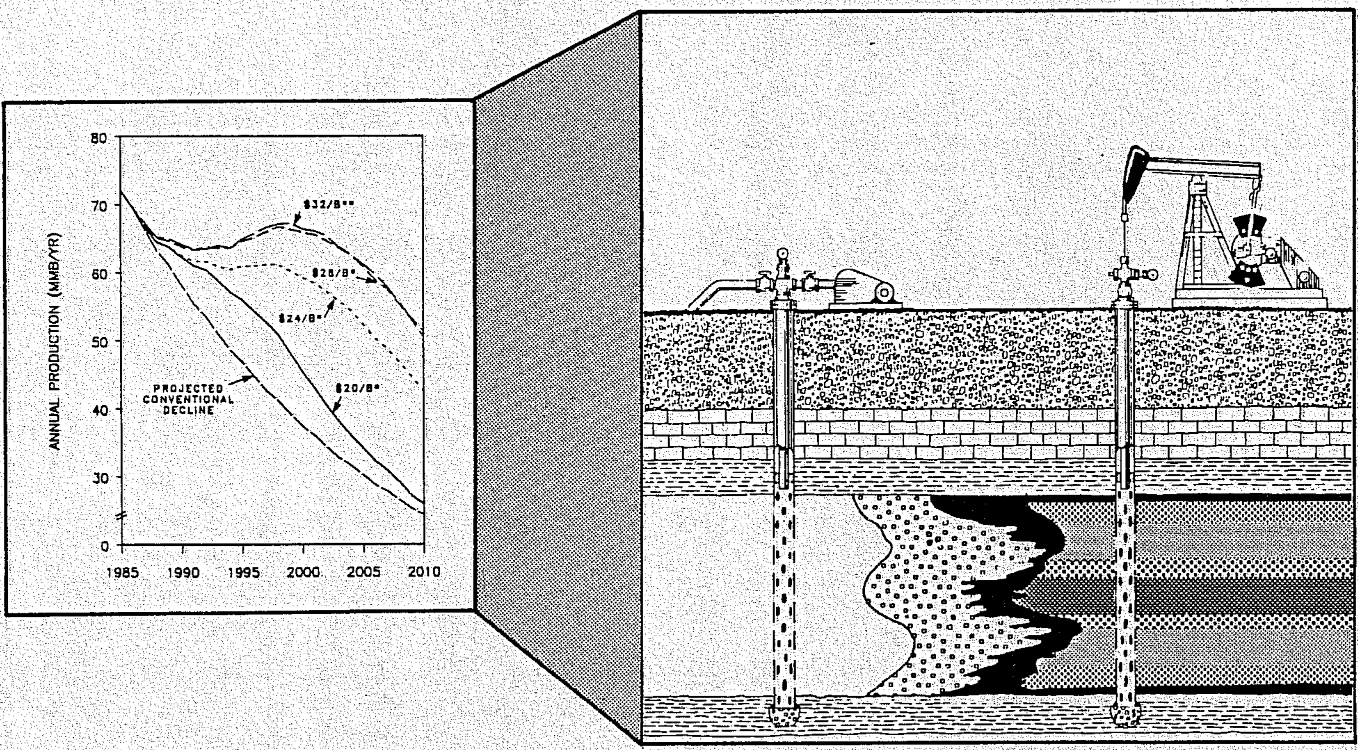
THE POTENTIAL OF ENHANCED OIL RECOVERY BY CARBON DIOXIDE FLOODING IN NEW MEXICO



By the
Interstate Oil Compact Commission
Project On Enhanced Oil Recovery
And the States

December 1986

THE POTENTIAL OF ENHANCED OIL RECOVERY BY CARBON DIOXIDE FLOODING IN NEW MEXICO

DECEMBER 1986

Interstate Oil Compact Commission

P.O. Box 53127

Oklahoma City, Oklahoma 73152

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THE POTENTIAL OF ENHANCED OIL RECOVERY BY
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The Potential of Enhanced Oil Recovery by Carbon Dioxide Flooding in New Mexico is the first report of a larger program, the Project on Enhanced Oil Recovery and the States, being conducted by the Interstate Oil Compact Commission (IOCC). This overall project was initiated by a "seed money" grant from the State of Oklahoma. The present analysis and report was prepared under contract between the New Mexico Research and Development Institute (NMRDI) and the IOCC (Contract No. 2-74-4806), under the direction of Mr. Robert H. Rea, Assistant Director, and under the general supervision of Dr. Larry Icerman, Acting Director of NMRDI.

The basic data and models used in the analysis were developed and validated in the 1982-84 study of the nationwide potential of enhanced oil recovery by the National Petroleum Council (NPC). The NPC data and models as well as computer time were made available to the present project by the U.S. Department of Energy, Office of Fossil Energy, Bartlesville Project Office. Special acknowledgment to Mr. R. Mike Ray of that office is extended for his invaluable technical advice and to Mr. Robert L. Folstein, the Director of the Office, for his encouragement, suggestions, and reviews.

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The final acknowledgments go to those who directly performed the work of the project. The National Institute for Petroleum and Energy Research of Bartlesville, Oklahoma, validated, edited, and added to the reservoir data base. Mr. Rex Thomas directed this effort under the general supervision of Mr. Herb Carroll. Lewin and Associates, Inc., of Washington, D.C., served as the IOCC's principal subcontractor, responsible for the study design, computer modeling, analysis, and report preparation. Lewin's project director was Dr. J.P. Brashear; Mr. Alan B. Becker was the project manager; and the critical project staff included Mr. Khosrow Biglarbigi (manager of Lewin's Bartlesville Office); Mr. Peter M. Crawford and Ms. Maria A. D'Andrea (editors and researchers); Mrs. Angela B. Taylor (administrative assistant); Mr. Vernon Dunning (graphics supervisor); and Mrs. Iris Dickens-Drayton and Ms. Yvonne V. Tilghman (word processors). Mr. Robert Cooper, Associate Director of the IOCC, assisted me in providing liaison and coordination among the subcontracting organizations and NMRDI. While acknowledging the assistance of all of these contributors, errors of fact, analysis, or interpretation are the responsibility of the Interstate Oil Compact Commission staff and the principal subcontractor's project director.

W. Timothy Dowd
Executive Director
September 1986

I. EXECUTIVE SUMMARY

A. THE PROBLEM: DECLINING NEW MEXICO OIL PRODUCTION

New Mexico's tax base and economy are heavily dependent on crude oil production. Between 1969 and 1982, oil production decreased dramatically, only to increase slightly in the past three years. While this recent trend is promising, it results from extensive infill drilling and expanded waterflooding. Each of these approaches can increase reserves, but they can also accelerate the production of previously proved reserves. The number of such opportunities for the future is becoming limited.

Significant production decline is projected for the future in New Mexico (Exhibit I-1). At the end of conventional (primary and secondary) production, however, more than 70% of the state's known oil resource will remain unrecovered in New Mexico's reservoirs (Exhibit I-2). Only improved recovery technology -- enhanced oil recovery (EOR) -- can substantially increase future oil production. For New Mexico's reservoirs, the most applicable EOR technique is carbon dioxide miscible flooding.

B. THE PROMISE: CARBON DIOXIDE MISCIBLE FLOODING

Based on methods developed and validated in the two-year, 50 professional-person-year study by the National Petroleum Council* of enhanced oil recovery, the potential of miscible carbon dioxide flooding was analyzed in detail. A total of 97 New Mexico reservoirs, accounting for 81% of the state's original oil-in-place, were assessed individually for their technical and economic potential. The results showed that, at oil prices that can reasonably be expected over the next 25 years, carbon dioxide miscible flooding could more than replace New Mexico's currently proved reserves (potentially adding up to 750 million barrels at prices up to $32/B), substantially offset the projected decline in production, and help sustain New Mexico's oil industry well into the twenty-first century (Exhibit I-3). The

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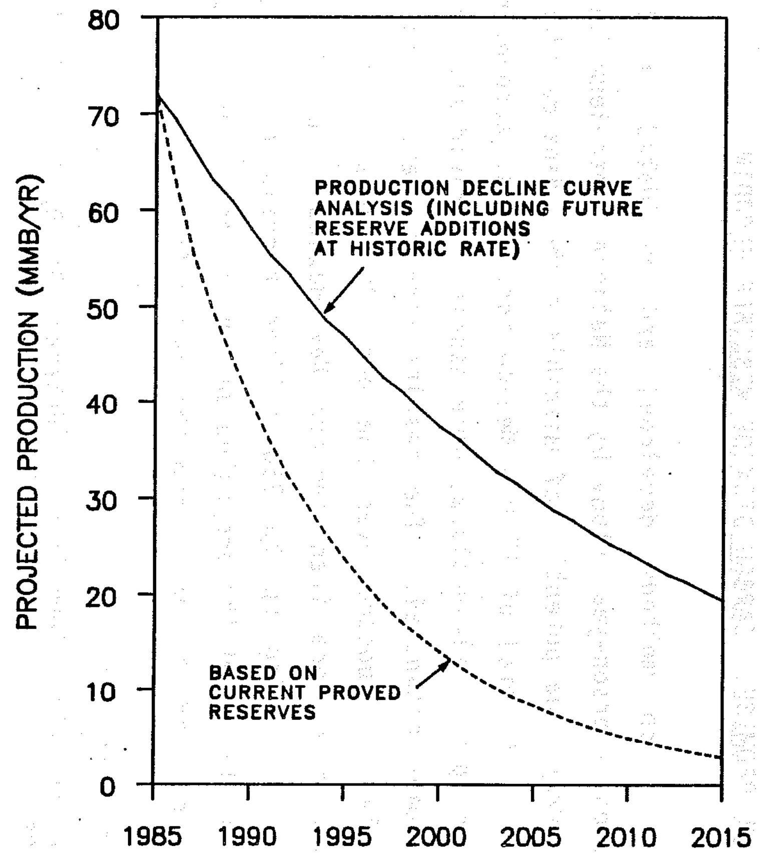
* National Petroleum Council, Enhanced Oil Recovery, Washington, D.C., 1984.

EXHIBIT I-1

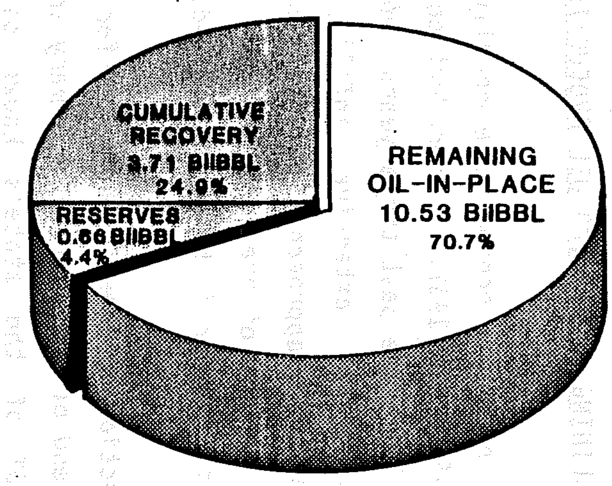
PROJECTED DECLINE IN NEW MEXICO CRUDE OIL PRODUCTION



SOURCES:API, 1980; EIA, 1985; LEWIN AND ASSOCIATES, INC., 1985

EXHIBIT I-2

DISTRIBUTION OF KNOWN OIL-IN-PLACE IN NEW MEXICO



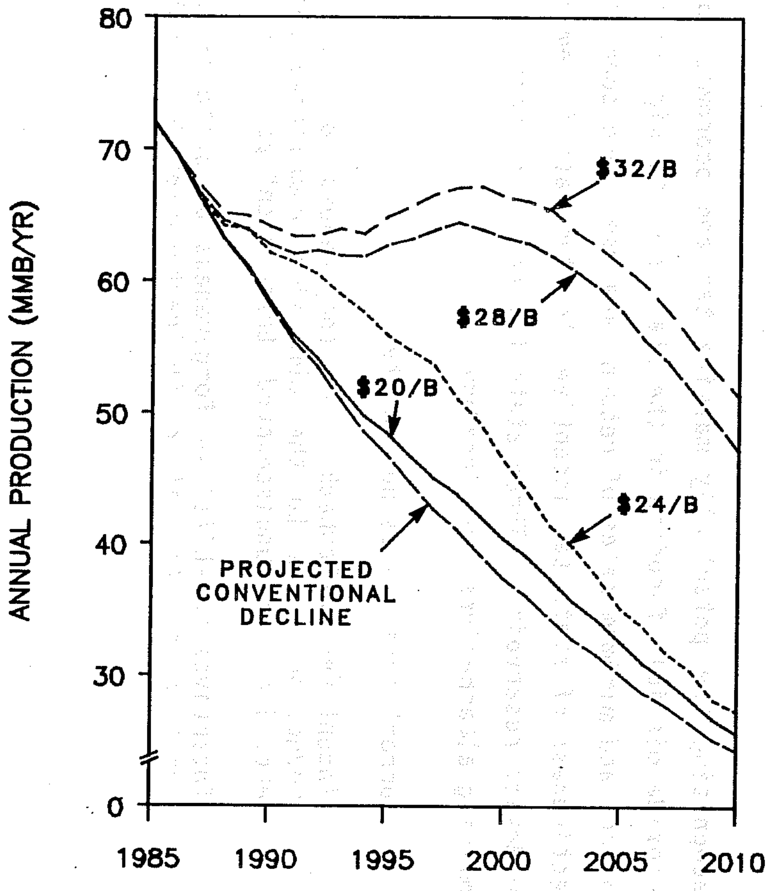
TOTAL ORIGINAL OIL-IN-PLACE
14.91 Billion Barrels

SOURCES: API 1980, EIA 1985.

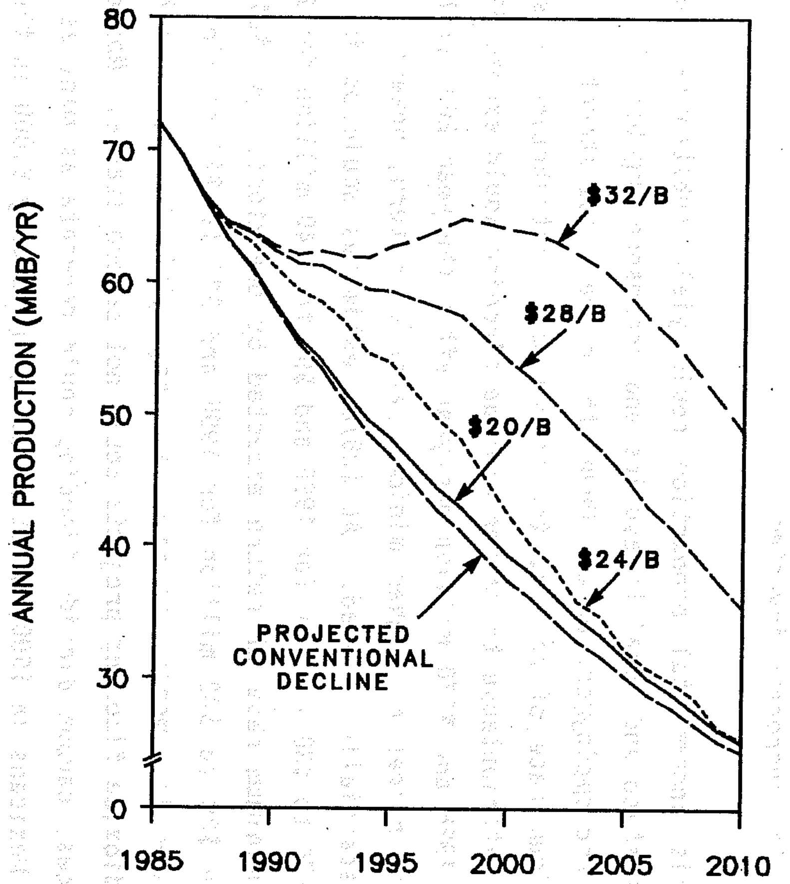
EXHIBIT I–3

ESTIMATED NEW MEXICO TOTAL PRODUCTION FOR CONVENTIONAL AND CARBON DIOXIDE FLOODING TECHNIQUES AS A FUNCTION OF OIL PRICE WITH CURRENT TAXES

A. 10% RATE OF RETURN



B. 15% RATE OF RETURN



SOURCE: IOCC AND LEWIN AND ASSOCIATES, INC., 1986

results also show, however, that the potential future production by carbon dioxide flooding is highly sensitive to oil price and minimum rate of return required for corporate investment.

This incremental production could yield substantial revenues to New Mexico's state and local treasuries and corresponding benefits to the state's economy and employment base.. Under the current tax structure, at $32/B and a 10% minimum rate of return, the incremental contribution to state and local revenues attributable to carbon dioxide flooding would exceed $100 million per year in 1995 and $170 million per year after the year 2000 (Exhibit I-4). At lower oil prices or higher minimum rates of return, however, these benefits are substantially reduced. At $28/B, estimates would be in the range from almost $70 to $80 million for 1995 and $94 to $140 million for 2000, depending on the minimum rate of return expected by operators. At $24/B, the ranges would be $28 to $42 million for 1995 and $22 to $43 million for 2000. At $20/B, the incremental revenues are negligible because at that price most carbon dioxide flooding projects would not be profitable. Moreover, at higher oil prices, carbon dioxide flooding could generate as many as 3,000 new jobs for New Mexicans in 1990, 5,500 in 1995, and nearly 8,000 in the year 2000.

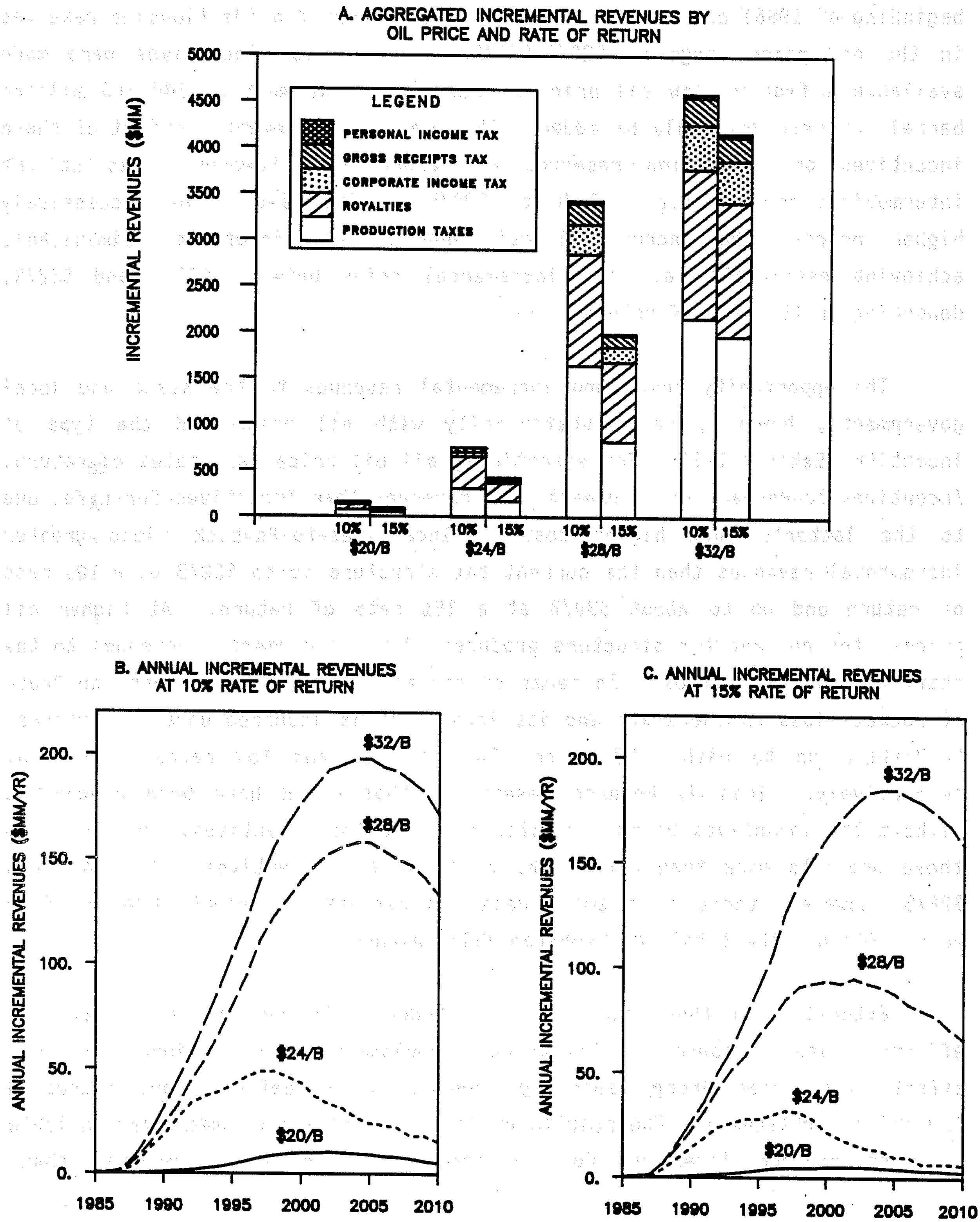
C. POTENTIAL FOR STATE INCENTIVES TO STIMULATE CARBON DIOXIDE FLOODING PROJECTS

Recognizing the potentially massive tax and economic contributions of carbon dioxide miscible flooding in the state and its significant sensitivity to oil prices and minimum rates of return, analyses were conducted to evaluate the effectiveness of state tax incentives to stimulate incremental production from New Mexico reservoirs. Three state tax cases, selected to "bracket" the more promising alternatives, were analyzed:

- Current taxes -- as now enacted;
- "Incentives-to-Payback" -- forgiveness of state income and production taxes to the time when cumulative cashflow exceeds zero, i.e., the undiscounted "break even" point; and
- "Incentives-for-Life" -- forgiveness of state income and production taxes for the life of the carbon dioxide flooding project.

EXHIBIT I–4

POTENTIAL NEW MEXICO STATE AND LOCAL REVENUES FROM CARBON DIOXIDE FLOODING UNDER CURRENT TAX STRUCTURE



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

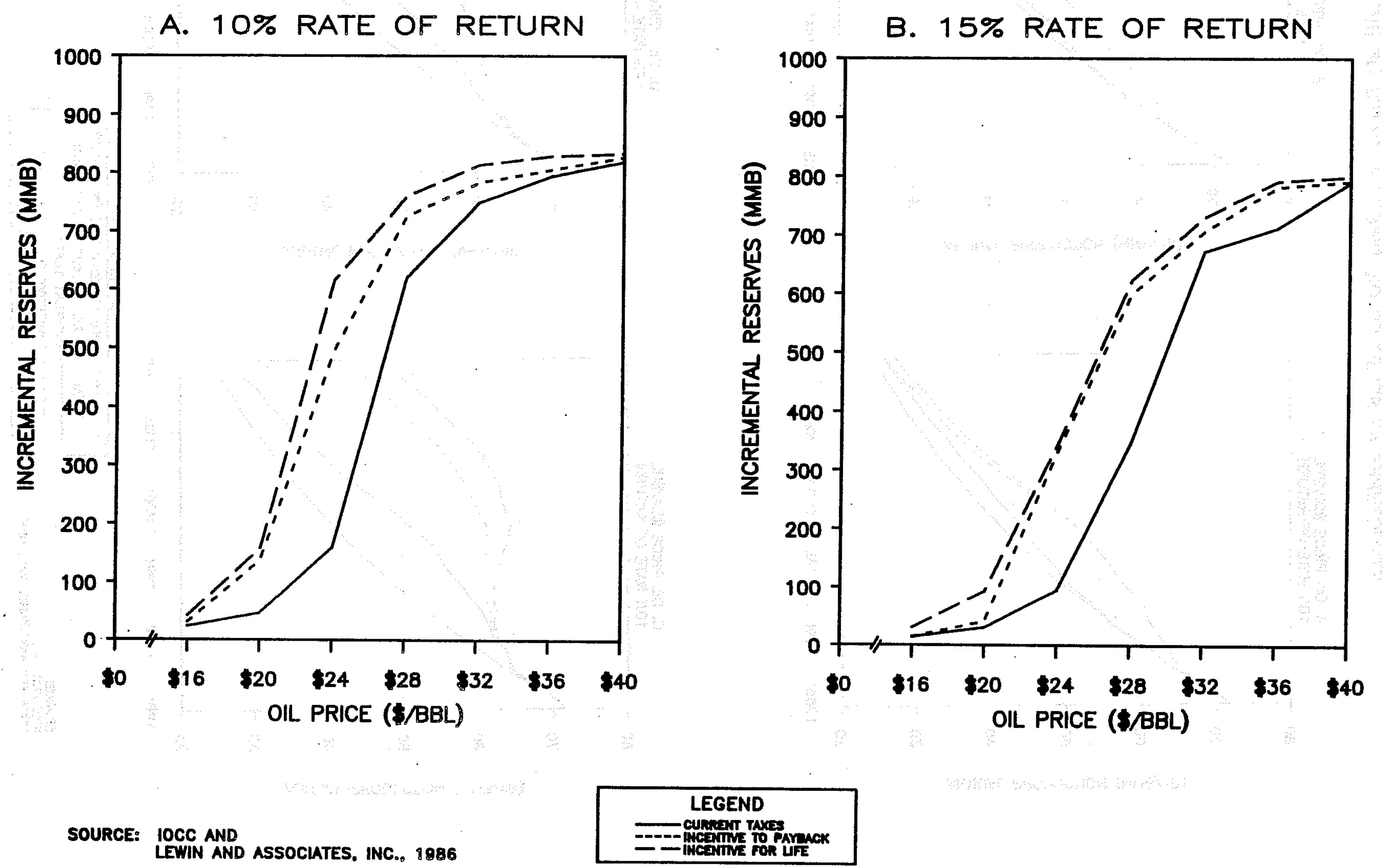
Application of the incentives can add major quantities of reserves in New Mexico even at prices as low as \$20/B-\$24/B (Exhibit I-5). Depending on the minimum acceptable rate of return the operators will apply, New Mexico's currently proved conventional reserves of 660 million barrels (as of the beginning of 1985) could be fully replaced by carbon dioxide flooding reserves in the oil price range of \$25/B-\$30/B, if state tax incentives were made available. Even at low oil prices, e.g., \$20/B, as much as 140-160 million barrels of reserves could be added. The greatest incremental effect of these incentives on increasing reserves and production, however, lies at the intermediate prices, e.g., \$24/B to \$28/B (Exhibit I-6). At successively higher prices, the incremental gain due to the incentives diminishes, achieving essentially all the incremental gains between \$28/B and \$32/B, depending on the rate of return.

The opportunity costs and incremental revenues to the state and local governments, however, vary substantially with oil price and the type of incentive (Exhibit I-7). For essentially all oil prices and rates of return, Incentives-to-Payback yield greater net revenues than Incentives-for-Life, due to the latter's much higher costs. Incentives-to-Payback yield greater incremental revenues than the current tax structure up to \$28/B at a 10% rate of return and up to about \$30/B at a 15% rate of return. At higher oil prices, the current tax structure produces higher incremental revenues to the state and its localities. In terms of annual incremental revenues, no "out-of-pocket" loss to the state and its localities is incurred under Incentives-to-Payback up to either \$28/B or \$30/B at 10% and 15% rates of return, respectively. This is because reservoirs that would have been uneconomic without the incentives become profitable due to the incentives; revenues from these projects more than offset the costs of the incentives. At \$24/B and \$28/B, however, there is a small delay in receipts of about three to five years although the totals are substantially higher.

Extensions of these analyses were conducted to consider state economic effects (direct economic activity and employment) and national economic effects (increased energy security, reduced trade deficits and increased federal tax revenues). The results of these analyses are summarized in Table I-1. As expected, Incentives-for-Life produce equal or greater benefits than

EXHIBIT I–5

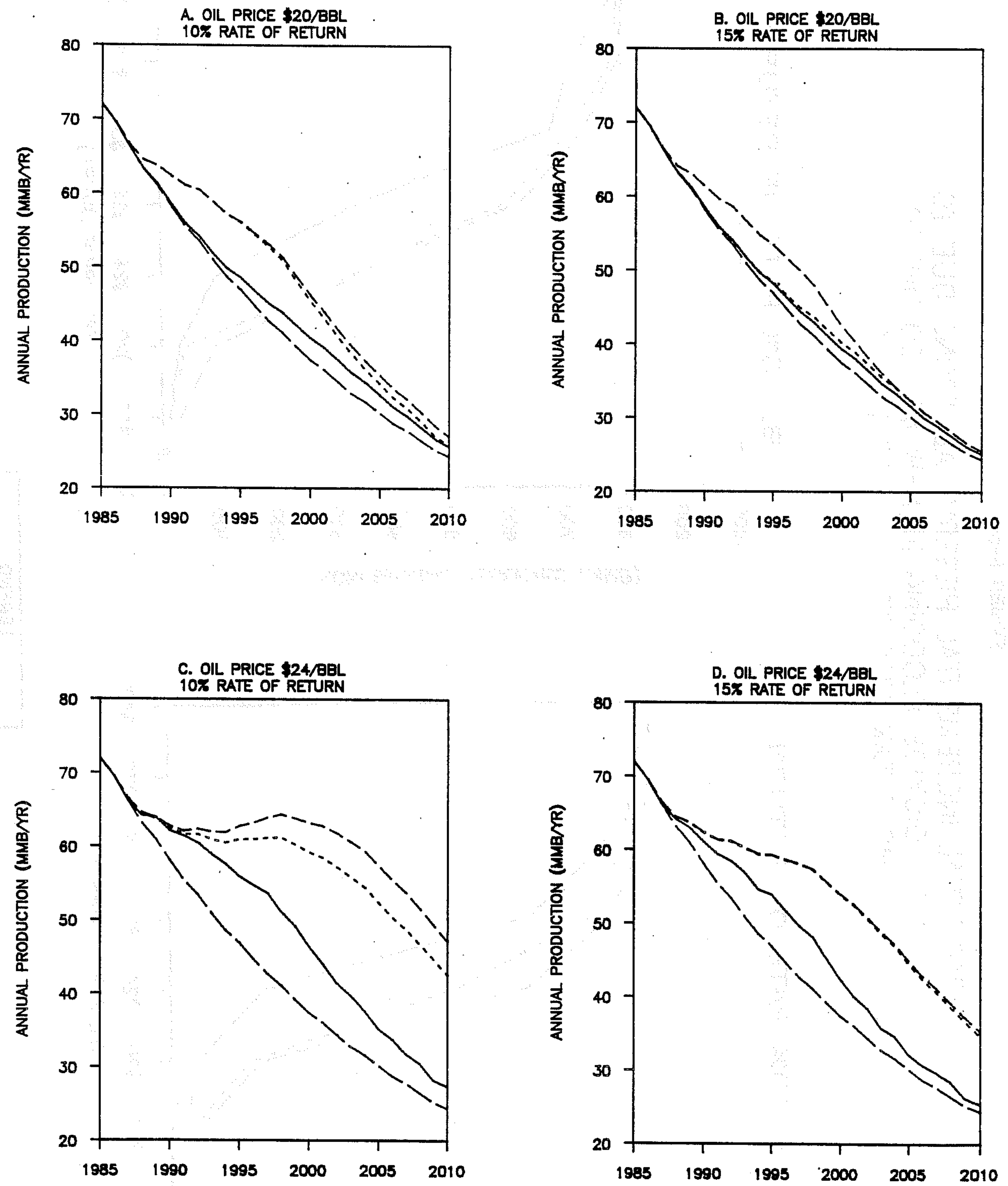
POTENTIAL INCREMENTAL RESERVE ADDITIONS DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO UNDER THREE TAX STRUCTURES BY OIL PRICE



SOURCE: IOCC AND LEWIN AND ASSOCIATES, INC., 1986

EXHIBIT I-6

POTENTIAL EFFECTS ON TOTAL PRODUCTION DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO FOR THREE TAX STRUCTURES AT SELECTED OIL PRICES & RATES OF RETURN



LEGEND

PROJECTED CONV. PRODUCTION

TOTAL PRODUCTION W/CO2, ASSUMING

CURRENT TAXES

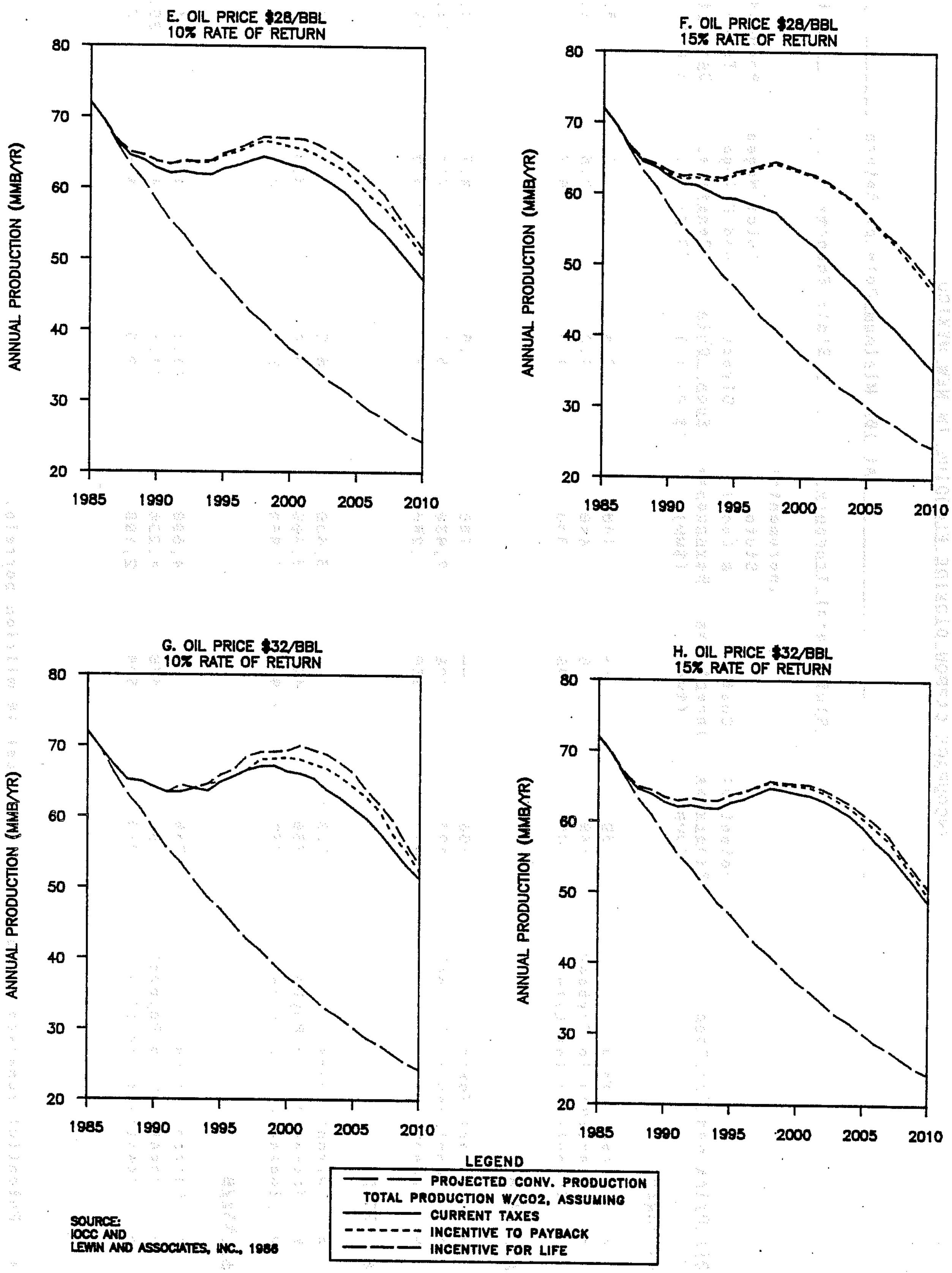
INCENTIVE TO PAYBACK

INCENTIVE FOR LIFE

SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

EXHIBIT I-6 (CONT.)

POTENTIAL EFFECTS ON TOTAL PRODUCTION DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO FOR THREE TAX STRUCTURES AT SELECTED OIL PRICES & RATES OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

TABLE I-1

SUMMARY OF TRADE-OFFS AMONG STATE TAX INCENTIVES TO ENCOURAGE CARBON DIOXIDE FLOODING IN NEW MEXICO

	At 10% Minimum Rate of Return						
		State/Local Treasury		State Economy		National Economy	
Oil Price and Tax Case	Potential Reserves* (MMB)	Cost of Incentives ($MM)	Incremental State & Local Revenues** ($MM)	Direct Econ. Gain ($ Bill.)	Total Wages and Fringe Benefits ($ Bill.)	Reduced Trade Deficit ($ Bill.)	Increased Federal Revenues ($ Bill.)
At $20/B							
• Current Taxes	50	--	160	0.4	0.2	0.9	0.1
• Incentives to Payback	140	10	440	1.0	0.6	2.7	0.2
• Incentives for Life	160	90	330	1.0	0.7	3.7	0.4
At $24/B							
• Current Taxes	160	--	760	1.5	0.7	3.8	0.4
• Incentives to Payback	490	100	2,030	5.9	2.4	12.7	1.4
• Incentives for Life	620	350	1,280	6.1	3.0	15.4	2.2
At $28/B							
• Current Taxes	620	--	3,430	8.5	3.2	18.4	2.3
• Incentives to Payback	730	420	3,400	9.4	3.9	21.3	2.8
• Incentives for Life	760	2,040	1,800	8.3	4.0	22.4	3.7
At $32/B							
• Current Taxes	750	--	4,590	11.1	4.1	24.9	3.4
• Incentives to Payback	780	470	4,230	11.1	4.4	25.9	3.7
• Incentives for Life	810	2,590	2,190	9.5	4.6	27.0	4.8

* Potential reserves rounded to the nearest 10 million barrels.

** Net state and local revenues rounded to nearest 10 million dollars.

TABLE I-1 (CONTINUED)

SUMMARY OF TRADE-OFFS AMONG STATE TAX INCENTIVES TO ENCOURAGE CARBON DIOXIDE FLOODING IN NEW MEXICO

	At 15% Minimum Rate of Return						
		State/Local Treasury		State Economy		National Economy	
Oil Price and Tax Case	Potential Reserves* (MMB)	Cost of Incentives ($MM)	Incremental State & Local Revenues** ($MM)	Direct Econ. Gain ($ Bill.)	Total Wages and Fringe Benefits ($ Bill.)	Reduced Trade Deficit ($ Bill.)	Increased Federal Revenues ($ Bill.)
At $20/B							
• Current Taxes	30	--	90	0.2	0.1	0.6	0.1
• Incentives to Payback	40	10	130	0.3	0.2	0.8	0.2
• Incentives for Life	90	60	200	0.5	0.4	1.8	0.2
At $24/B							
• Current Taxes	100	--	430	0.8	0.4	2.2	0.2
• Incentives to Payback	330	40	1,390	3.4	1.6	8.0	0.9
• Incentives for Life	340	200	860	3.0	1.6	8.3	1.2
At $28/B							
• Current Taxes	350	--	1,990	4.2	1.7	9.8	1.2
• Incentives to Payback	600	200	2,920	7.9	3.1	17.8	2.4
• Incentives for Life	620	840	1,540	6.9	3.2	18.5	3.1
At $32/B							
• Current Taxes	670	--	4,160	10.0	3.7	22.5	3.1
• Incentives to Payback	710	410	3,890	10.1	3.9	23.7	3.5
• Incentives for Life	730	2,250	1,930	8.4	4.0	24.4	4.5

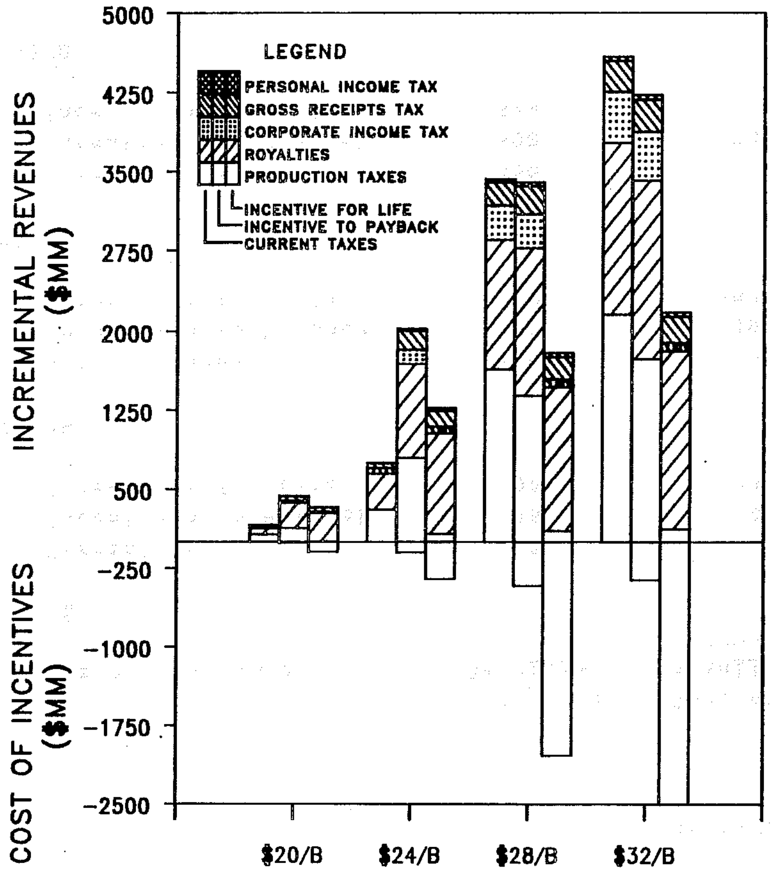
* Potential reserves rounded to the nearest 10 million barrels.

** Net state and local revenues rounded to nearest 10 million dollars.

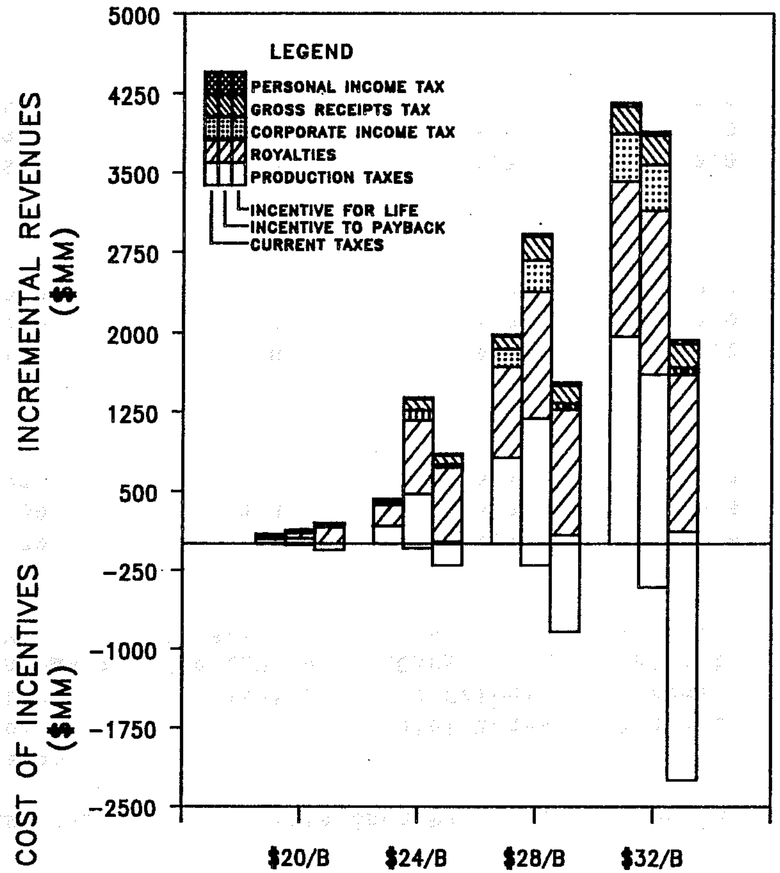
EXHIBIT I-7

POTENTIAL AGGREGATED INCREMENTAL REVENUE AND COST OF INCENTIVES TO STATE AND LOCAL TREASURIES FROM CARBON DIOXIDE FLOODING FOR THREE TAX STRUCTURES AT SELECTED OIL PRICES AND RATES OF RETURN

A. 10% RATE OF RETURN



B. 15% RATE OF RETURN



SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

either Incentives-to-Payback or the current tax structure in terms of increased reserves, New Mexico jobs, gross domestic product, and federal revenues. However, these gains are achieved only at significant costs to the state and local treasuries and, at prices above $28/B, with severe negative impacts on the state economy.

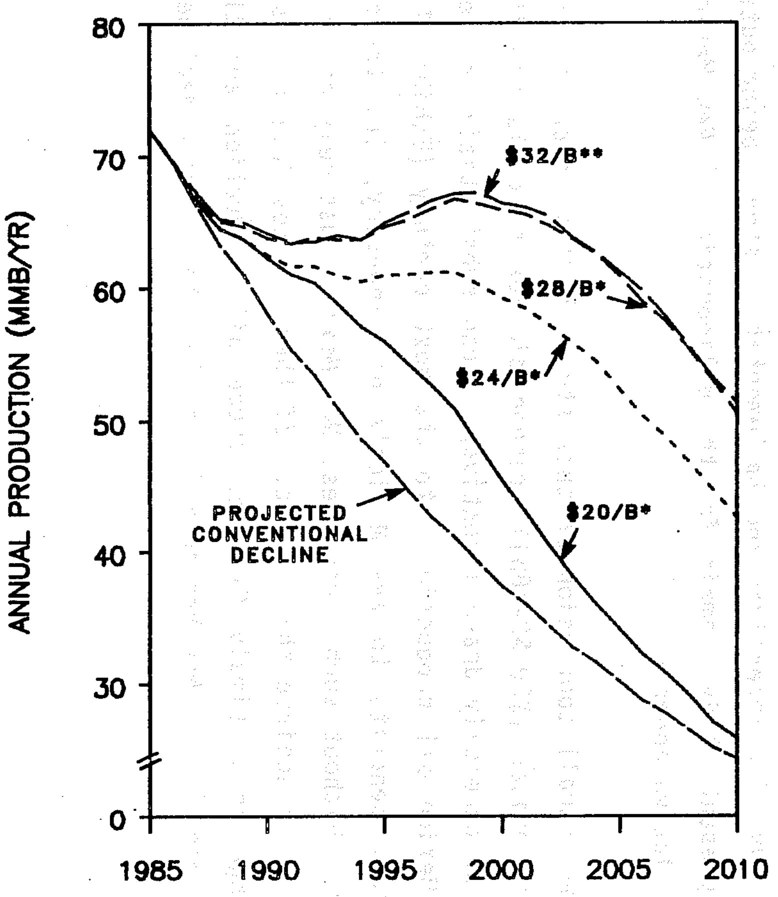
Based on these analyses, the present study concludes that: (1) at lower oil prices, state tax incentives are necessary to realize the potential of carbon dioxide miscible flooding in New Mexico; (2) state tax incentives will under no circumstances decrease total state and local revenues as the incentives, if properly designed, will always yield more incremental revenues than the revenues foregone (although some short-term shifts in timing may occur); (3) the incentives should phase out at higher oil prices, specifically at about $30/B; and (4) self-limiting incentives (e.g., to payback) will be more cost-effective than open-ended incentives. Incentives that are not capped at higher prices or are not self-limiting could be detrimental to the economic well-being of the state's economy and treasury, and especially so at higher oil prices. Because Incentives-to-Payback could impose undesirable, perhaps crippling, administrative burdens on operators and the state, a readily reported and verified "surrogate" indicator is suggested and analyzed. However, specific incentives and implementation steps, being outside the scope of the present study, remain for the deliberation of New Mexico's executive and legislative agencies.

The overall conclusion of this study is that, even with relatively low crude oil prices ($20-$24/Bbl), carbon dioxide miscible flooding -- in the context of carefully drawn incentives -- can substantially offset the decline in New Mexico oil production into the next century (Exhibit I-8), with the concomitant benefits to New Mexico's oil industry, its treasury, and its citizens. Without such incentives, New Mexico must rely on uncertain future oil prices to achieve this result. If these prices fail to rise to the $28-32/B range in a timely fashion, crude oil production and the associated economic benefits to New Mexico will continue their rapid decline.

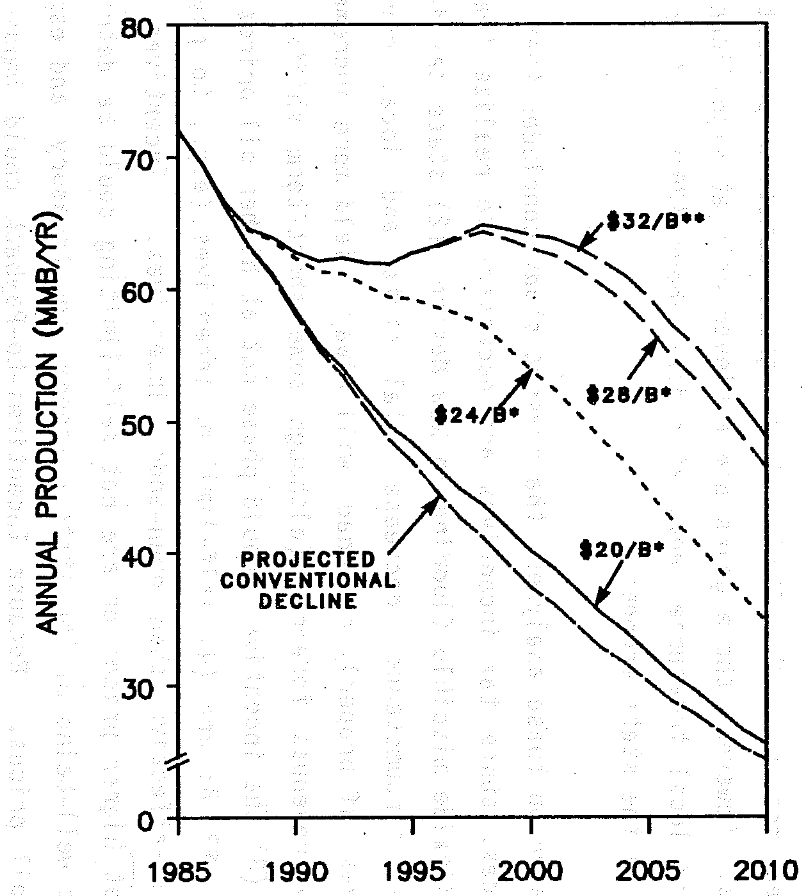
EXHIBIT I-8

ESTIMATED NEW MEXICO TOTAL PRODUCTION FOR CONVENTIONAL AND CARBON DIOXIDE FLOODING TECHNIQUES AS A FUNCTION OF OIL PRICE WITH INCENTIVES TO PAYBACK* AND AT $32/B WITHOUT INCENTIVES**

A. 10% RATE OF RETURN



B. 15% RATE OF RETURN



SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

II. BACKGROUND AND OBJECTIVES

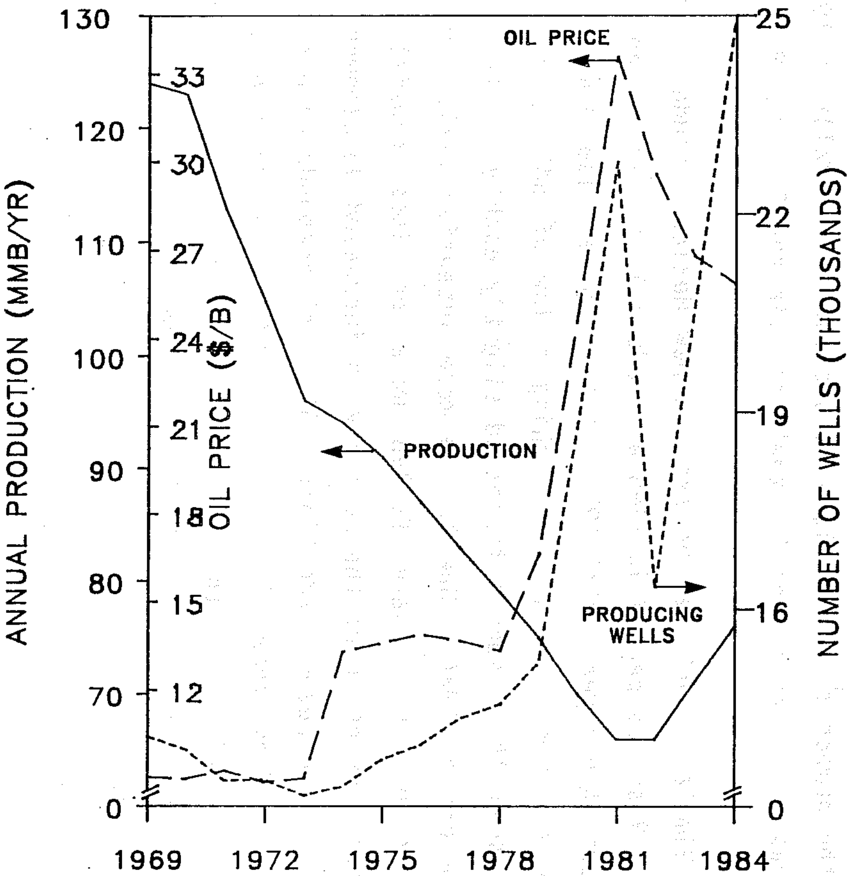
A. DECLINE IN NEW MEXICO OIL PRODUCTION AND RESERVES

Oil production in New Mexico peaked in 1969, when 123.7 million barrels were produced. After that date, it declined at an average rate of 4.7 percent per year until its lowest production of 66.1 million barrels in 1982 (Exhibit II-1). Due to more intensive field development (infill drilling and water flooding), production increased slightly over the next two years, to 75.5 million barrels in 1984, about its 1979 level. This increase is due largely to the unitization of the Hobbs Field, which was negotiated when prices were still high. Thus, the long-term decline occurred despite two major price increases, while the latest production upturn coincided with the most significant price decrease in recent history. Although production does not appear to respond directly to price, the number of wells does, at least through the 1981 price peak and subsequent decline in 1982. In 1984 and 1985, however, the number of wells returned to its earlier maximum (indicating infill drilling), with an accompanying rise in production. It is anticipated that the number of new wells will decline dramatically in 1986 in response to the drastic oil price decline that began in the fall of 1985.

Similar trends can be seen in New Mexico's crude oil reserves (Exhibit II-2). Reserves peaked in 1966 at 1,025 million barrels and declined steadily at about 9% per year until 1972. After a brief rise, the decline continued at nearly the same rate until reaching a low of 547 million barrels in 1980, after which the reserves increased slightly each year, to 660 million barrels at the end of 1984. Due to the more intensive field development, however, reserves per well have fallen more or less consistently since 1973. Additional evidence of the reliance on increased development intensity is the nature of the reserve additions. The vast preponderance of reserve additions have been from known fields. In 1984, total reserve additions were 156 million barrels. Of this, two million barrels (1.3%) were in new fields, while 154 million barrels (98.7%) were from net revisions, extensions, and new pools in known fields.

EXHIBIT II-1

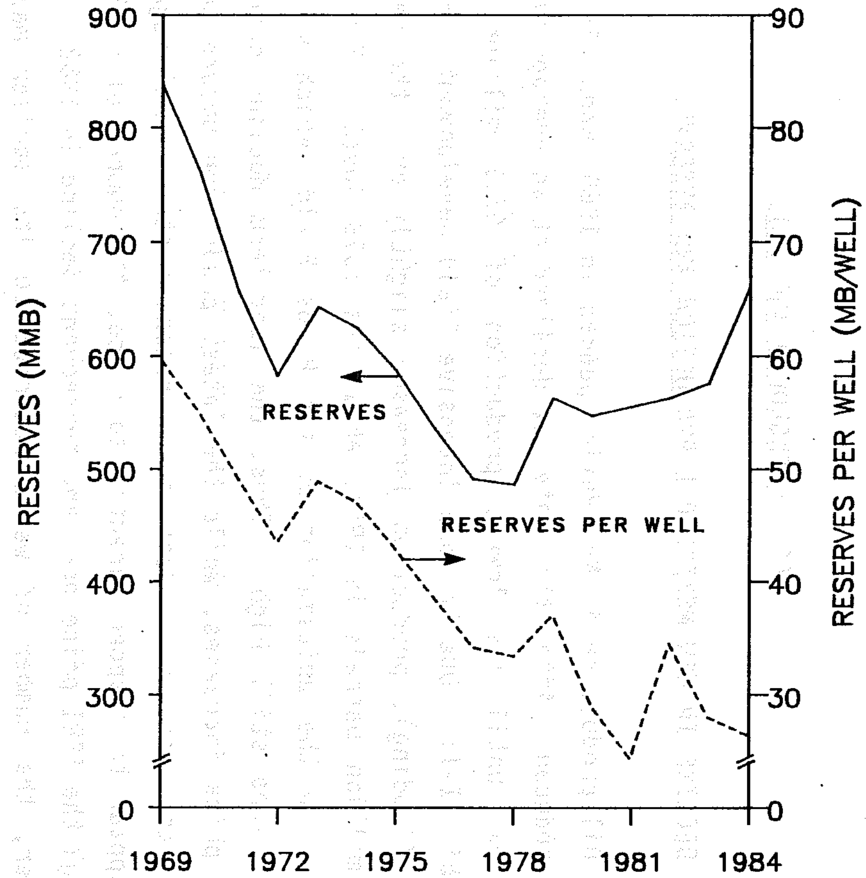
NEW MEXICO CRUDE OIL PRODUCTION, OIL PRICE, AND NUMBER OF OIL WELLS



SOURCES: NEW MEXICO ENERGY AND MINERALS DEPT., 1984; IOCC, 1984; IPAA, 1975–1985; DOI, 1969–1974

EXHIBIT II-2

NEW MEXICO CRUDE OIL RESERVES AND RESERVES PER WELL



SOURCES: API, 1970–1980, EIA, 1980–1985. NEW MEXICO ENERGY AND MINERALS DEPT., 1985.

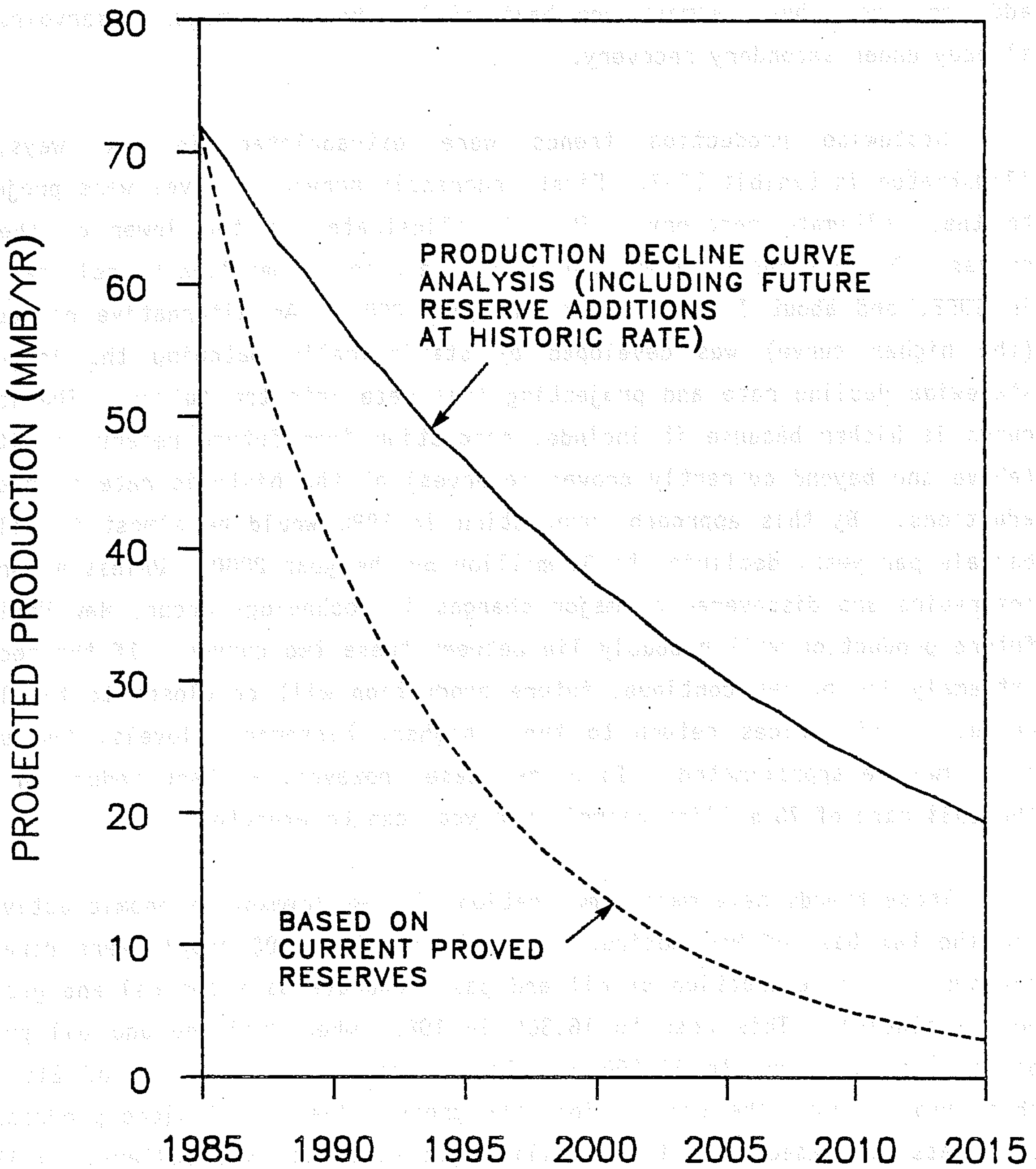
All these trends reveal the advanced maturity of New Mexico's resource base. While continued infill drilling and secondary recovery may sustain New Mexico's reserves temporarily, these developments are limited by the number of opportunities available. Further, although infill drilling adds some new reserves, it also depletes existing reserves more rapidly. Secondary recovery adds reserves, but almost one half of New Mexico's major reservoirs are already under secondary recovery.

Statewide production trends were extrapolated in two ways, as illustrated in Exhibit II-3. First, currently proved reserves were projected to their ultimate recovery. This is illustrated in the lower of the two curves. On this basis, production would be about 24 million barrels per year in 1995, and about 14 million in the year 2000. An alternative projection (the higher curve) was developed by statistically matching the long-term statewide decline rate and projecting this rate into the future. The latter curve is higher because it includes production from future reserve additions (above and beyond currently proved reserves) at the historic rate of reserve additions. By this approach, production in 1995 would be almost 47 million barrels per year, declining to 36 million by the year 2000. Unless major new reservoirs are discovered or major changes in technology occur, New Mexico's future production will probably lie between these two curves. If the recent, extremely low prices continue, future production will be closer to the lower curve; if oil prices return to their higher, historical levels, the upper curve may be approximated. In either case, however, a sharp reduction from the 1984 rate of 76 million barrels per year can be expected.

These trends have major implications for employment, economic activity, and the tax base of New Mexico. In 1975, nearly 8,900 people were directly employed in the extraction of oil and gas (separate data for oil and gas are not available). This rose to 16,300 in 1981, when drilling and oil prices peaked, and declined to 13,500 in 1984 (Exhibit II-4), a drop of 21% over three years. Over the same period, the gross value of oil alone produced in the state increased from $1.33 billion (in constant 1984 dollars) in 1975, peaked at $2.48 billion in 1981, and declined 18.5% to $2.02 billion in 1984. Severance and other production taxes on crude oil, which are based on the value of production, increased from $96.0 million in 1975 to a peak of $179.7

EXHIBIT II-3

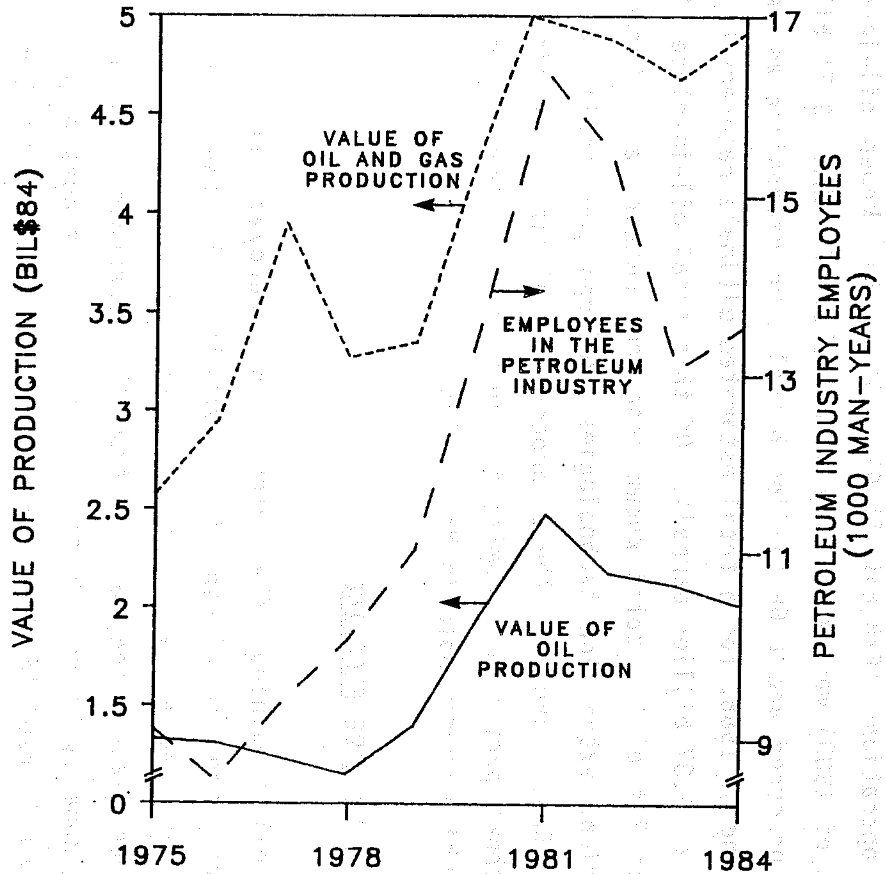
PROJECTED DECLINE IN NEW MEXICO CRUDE OIL PRODUCTION



SOURCES:API, 1980; EIA, 1985; LEWIN AND ASSOCIATES, INC., 1985

EXHIBIT II-4

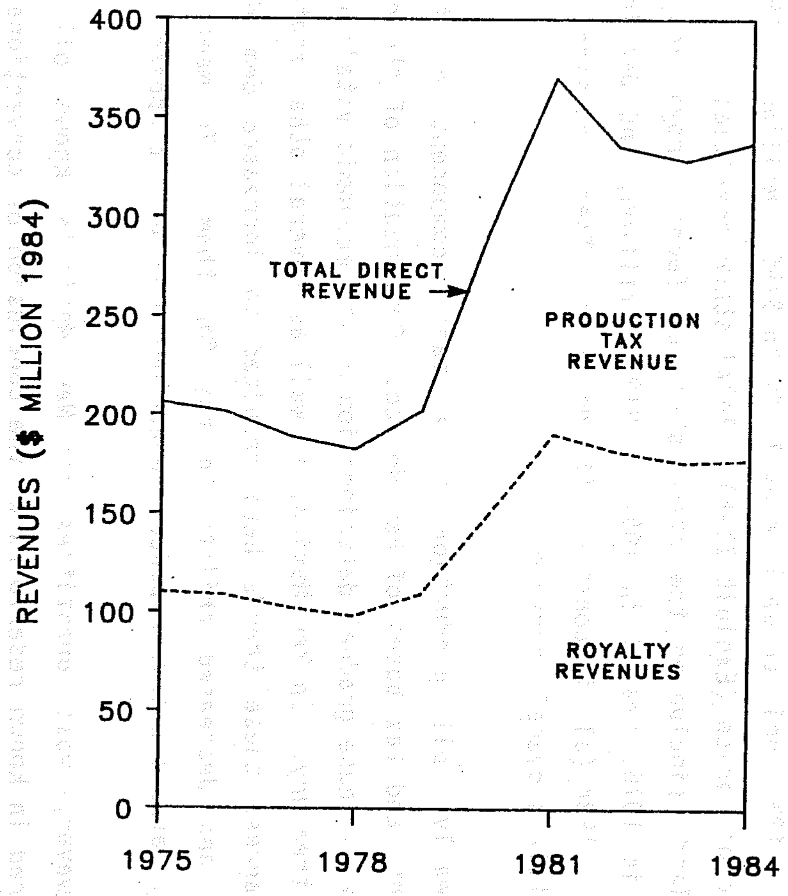
TOTAL VALUE OF PETROLEUM PRODUCTION AND PETROLEUM INDUSTRY EMPLOYMENT IN NEW MEXICO



SOURCE: IPAA, 1976-1985.

EXHIBIT II-5

DIRECT REVENUES TO THE STATE FROM ROYALTIES AND PRODUCTION TAXES ON CRUDE OIL



SOURCE: NEW MEXICO ENERGY AND MINERALS DEPT., 1985.

million in 1981, only to decline by 11.2% to $159.5 million in 1984 due to the decreased oil price (Exhibit II-5). Total state royalties from production on public lands (including the state share of federal royalties) were $110.2 million in 1975, peaked in 1981 at $190.3 million, and declined to $177.3 million in 1984 (all in constant 1984 dollars). These are significant factors in the state's overall revenues.

Clearly, oil production is a major component of the economic, employment, and tax bases of New Mexico. Continuation of the oil production decline will cause gradual deterioration of the economic vitality of the state and its treasury. In New Mexico, as well as several other states in similar circumstances, these trends have resulted in increased demands for public services and decreased ability to pay for them. To meet these needs, emergency taxes and severe budget reductions have been proposed.

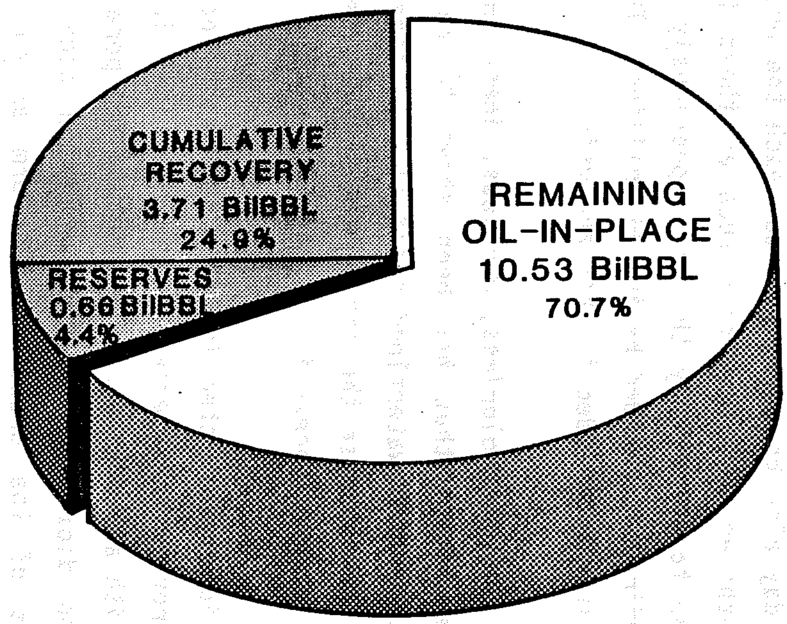
However, vast quantities of New Mexico's known oil will remain unrecovered in known reservoirs at the conclusion of conventional primary and secondary operations (Exhibit II-6). The total known oil-in-place in New Mexico (as of 1980) was 14.91 billion barrels. Of this, 3.71 billion barrels have been produced and 0.66 billion barrels are recognized as reserves as of the beginning of 1985, for a total estimated ultimate recovery by conventional technology of 4.37 billion barrels. Of this total oil-in-place, 10.53 billion barrels, or 71% of the total known resource, remains as a target for newer, more efficient extraction technologies, defined generically as enhanced oil recovery (EOR). One of these processes, miscible flooding with carbon dioxide, shows particular promise for increasing recovery from reservoirs of the types which predominate in New Mexico.

B. CARBON DIOXIDE FLOODING

The oil remaining after conventional recovery lies in two types of regions (or "zones") within the reservoir. In the first, conventional operations have moved (or "swept") a significant portion of the original concentration (saturation) of oil from the reservoir. The oil remaining in this swept zone is trapped in the reservoir pore spaces or on the surface of the pores due to capillary and surface tension forces. Additional flooding by

EXHIBIT II-6

DISTRIBUTION OF KNOWN OIL-IN-PLACE IN NEW MEXICO



TOTAL
ORIGINAL OIL-IN-PLACE
14.91 Billion Barrels

SOURCES: API 1980, EIA 1985.

water can produce very little of this oil, so it is said to be at the "waterflood residual" level of saturation. The volume previously occupied by displaced oil is, at this point, occupied by the injected water (or, occasionally, natural gas). In the other zone of the reservoir, conventional recovery processes have not swept the pore space, so the oil saturation can approximate its original level. The objective of many infill drilling, waterflooding, and other reservoir management techniques is to reach the oil in these unswept zones. Continued development drilling and reservoir management will continue to improve sweep within the reservoir. Enhanced oil recovery may one day also be engineered to reach the unswept zone, but in its current state-of-the-art in reservoirs such as those in New Mexico, EOR is generally expected to reach only the zones previously swept by conventional techniques, including those added by infill drilling. Thus, the EOR potential in unswept zones is not included in this analysis.

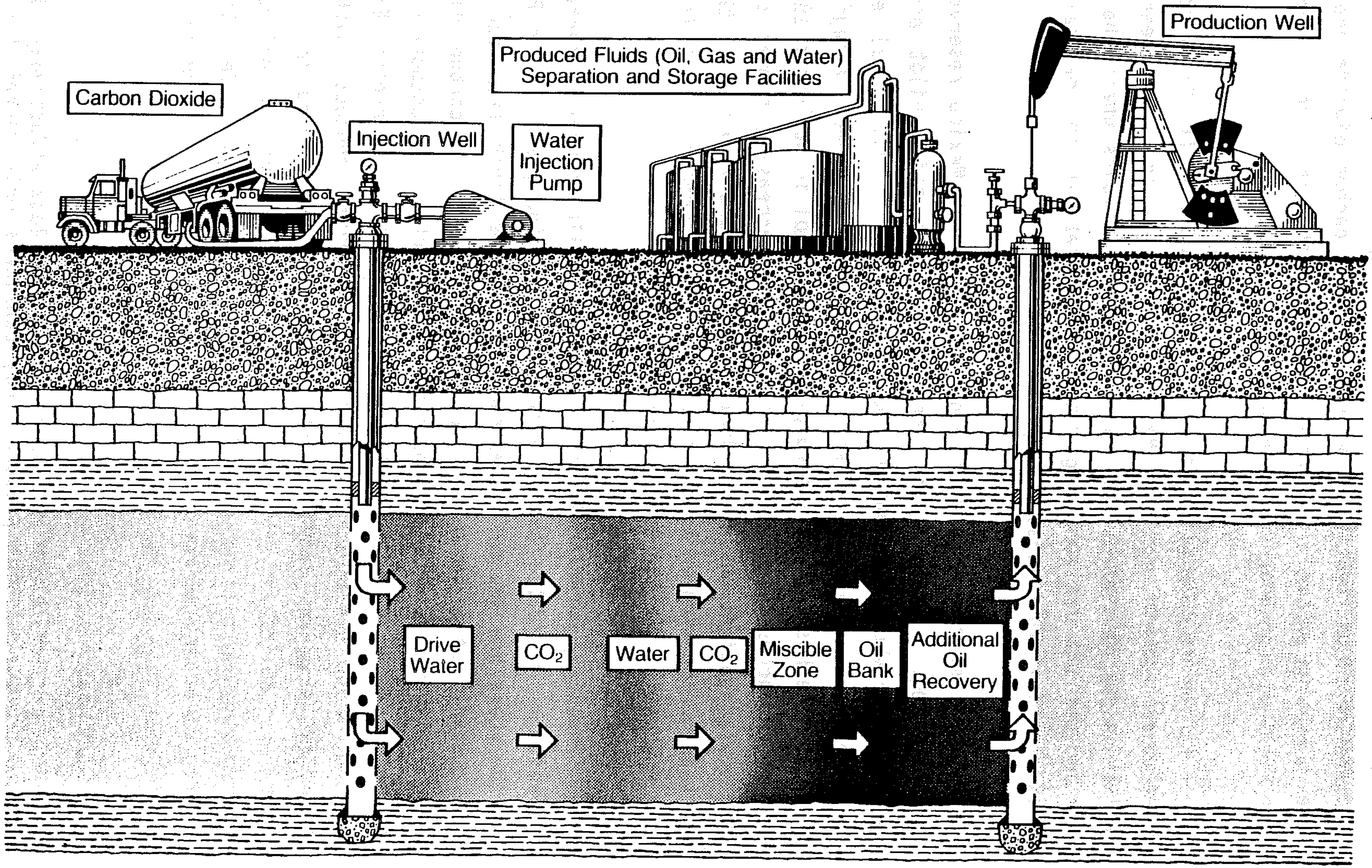
Carbon dioxide is a colorless, odorless, inert gas (used, for example, in carbonated beverages) that has been shown to be highly effective in displacing and mobilizing waterflood residual oil, especially if injected at pressure high enough to cause the carbon dioxide and components of the oil to mix and stay mixed. The process is illustrated in Exhibit II-7.

Carbon dioxide is injected into the reservoir rock, where it generally flows into the previously waterswept zones. There, it displaces the mobile water and mixes with and swells the oil left in the pore space. With repeated contact of carbon dioxide and oil, the carbon dioxide extracts the more volatile portions of the crude oil to form an enriched carbon dioxide-hydrocarbon mixture. This mixture then displaces most of the oil it contacts, leaving behind a very small quantity of tar-like residue.

Because carbon dioxide has low viscosity relative to crude oil, it tends to preferentially sweep through the more permeable parts of the reservoir. To minimize this effect, water is often injected in alternating "slugs" with the carbon dioxide to increase the portion of the previously waterswept zone that is also swept by carbon dioxide. Other materials, e.g., surfactant foams, are under development to sweep larger portions of the reservoir. The combination of swelling, mixing, and sweep can effectively contact, mobilize, and recover

EXHIBIT II-7

SCHEMATIC REPRESENTATION OF CARBON DIOXIDE MISCIBLE FLOODING



SOURCE: NPC, 1984

a significant portion of the oil remaining in the reservoir. As carbon dioxide injection continues, water, oil, and carbon dioxide are recovered at the producing wells. In larger projects, the recovered carbon dioxide is purified, repressured, and reinjected.

Carbon dioxide flooding is the most promising EOR technique for use in reservoirs such as those in New Mexico. The process has been shown to be effective in both sandstone and carbonate reservoirs where the oil is light enough and the pressure high enough to establish and maintain the carbon dioxide-oil mixture (miscibility).*

Interest in applying carbon dioxide to New Mexico reservoirs has been demonstrated. CONOCO, Inc., has conducted a major pilot project in the Maljamar Grayburg-San Andres pool since 1981. Its final evaluation is expected in the next year or so. Phillips Petroleum began a major field-scale flood in the East Vacuum Grayburg-San Andres pool in September 1985. A number of other successful pilot projects and an increasing number of full field scale applications of carbon dioxide flooding are underway in the West Texas portion of the Permian Basin in reservoirs with properties similar to those in the New Mexico portion of the same basin.

Three major trunk pipelines have been built to provide carbon dioxide to these major projects, one of which is delivering gas from the Bravo Dome in northeastern New Mexico. Combined, these three trunk lines can supply up to 2.5 billion standard cubic feet (Bcf) per day of carbon dioxide. Two significant branch pipelines have been constructed to transport carbon dioxide from these trunk lines to Southeastern New Mexico's reservoirs (Exhibit II-8). One of these branches, the 12-inch Llano line, connects with the Cortez Pipeline, a major trunk line which traverses New Mexico in a northwest to southeast direction. The Cortez Line has an overall delivery capacity approaching one billion cubic feet per day of carbon dioxide. The Llano line is currently delivering a portion of that capacity to serve the East Vacuum project.

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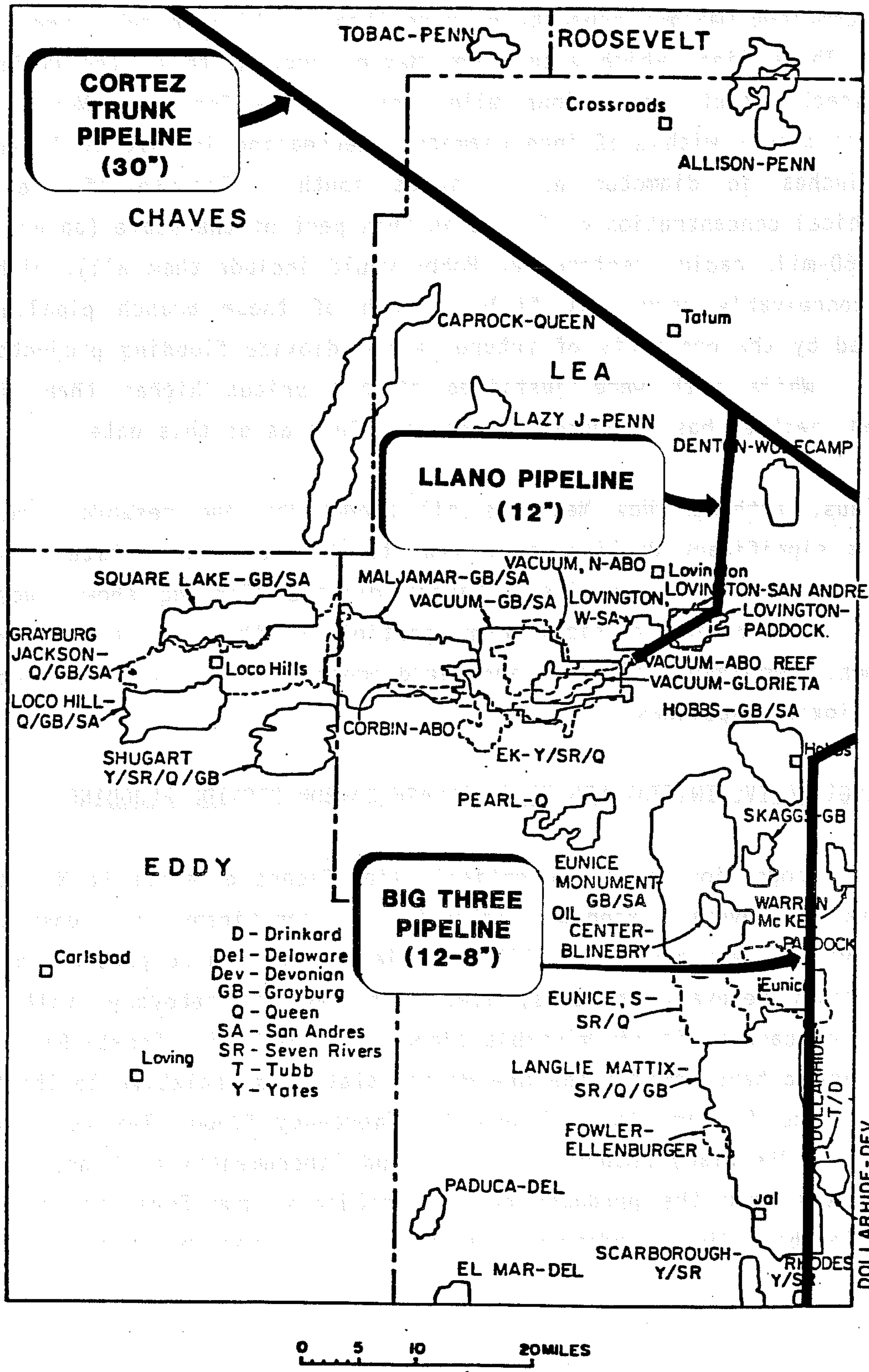
* Carbon dioxide can also be used, although less effectively, in its immiscible state. The present study considers only carbon dioxide miscible flooding.

EXHIBIT II-8

TRUNK AND BRANCH CARBON DIOXIDE PIPELINES IN SOUTHEASTERN NEW MEXICO



The second branch pipeline, the Big Three Pipeline, originates at Denver City, Texas, where the other two major trunk lines, the Sheep Mountain Pipeline and Bravo Pipeline, terminate. The Bravo and Sheep Mountain lines have a combined maximum capacity of more than 1.5 billion cubic feet per day. The Big Three line, which enters New Mexico just north of the Hobbs Field, runs directly south about four miles west of the Texas-New Mexico border. This line starts with a 12-inch diameter, decreasing in size to 10 and later to 8 inches in diameter as it moves south. Because of the intense geographical concentration of fields in this part of the state (an arc of less than a 60-mile radius centered at Hobbs would include them all), either line could conceivably serve any field. Both of these branch pipelines were justified by the prospects of future carbon dioxide flooding projects in New Mexico. While both were justified at oil prices higher than presently received, neither has announced changes in plans as of this date.

Thus, although New Mexico's oil production and reserves are moving toward a significant decline, more than two-thirds of the state's known oil will remain in its reservoirs. Carbon dioxide flooding shows substantial promise of producing a significant portion of this oil as evidenced by investment commitments in pilot and field projects and in the construction of carbon dioxide pipelines.

C. LEGISLATIVE INITIATIVES TO ENCOURAGE CARBON DIOXIDE FLOODING

In recognition of the potentially significant benefits to New Mexico's tax base and overall economic activity, a significant, but unsuccessful, initiative was launched in the 1985 legislative session to provide incentives for tertiary recovery projects, i.e., enhanced oil recovery, with special emphasis on carbon dioxide miscible flooding. New Mexico Senate Bill 207, if passed, would have amended the New Mexico state code relative to the Oil and Gas Severance Tax and the Oil and Gas Emergency School Tax to define the concepts of "tertiary recovery project" and "incremental oil" and to exempt the revenues from the products of such projects from Severance and School Taxes. The bill did not address conservation or ad valorem taxes.

The original bill exempted the "total gross" value of incremental oil produced for a period of 12 years from the start date of the injection phase of a tertiary production project. It was amended to strike the 12 year grace period in favor of exempting a declining percentage of the value of incremental oil based on the price of West Texas Intermediate crude oil, and then amended again in favor of exempting the value of all incremental production until the point of "payback," full recovery of investment and operating costs.

The bill, as amended, was debated extensively but died on the floor of the legislature on the last day of the 1985 legislative session. Its proponents were expected to introduce a similar bill in 1986, but with severely depressed oil prices the measure was deemed untimely. It is anticipated that the measure will be reintroduced once oil prices have stabilized.

D. OBJECTIVES OF THE PRESENT STUDY

The present study is part of a larger effort, the Interstate Oil Compact Commission's Project on Enhanced Oil Recovery and the States, the objective of which is to estimate the impact on state revenues and economic activity of the application of enhanced oil recovery as a function of oil price, EOR technology, and state initiatives. The scope of the present assessment is to estimate the potential in New Mexico of miscible carbon dioxide flooding (a subset of all EOR) at its current state of technological development by assessing a number of oil prices and applying a limited set of financial incentives that the state might make available. For each of several oil prices, anticipated potential incremental production, reserves, and impacts on state revenues and economic activity are estimated. The crude oil prices considered range from $16 to $40 per barrel (in constant 1985 dollars).* These were selected to encompass the long-term prices likely to be experienced

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* All references to oil prices in this and later chapters are stated, by convention, in 1985 dollar terms. The analysis was actually conducted in 1983 dollars to be consistent with the cost data. The estimated dollar quantities, e.g., net revenues to the state, etc., are reported in 1983 dollars consistent with the analysis.

over the period being projected. While lower prices may be experienced in the very near term due to contemporary international oil price adjustments, it is believed that the above prices provide adequate range to incorporate the most likely prices for the 25-year period (1986-2010) for which the study makes projections. These price cases were evaluated at two "real" (i.e., before the effects of inflation) minimum rates of return, 10 and 15 percent, which are believed to "bracket" the range of investment "hurdle rates" applied by most potential operators of carbon dioxide flooding projects.

These cases were evaluated under the current tax structure and two state incentives: (1) forgiveness of state production taxes and state corporate income taxes for the life of the project and (2) forgiveness of these taxes until "payback," the point in time at which the project's undiscounted cumulative after-tax cashflow exceeds zero (i.e., breaks even), given all cash outlays and revenues. These incentives are believed to include the most practical choices facing New Mexico's executive and legislative agencies well enough to provide useful guidance as to the costs and benefits of more specific proposals.*

Estimates of the impact of alternative oil prices and state incentives are expressed in terms of positive and negative consequences for the state treasury. Impacts on the state and national economies and federal taxes (under law existing at the time of the analysis, i.e., prior to the tax revisions of Fall 1986) are also projected. The projections are not forecasts; they represent what reasonably could happen, but do not presume to predict what will happen. Even with this caveat, the results of the present study should enlighten the debate on incentives for carbon dioxide EOR in New Mexico.

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* A separate product of the present study is a series of detailed cashflow analyses of typical reservoirs that permit more fine-grained analysis of particular incentives. These were provided directly to the appropriate New Mexico state officials.

III. APPROACH TO THE ANALYSIS

A. GENERAL METHODOLOGY: THE NPC BASIS

In March 1982, the U.S. Secretary of Energy requested that the National Petroleum Council (NPC) prepare a report* on the nationwide potential and economics of incremental enhanced oil recovery. The NPC, the official petroleum industry advisory committee to the Secretary, is composed of members, including many chief executive officers, who represent all segments of petroleum interests: production, refining, marketing, and environmental protection. Members are appointed by the Secretary. The NPC is supported entirely by voluntary contributions of its members.

In response to the Secretary's request, the NPC mounted a two-year effort that consumed more than 50 professional person-years and nearly $7 million of in-kind services. EOR experts from industry (majors, independents, service, and consulting companies), universities, government, and private non-profit organizations participated. The NPC EOR study committee utilized and built upon data bases of individual reservoir characteristics and computer models then under development by the U.S. Department of Energy, Office of Fossil Energy (Bartlesville Project Office). After augmentation, adaptation, and validation, the data bases and models were returned to the Bartlesville Project Office (BPO) for maintenance, updating, and subsequent application. Collectively, these data bases and models are referred to as the Tertiary Oil Recovery Information System (TORIS).

By agreement with the Assistant Secretary for Fossil Energy, the present study enjoys access to TORIS and the assistance of BPO, although its participation is strictly limited to the data base, models, and assistance in technical analysis. Neither the BPO nor the U.S. DOE has contributed to nor endorses the interpretations presented in this report.

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* National Petroleum Council, <u>Enhanced Oil Recovery</u>, 1984.

The approach used by the NPC and in the present study consists of the following major phases:

1. <u>Reservoir Data</u>. Detailed data describing the properties of the individual major oil reservoirs were compiled. Numerous public and private sources of information were consulted to complete and validate the reservoir data base. The principal elements of the TORIS data base are displayed in Exhibit III-1. Each reservoir was reviewed for consistency and accuracy by representatives of the operating companies at least three times and automated validity checks were performed on the entire data base. Additional review and editing of both the existing NPC and newly added New Mexico reservoir data were conducted for the present study by the study participants.

2. <u>Resource Screening Models</u>. Each reservoir was subjected to a screening process designed to identify technical applicability of the respective EOR processes. For carbon dioxide flooding, the criteria were that the oil gravity be greater than 25° API, that the reservoir be capable of reaching minimum miscibility pressure, and that there be no known major gas caps, major faults, or major fracture systems which would impede the effectiveness of the carbon dioxide flood.

3. <u>Process Performance Models</u>. Each reservoir that satisfied the technical criteria was then analyzed by a detailed process performance model.* The models for each process had been previously reviewed in detail and calibrated to actual field results. This calibration was reviewed and tested by the NPC study committees. It was necessary to model accurately the demonstrated performance of several fields where pilot or

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* The NPC study evaluted EOR potential using a series of models specific for polymer, alkaline, micellar-polymer, CO_2 miscible, steam, and combustion floods. This study only evaluated CO_2 miscible floods in applicable reservoirs. Documentation of these models is available in the NPC (1984) report.

EXHIBIT III-1

KEY ELEMENTS IN TORIS RESERVOIR DATA BASE*

• ORIGINAL VOLUMETRICS

--Original Oil-in-Place
--Reservoir area
--Net thickness
--Porosity
--Initial water saturation
--Initial oil saturation
--Initial formation volume factor

• CURRENT VOLUMETRICS

--Current oil satruration (swept zone)
--Current formation volume factor

• FLUID DATA

--Oil gravity & viscosity
--Connate waster viscosity
--Connate water salinity
--Initial GOR
--Current GOR
--Injection water salinity
--Crude oil fractions & properties (being added)

• GEOLOGIC VARIABLES

--Lithology
--Depth
--Temperature
--Original and Current pressure
--Permeability
--Permeability variation index
--Clay content
--Gross thickness
--Dip angle
--Geologic age code
--Presence of gas cap, faults, shale breaks

• DEVELOPMENT & PERFORMANCE DATA

--Recovery efficiency
--Cumulative production
--Annual production (being added)
--Current injection rate
--Well spacing
--Number of producing & injecting wells
--Water cut (being added)

* Tertiary Oil Recovery Information System, maintained and operated by the Bartlesville Project Office of the U.S. Department of Energy

full-scale project results were known. The model is reservoir-specific and therefore estimates total incremental EOR production as a function of reservoir properties and EOR process design for each reservoir independently. Incremental production is that which is recovered in excess of production by conventional primary and secondary techniques.

4. <u>Economic Evaluation</u>. Each reservoir was then evaluated for its economic feasibility by estimating the income attributable to the incremental EOR production and the investment, operating costs, and taxes of the EOR process as designed and installed in the field. Detailed costing algorithms reflected EOR design, reservoir depth, region, and other factors. The energy component of each cost element was adjusted to reflect the oil price being analyzed. A discounted cashflow analysis was performed for each reservoir at a number of oil prices.

5. <u>Technology Deployment</u>. For each reservoir that was determined to be economic at a given price, the performance of the applicable EOR processes was compared. The process producing the greatest quantity of incremental oil was assigned to the reservoir. The reservoirs were then scheduled for development on the basis of their relative economic attractiveness and time-phased against a series of supply and environmental constraints. This procedure was modified somewhat in the present study, as described below.

The NPC reported its findings on a national basis for four prices, ranging from $20 to $50 per barrel, three minimum rates of return, and two levels of technology performance -- "implemented," meaning available at present, and "advanced," meaning available in the future due to successful completion of currently ongoing research and development. The present study uses the NPC reservoir data base, models, and methodology just as the NPC developed them, except as described in the next section. The NPC methodology is reported at length in its final report.

B. ADAPTATIONS IN APPROACH FOR THE PRESENT STUDY

The scope of the present study is limited to the reservoirs in New Mexico, the carbon dioxide miscible flooding process (in its "implemented," or state-of-the-art level of effectiveness), a range of oil prices from $16/B to $40/B, and minimum rates of return (without inflation) of 10% and 15%. To conduct the present analysis, several adaptations to the NPC approach were necessary, although none is a significant departure from the NPC methodology. The modifications were as follows:

State taxes. Because the NPC utilized a national perspective, it chose to simplify the analysis by assuming uniform state severance and income taxes. The present study has replaced these with the current New Mexico tax structure. State production taxes on oil in New Mexico are based on the gross value of production less royalties on State, Federal, or Indian lands, including the following:

-	Oil Severance Tax:	3.75%	
-	Oil and Gas School Tax:	3.15%	
-	Oil and Gas Conservation Tax:	.18%	
-	Ad Valorem Tax on Oil and Gas:	.70%*	(approximately)
	Total Production Taxes on Oil	7.78%	

The severance tax on associated/dissolved natural gas was set at $0.152/Mcf.** State corporate income taxes were set at 7.2%, the marginal state rate. The correct state taxes for Texas were also incorporated for the comparative analyses reported in Chapters IV and V.

Federal taxes were calculated based on corporate tax rates in effect through September 1986. The analysis does not incorporate the change made to federal tax structures as part of the Tax Reform Act of 1986.

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* Actual rate varies based on local property tax rate. Rate used was statewide average rate in 1983.

** Actual rate is $.087/Mcf with an inflation adjustment. Rate used was average rate for 1983.

Gas valuation. The NPC chose not to value associated/dissolved natural gas produced with the incremental oil production. The present study has valued the gas, conservatively, at the price it would receive assuming it were regulated as "old gas" under Section 104 of the Natural Gas Policy Act of 1978. Some of this gas might be used as fuel for field compression and operations. If it is so used, royalty and production taxes would not be paid and overall revenues would be slightly reduced, but costs would be lower than those used in the analysis.

Data editing and additions. Using state sources, the NPC reservoir data were reviewed and updated; further, new reservoirs were added. Where the NPC study included only about 69% of the known original oil-in-place (OOIP)in New Mexico, the present study includes more than 81% of OOIP in 97 reservoirs. Data on production of oil, gas, and water were added for all reservoirs, thereby permitting decline curve analyses (used in the timing algorithm, below), validation of the estimated ultimate conventional recovery, and differentiation of the portions of each reservoir on private, state, and federal lands.

Cost and price data. Based on an informal survey of industry representatives, it was concluded that the NPC costing algorithms were still valid for the present study, provided that prices analyzed were consistent with the year of the cost data. The prices and costs actually used in the analysis were stated in 1983 dollars. For the convenience of the contemporary reader, however, the oil prices are discussed in 1985 terms. Thus, for example, the average benchmark price for West Texas intermediate crude for the year ending October 1985 is, as described in the text, $28/B. In the actual analysis, the price used was $26.50/B in 1983 dollars to be consistent with the cost data. All of the dollar quantities estimated in the analysis (e.g., state revenues, economic activity, federal taxes, etc.) are stated in 1983 dollars, and are underestimated by seven percent relative to 1985 dollars. Note that, as in the NPC study, the energy component of all major cost elements was explicitly identified and adjusted to incorporate the effects of changes in oil prices on costs.

The only exception to the NPC cost algorithms was the cost of carbon dioxide delivered to the field. The NPC assumed a carbon dioxide purchase price in the Permian Basin of $1.25 per thousand standard cubic feet at an oil price of $30/B. This was adjusted for changes in oil price using the equation: CO_2 Price ($/Mcf) = $.50 + $.025 X Oil Price ($/B).* This NPC estimate was developed prior to completion of major carbon dioxide pipelines or significant carbon dioxide deliveries. An informal poll of pipelines and field operators suggested that the carbon dioxide prices at present and into the near term would be slightly lower (relative to oil prices) than the NPC had assumed. The average delivered carbon dioxide price was assumed to be $1.06 per thousand standard cubic feet at an oil price of $28/B. This was adjusted for changes in oil price using the equation: CO_2 Price ($/Mcf) = $.50 + .02 X Oil Price ($/B).

<u>Benefits estimation</u>. The NPC did not estimate all of the individual items used in the present study's estimation of benefits. Special algorithms were developed to estimate the number of jobs created, personal income taxes paid, and public royalties, for example, on the basis of other elements already contained in the economic model. These are discussed further in Section D, below.

<u>EOR timing</u>. The NPC's national perspective permitted a timing algorithm based principally on the assumption that the most economically attractive reservoirs would be developed first, given some broad constraints. For the present study, a more detailed timing approach was necessitated by the smaller geographic scale of the analysis. Timing for EOR in New Mexico reservoirs (assuming they would be economic) was estimated in two steps. First, based on a projection of the rate of decline and economic limit of conventional recovery, a latest date of abandonment was estimated for each reservoir. It was then assumed that EOR would begin a multi-year phasing that would result in full field application by the year the reservoir would have been abandoned. This is consistent with the development model's assumption that currently existing wells will be utilized in a carbon dioxide flood. As a second step,

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* The NPC used different prices for CO_2 at locations outside the Permian Basin but all prices were determined from the Permian Basin "base" cost.

an informal poll was conducted of major and independent operators and pipelines active in the area, requesting their best estimate of the most likely year in which EOR would be initiated. Only the 18 largest reservoirs were included in the poll. Based on a high degree of consensus, EOR initiation years were assigned for each of the larger reservoirs, provided that these estimates were before the estimated conventional economic limit was reached.

C. CASES ANALYZED

As described in Chapter II, the structure of the analysis is quite simple. Using the currently applicable tax statutes, the reservoirs were analyzed at seven different nominal crude oil prices (adjusted for gravities less than 40° API) -- \$16/B, \$20/B, \$24/B, \$28/B (approximately the average price for the benchmark West Texas intermediate for the 12 months ending in October 1985), \$32/B, \$36/B, and \$40/B, all stated in constant 1985 dollars. These were selected to bracket the likely prices over the next 25 years while being close enough together to permit relatively fine-grained analysis of the sensitivity to oil price. Each of these cases was analyzed at two discount rates, or required minimum rates of return, 10% and 15%. These ranges are considered to bracket the "hurdle rates" that projects will need to meet or exceed in order to be financially attractive. The NPC reported the majority of its results at the 10% rate, although it examined 0% and 20% as sensitivity studies. These are "real" rates of return, disregarding the effects of inflation. For example, a 10% real rate of return factor under conditions of 5% inflation would result in a nominal rate of 15.5% (1.10 X 1.05 = 1.155). Similarly, the 15% real rate of return would be a nominal 20.8% under 5% inflation (1.15 x 1.05 = 1.208).

A minimum "real" rate of return (or "hurdle rate") of 10% is typical of the criterion for relatively routine reservoir management techniques with well-understood and limited risks, e.g., waterfloods or infill drilling. A higher rate, 15%, or even higher, is more typically applied to higher risk (larger technical uncertainty, higher "front-end" investment) projects, such as enhanced oil recovery in its current stage of development. In the near-term, as carbon dioxide flooding is still considered relatively risky, the 15%

minimum rate of return might be considered more "realistic." However, as experience in applying carbon dioxide floods in Permian Basin reservoirs accumulates and as competing reservoirs' management options become more limited, the 10% minimum rate of return is expected to become more typical of operators' investment criteria. Conversely, if world prices continue to be as volatile as they have been over the past year, operators may insist on higher "hurdle rates" to compensate for uncertain future prices. Thus, the results of the present analysis are presented at both 10% and 15% minimum rates of return.

The results of the assessments analyzed at the current tax structure were then compared with the results of assessments which were otherwise identical except for the inclusion of incentives involving state corporate income and production taxes. The two incentive cases were:

- "Incentives-for-Life" -- forgiveness of both state corporate income taxes and operators' share of production taxes (school, severance, conservation, and ad valorem taxes) on <u>incremental</u> oil and gas sales for the life of the project; and
- "Incentives-to-Payback" -- forgiveness of these same taxes on <u>incremental</u> production until the year in which each project's cumulative cash flow moves from negative to positive, i.e., the "break-even" point without discounting. This "payback" term is often used in oil-field contracts, e.g., for establishing "back-ins" of net working interests, so it is a well-understood concept to operators.

These cases were defined to examine the positive and negative effects of incentives near the maximum that the state could provide. Other incentives are possible, so detailed cashflow analyses of typical reservoirs have been provided under separate cover to permit more in-depth tax analyses.

All of the forty-two cases (seven prices, two rates of return, and three tax structures) were analyzed in detail to examine their impact on estimated reserves and production and their impact on the treasuries and economies of both the state of New Mexico and the nation as a whole. The results of these analyses, addressing only incremental production, are reported in Chapters IV and V. Additional analyses, reported in Chapter VI, were conducted to establish whether administratively practical incentives could be derived.

For reasons discussed in the next chapter, the majority of the reported results focus on the prices in the range \$20/B to \$32/B.

D. ESTIMATION OF BENEFITS, COSTS, AND ECONOMIC IMPACTS

The NPC study analyzed each reservoir from the perspective of the operator deciding whether to implement EOR. The present study does the same in evaluating the economic viability of each reservoir. Thus, the benefits and costs to the operators are explicitly captured in the net present value calculations. Under each of the various cases analyzed, reservoirs yielding a net present value greater than zero at the respective minimum rates of return are assumed to be developed. This is the basis for the projection of incremental production and reserves.

However, the present study also adopts the state's perspective in deciding whether to offer incentives. To do this, the consequences of interest to the state, as separate from those of the operators, must be carefully defined and analyzed. For this study, the consequences of concern to the public are estimated at three levels -- the direct benefits and costs to the state and local treasuries of New Mexico, the direct effects on the state economy and employment, and the impacts on the gross domestic product and federal tax and royalty revenues.* The benefits and revenue flows reported relate only to incremental crude oil that would not be produced under primary and secondary operations.

The incremental benefits and costs of enhanced oil recovery are estimated and reported on an annual basis as well as a total, or aggregate, basis. As previously discussed, reservoir timing is based on estimated abandonment of the resource due to production decline, except major reservoirs for which survey results suggested earlier start dates. Projects are phased in over a 5 to 10 year period in order to achieve full project development before this abandonment would occur. Annual estimates of benefits are based

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* As noted above, the dollar benefits are estimated in 1983 dollars; they are underestimated by seven percent relative to 1985 dollars.

on the total economic resource produced in a given year. These annual values are reported for a twenty-five year period, 1985 to 2010. Aggregate benefits include the sum of the reported annual benefit plus any additional benefits which would occur after 2010. The total length of time for the life of all projects varies considerably with oil price and tax treatment. The vast majority of aggregate production and benefits occur in the period 1985 to 2010. The additional benefits that occur after 2010 are small relative to the total benefit, but important to the overall aggregate analysis.

Benefits and Costs to State and Local Treasuries. The benefits to New Mexico's state and local treasuries from carbon dioxide miscible flooding are the incremental tax and royalty revenues attributable to the projects. These include production taxes (severance, conservation, ad valorem, and school taxes), gross receipts (sales) tax, personal and corporate income taxes, royalties on state lands, and the state's share of royalties on federal lands. In evaluating these benefits under the current tax structure, the sum of these as they apply to the development of the projects and the incremental production from these projects was estimated. In appraising alternative incentive programs, the benefits are evaluated as the net incremental revenues after deducting the cost of the incentives.

The cost of the incentives is estimated as the sum of two components: opportunity costs and the reduction in state income taxes due to losses during the initial years of the project. First, the "opportunity" cost of the incentive is the amount of revenue that was, in fact, unnecessary to stimulate the desired result. Such an opportunity cost would result if a reservoir that would be economic in the absence of an incentive nevertheless receives the incentive; the revenue foregone -- the opportunity -- is lost to the state. If, on the other hand, a reservoir that would be uneconomic without the incentive becomes profitable due to the incentive, no opportunity cost is incurred by the treasury. Had the reservoir not been developed under EOR, it would have been abandoned at its conventional technology economic limit, so no revenue (hence, no opportunity cost) would have accrued to the treasury. Second, in computing corporate income tax liability, losses in taxable income incurred in the early years of a project, even if it had been uneconomic without incentives, can result in a "negative tax" as the losses are used to offset taxable profits from other operations. This reduces the revenue from corporate income taxes to the state. The sum of these, termed the "cost of the incentive," is compared with the increase in net state and local revenues to evaluate the desirability of the incentives (note: "cost of the incentive" is already deducted from revenues as reported; the revenues, both annual and total, are net incremental revenues due to enhanced recovery).

Direct State Economic Effects. The effect on the state's treasury is only one way of viewing the benefits of EOR and state incentive programs. Also important is the gain to the state's citizens due to increased economic activity. The present study estimates the incremental impact on the state economy of the incentive case over the no-incentive case in a highly conservative fashion. First, it considers only the direct effects of the incremental activity, i.e., no economic "multiplier" or indirect activity (e.g., pipeline construction, retail sales, etc.) is included. Second, it defines the direct impact on the state economy as the sum of net revenues to the state and local treasuries (defined above), royalties to individuals, corporations, and Indian tribes, expendable (intangible) drilling materials and services, and operating costs excluding carbon dioxide purchases. These funds are assumed to predominantly flow directly to the state and its citizens.

Excluded from this definition are cashflows that generally benefit citizens of other states in larger proportion than they benefit New Mexico's citizens. These include tubular steel products installed in wells, injection and production equipment, purchased carbon dioxide, and other oil field materials typically manufactured out of state. To the extent that these goods are marketed by distributors in New Mexico, the direct benefits of these "retail pass-throughs" to the state are omitted from the estimates of direct state economic activity. Similarly, while it is recognized that a significant portion of purchased carbon dioxide will probably originate in New Mexico (generating royalties, taxes, and other economic activity), estimating these quantities is outside the scope of the present study. Other excluded items include federal taxes, corporate debt service, and return on capital. While New Mexico's citizens obviously benefit from these excluded elements as U.S. citizens and stockholders, they share them with the much larger population.

Thus, the definition used here for direct economic effects represents something of a "lower bound" of the true amount of New Mexico's benefits.

The number of incremental jobs and wages and benefits are also estimated. The basis for estimating labor costs (wages and fringe benefits) was to isolate the labor component of all major cost elements. Table III-1 summarizes the major cost elements and their respective labor components. These labor costs were then converted into estimated numbers of jobs by dividing total wages by the average oil field wages (including benefits) as reported by the U.S. Department of Labor.*

National Effects. The nation as a whole benefits from increased oil production in New Mexico. Each additional barrel of domestic production is one less barrel of imports. Each dollar's worth of increased gross domestic product that would otherwise have been paid for imports is, potentially, a dollar less in the trade deficit.** To estimate the direct (i.e., as above, no "multiplier") effects on the gross domestic product, this study estimates the gross revenue from incremental EOR production. This would include both the included and excluded elements discussed under direct economic activity in the state. In this sense, the estimated increase in gross domestic product represents an "upper bound" of direct economic impacts on New Mexico, excluding multiplier effects. In addition to estimating the gain in gross domestic product, the income taxes and royalties paid to the federal government (net, after the state portion is deducted) are estimated to assess the effects on the federal treasury.

None of the results in the study include the application of the Windfall Profits Tax in the economic calculations. Under current law the Windfall Profits tax would phase out in 1993 and, under currently considered federal legislation, it could be repealed substantially sooner. The vast majority of

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* U.S. Department of Labor, Bureau of Labor Statistics, 1985.

** Although constraints caused by limited financial or personnel resources may result in delayed national benefits due to short-term deferral of projects in other states, the aggregate benefits to the nation should be achieved as all economic projects will ultimately be developed.

TABLE III-1

LABOR AND MATERIAL
PERCENTAGE OF TOTAL COST
EOR PROJECTS

INVESTMENTS	% LABOR	% MATERIALS	% OTHER
Drilling Wells	18	55	27
Work-overs	15	63	22
Equipping Wells	10	50	40
Pipe Installation	10	50	40
Plant Installation	16	46	38
EXPENSES			
Field Operations	33	58	9
Plant Operations	38	57	5
Production Treating	0	100	0
Overhead	100	0	0

Sources:

Investments

- Drilling and Work-overs -- NPC, 1984.
  -- EIA, 1984.
  -- Professor Neil J. Dikeman, University of Oklahoma, 1986.
- Equipping wells -- Industry estimate
- Pipe Installation -- Industry estimate
- Plant Installation -- Modern Cost Engineering Technologies, Herbert Popper, page 82-83.

Expenses

- Field operations -- EIA, 1984.
- Production Treating -- by definition
- Plant Operations -- NPC, 1984.
  -- EIA, 1984. (power and chemicals)
- Overhead -- NPC, 1984.

production estimated in this study would come after the tax has expired and, as such, would not be subject to the tax. Even if the tax were to remain in effect, the majority of the oil prices being analyzed fall well below the 1985 "incremental tertiary base" price of $25.90, which rises yearly. Moreover, incentive features in the tax to encourage EOR projects minimize the impact on incremental recovery, which this study estimates, even at the higher prices. The NPC, in its analysis, took a similar approach and tested its validity in an evaluation of approximately 100 reservoirs. Although some projects at some prices might be adversely effected by inclusion of the Windfall Profits Tax, many others would benefit. The bulk would have little change at all. Thus, it was concluded that it would be a better representation of likely benefits and economic effects of carbon dioxide flooding in New Mexico if this tax were excluded.

E. LIMITATIONS TO THE ANALYTIC APPROACH

The approach followed by this study has limitations that should be appreciated by the reader. Some of these follow from the adoption of the NPC methodology; others result from the need to limit the scope of the present effort.

The NPC approach, while the most credible and flexible methodology available, had certain distinct limitations. One of these is the reliance on averaged reservoir properties. Actual oil reservoirs are highly heterogeneous, with critical properties ranging dramatically from one point to another. The use of average properties can belie the fact that portions of an individual reservoir could be highly attractive as a carbon dioxide flooding prospect even if the whole, on average, is less attractive. Because, given the methodology, reservoirs are accepted or rejected economically as whole units, this could introduce systematic under-estimation of the recovery potential, especially at lower oil prices. In recognition of this limitation, where a major reservoir which had been identified in the industry survey as highly prospective failed to meet the economic threshold by a very small margin (e.g., 9.5% internal rate of return in a 10% minimum case), it was assumed that the portions of the reservoir with more favorable than average properties would be developed, while the economics of the remainder of the reservoir would be made more positive due to "sunk costs" of development of the more favorable portions. While this introduces an element of judgment, the results are considered more realistic than simply ignoring the methodological limitation imposed by averaged reservoir properties. Less often, the averaging of properties could also overestimate the potential of especially heterogeneous reservoirs. However, the method used by both the present study and the NPC assumed that the least favorable 20% of the reservoir would not be flooded in any reservoir, so the effects of this limitation are generally accounted for in the results.

A second limitation is the use of statewide costing algorithms. While these were developed from best available data and incorporate explicit adjustments for variations in energy costs and specific reservoir characteristics, they do not reflect site-specific cost variations due to specific operators, etc. Thus, the costs used in the study would not necessarily be the costs of individual projects.

A third limitation is the use of simplified process performance models. While the models used in this project were extensively calibrated by the NPC, they are designed to analyze large numbers of individual reservoirs quickly and simultaneously. To do this, they must be relatively simplified and generalized, although they do incorporate all the relevant reservoir engineering concepts. In this simplified state, the models cannot be as accurate as highly detailed reservoir simulators in which very specific reservoir features and process designs may be evaluated (as used in the actual design of an EOR project). The present study, following the approach of the NPC, assumes these models are appropriate for aggregate analysis but not necessarily for individual reservoirs. Further, these models are explicitly designed to estimate only <u>incremental</u> enhanced recovery. Laboratory and limited field data suggest that application of carbon dioxide flooding before the economic limit of secondary recovery could yield more than the sum of secondary and tertiary recovery. The model does not reflect this. Finally, the model is designed to reflect the state-of-the-art, conservatively defined, and therefore does not include technological advances now under development. In all, these limitations present conservative estimates of the potential for carbon dioxide miscible flooding.

None of these limitations invalidates the approach for a statewide study. However, to avoid misinterpretation of particular reservoirs, and to respect the confidence in which some project and reservoir data were obtained, no reservoir-specific data is provided in this report.

The approach is also limited by the necessary constraints on the scope of the project. Carbon dioxide pipeline economics and capacities are outside the scope of detailed analysis in this project. The benefits estimated exclude the carbon dioxide that will be produced in New Mexico. Further, the present report considers only carbon dioxide miscible flooding, excluding other EOR processes that might have application in certain New Mexico reservoirs (e.g., carbon dioxide immiscible flooding and chemical flooding).

An additional limitation arises from the methodological convention of "constant price" analysis. While use of this convention maintains comparability with the NPC's nationwide study and differentiates the effect of oil price from other effects, it can cause a distortion, especially in times of radically changing oil prices. The economic model assumes that all existing wells will be utilized, although older wells may require work-overs. The "hidden" assumption of this convention is that each of the respective oil prices being analyzed is attained (and expected to continue at that level) by the time of the respective decision to commit specific reservoirs to carbon dioxide flooding. This decision is generally made several years prior to the reservoir's final, actual economic limit under conventional technology. To the extent this condition is not met, existing wells meeting their economic limits at lower prices will be shut in, usually necessitating plugging and abandonment, making them unavailable for use in carbon dioxide flooding as assumed. Should such "premature" abandonments occur, these wells would need to be redrilled, resulting in investments that the present approach ignores (although necessary work-overs are included in the assumed cost). This would result in higher investment costs and, potentially, the reversal of the evaluation of whether certain reservoirs are or are not profitable at the respective prices being analyzed. The net effect of this analytic convention, then, could be to overstate the potentially economic revenues and production and their corresponding benefits. In adopting the "constant price" convention, the present approach could introduce an optimistic bias, assuming future prices fall -- or a pessimistic bias, assuming future prices rise.

Finally, some New Mexico reservoirs, accounting for approximately 19% of the state's total original oil-in-place, have been excluded in the absence of detailed data; no attempt is made to extrapolate the results to these reservoirs. Also, because of the long lead time of investment decisions for miscible floods, sustained oil prices in the assumed range must be attained by late this decade if the full benefits of these projects are to be realized.

Within these limitations, the following chapters report the results of the study.

IV. OIL PRODUCTION AND ECONOMIC EFFECTS OF CARBON DIOXIDE MISCIBLE FLOODING IN NEW MEXICO UNDER THE CURRENT TAX STRUCTURE

A. INTRODUCTION

A total of 97 reservoirs, collectively accounting for 81% of the known oil in New Mexico, were individually analyzed to estimate their potential for incremental recovery by carbon dioxide miscible flooding. Of these, 80 met the technical criteria for carbon dioxide miscible flooding and were analyzed in detail using the process performance and economic models described in Chapter III.

Each of the 80 reservoirs was analyzed at seven constant oil prices ranging from $16/B to $40/B in four-dollar intervals, assuming minimum rates of return of 10% and 15%. The analysis was done in "real" terms, i.e., assuming no inflation of prices or costs, although the energy components of the costs were adjusted to reflect the respective oil prices. This range of prices was selected to encompass the likely range of stable, long-term prices over the 25-year period being analyzed. Similarly, the rates of return were selected to include the corporate investment threshold criteria (including risk premium) likely to be applied to carbon dioxide flooding projects over this period. It is anticipated that the minimum rate of return currently required to justify a project may be relatively high. As more is learned about carbon dioxide flooding, perceived risks will decrease and minimum rate of return will also decrease.

This chapter presents the results of these analyses as conducted under current state and federal tax structures. The results illustrate the extreme sensitivity of carbon dioxide flooding in New Mexico to both oil price and operators' expected rate of return, and lay the groundwork for the following chapter which provides an analysis of the effects of state tax incentives to encourage carbon dioxide applications.

B. PRODUCTION AND RESERVES

Depending upon the oil price and minimum rate of return, potential new reserves attributable to carbon dioxide flooding of New Mexico reservoirs range from 10 million barrels to 820 million barrels. These represent additions to the state's currently proved reserves (660 million barrels at the beginning of 1985), from as little as approximately 2% to more than 120% (Exhibit IV-1*). The true potential price-supply curve probably lies between these two curves, as different operators apply different investment thresholds between 10% and 15% (in real terms). The shapes of these curves offer important interpretations. For both rates of return, very little incremental reserves can be expected at the two lowest prices, $16/B and $20/B. As the price increases into the range $24-$32/B, however, substantial amounts of reserves are added for small increments in oil price. As prices exceed $32/B, the curves become relatively flat, which is characteristic of such curves for a finite resource. These observations suggest that the range of prices analyzed essentially encompasses the relevant responses of New Mexico reserves to economic stimuli under current taxes. Below $20/B, no significant amount of carbon dioxide flooded incremental reserves will be added; above $32/B to $36/B, very few additional oil reserves can be expected because nearly all prospects that would be economic have already become so at lower prices. Further, while the higher required rate of return depresses the reserves added at each price, as expected, the difference is greater at the intermediate prices, with a significant convergence at the extremes of high and low prices. This corroborates the interpretation of the price effects. These curves demonstrate that all essentially important results within the prices studied will lie between $20/B and $32/B. For these reasons, the remainder of this chapter will concentrate on the $20/B-$32/B range for both rates of return.

Table IV-1 provides the detail of the data displayed in Exhibit IV-I and also shows the number of reservoirs that are economic at each oil price-rate

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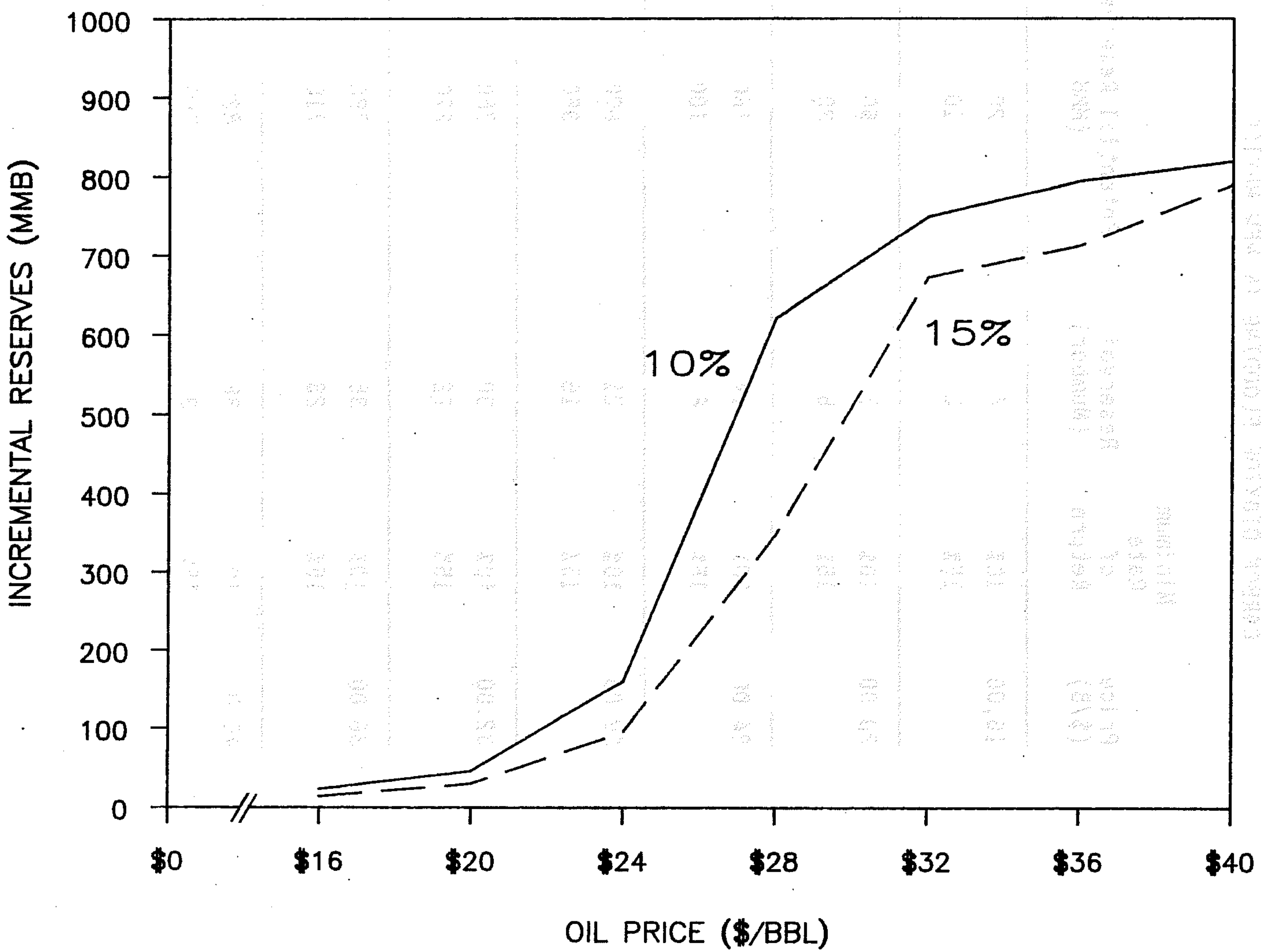
* With the axes reversed, this exhibit would take the form of a reserve-price curve more familiar to resource economists.

EXHIBIT IV–1

POTENTIAL INCREMENTAL RESERVE ADDITIONS DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO FOR CURRENT TAX STRUCTURE AT VARIOUS OIL PRICES –– 10% AND 15% RATE OF RETURN



SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

TABLE IV-1

ESTIMATED POTENTIAL RESERVE ADDITIONS* DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO

Price ($/B)	Minimum Rate of Return	Reservoir (Number)	Potential Reserves (MMB)
16.00	10%	4	20
	15%	2	10
20.00	10%	7	50
	15%	5	30
24.00	10%	14	160
	15%	8	100
28.00	10%	21	620
	15%	16	350
32.00	10%	30	750
	15%	22	670
36.00	10%	35	790
	15%	28	710
40.00	10%	38	820
	15%	34	790

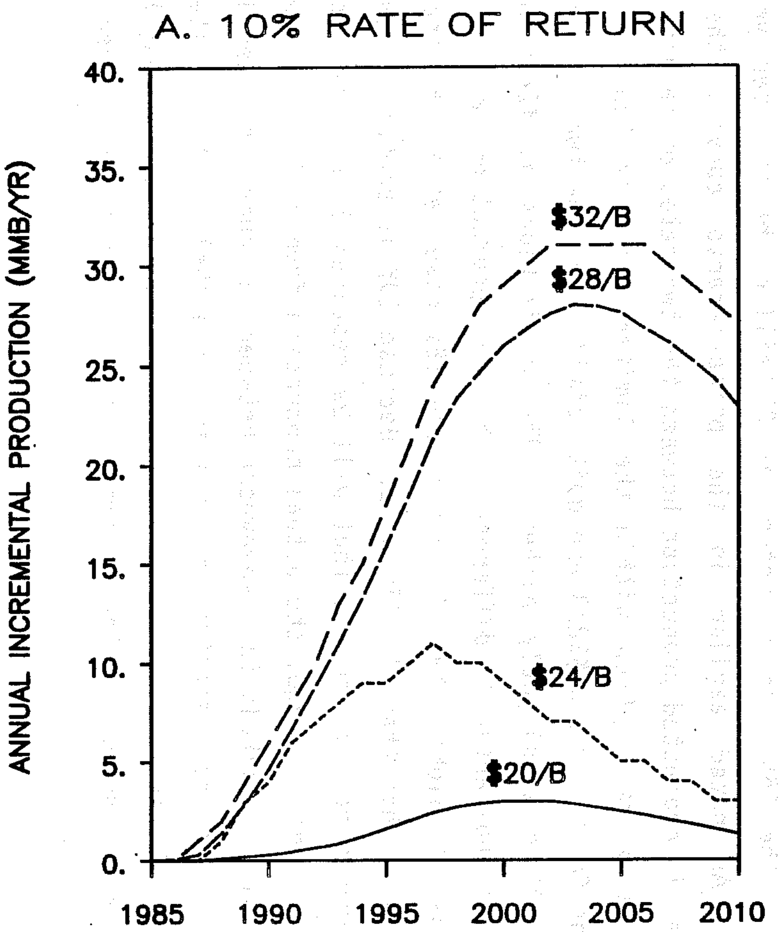
* Reserves additions rounded to nearest 10 million barrels.

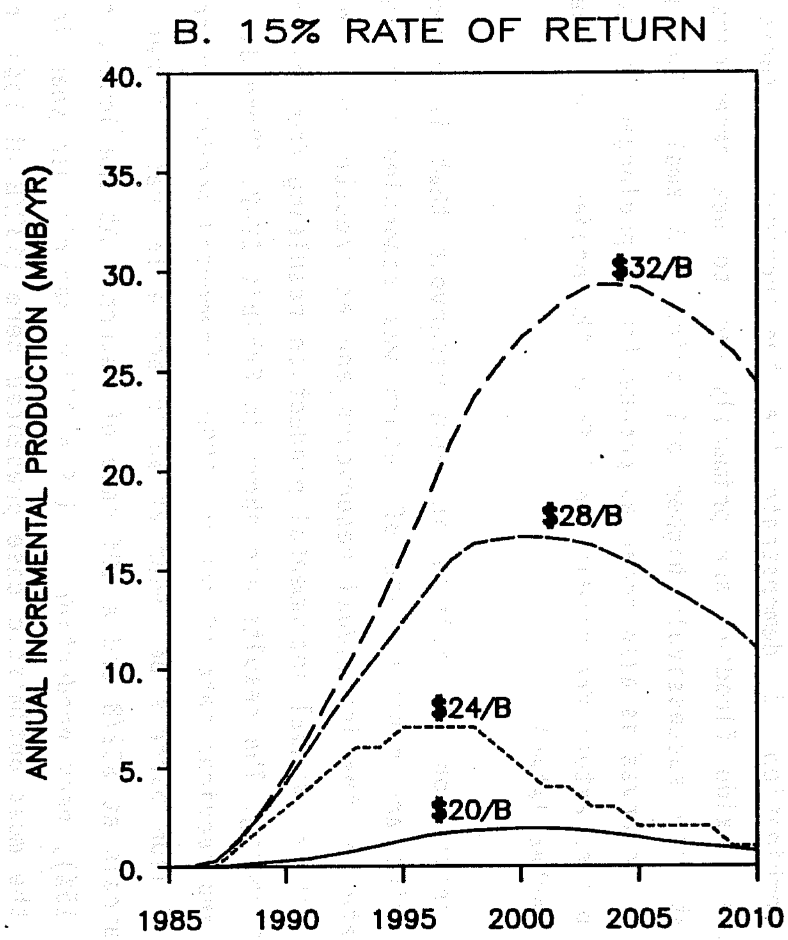
of return combination. It demonstrates that the incremental reserve additions from carbon dioxide flooding are primarily due to new reservoirs becoming economic at each successively higher oil price. A small, but important, increment to reserves is also added as production is prolonged in each project as higher prices extend the productive life of the project (i.e., the economic limit is reached later).

The initiation of projects in each reservoir that is economic at a specific price and minimum rate of return was scheduled according to the decline rates of the individual reservoirs and an industry poll in order to project timing of annual incremental production resulting from carbon dioxide miscible flooding. The results are shown in Exhibit IV-2. Depending upon the oil price and required rate of return, 1995 incremental production could range from 1.3 million barrels per year at $20/B and a 15% rate of return, to 18 million barrels at $32/B and a 10% rate of return. At the lowest case shown ($20/B at 15%), peak production is 1.9 million barrels per year in the year 2000. In the most optimistic case presented here ($32/B at 10%), production reaches over 30 million barrels per year just after the turn of the century and is sustained at about that level for several years. The comparable $32/B estimate at the 15% rate of return is 29 million barrels per year at its maximum. As noted earlier in the price-reserve curves, the greatest differences in projected production between the two rates of return lie at the intermediate prices. Even within the limited range in Exhibit IV-2, the projections for $20/B and $32/B are quite similar for the two rates of return, with the 10% case slightly higher. The projections at $24/B and $28/B, however, are substantially different. The peak production rate at $24/B and 10% rate is 50% higher than the comparable 15% case; at $28/B, the 10% case peaks at 65% higher than the 15% case. Because 10% is probably less than the average minimum rate of return that will be required of all projects and 15% may be higher than average, the actual production from carbon dioxide flooding in New Mexico will likely fall somewhere between the curves plotted in Exhibit IV-2 for each of the respective oil prices. Nonetheless, this reiterates the sensitivity of production from carbon dioxide projects in New Mexico to relatively small changes in the intermediate price range and the required rate of return.

EXHIBIT IV-2

POTENTIAL INCREMENTAL OIL PRODUCTION DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO UNDER CURRENT TAX STRUCTURE





SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

If oil prices rise to $24/B or higher in a timely fashion, incremental production from carbon dioxide could substantially offset the projected, steep decline in conventional production through the end of the century. Adding the production decline curve for New Mexico (including conventional reserve additions at the historical rate) to the estimated incremental production due to carbon dioxide flooding, the total state production in 2000 could be from about 50 to 70 million barrels per year (with oil prices of $24/B to $32/B at the 10% rate of return). This contrasts to our actual production rate of 75 million barrels in 1985 and a projected conventional production of 37 million barrels in 2000, using the most optimistic assumptions about conventional reserve additions. Thus, incremental production from carbon dioxide flooding, given the availability of oil prices of $24/B or greater, would appear to be a key to sustaining New Mexico's oil industry in the foreseeable future.

C. INCREMENTS TO STATE AND LOCAL REVENUES

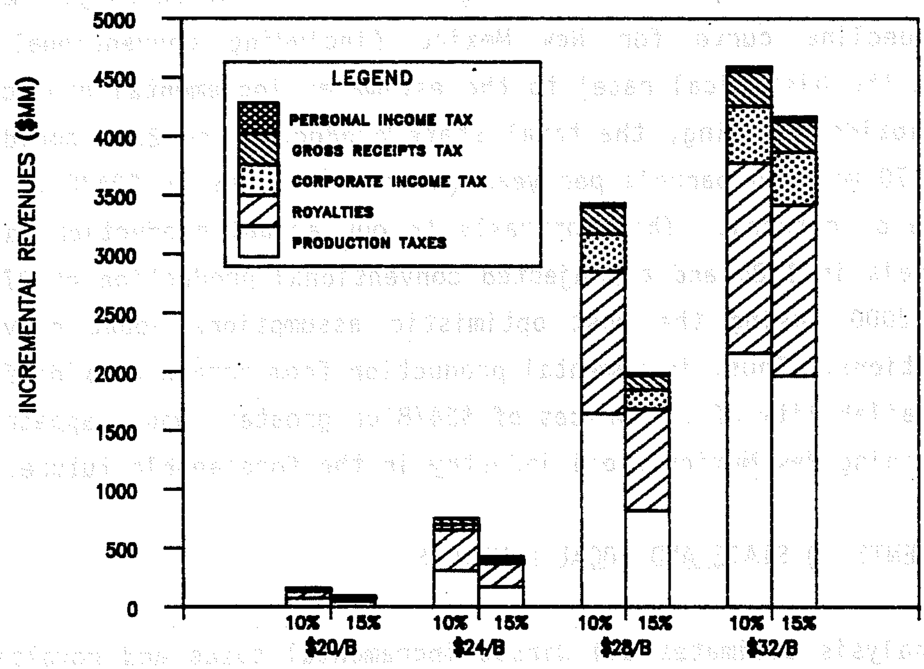
The analysis estimates all direct incremental taxes and royalties paid to the state and localities due to carbon dioxide flooding projects. These include personal and corporate income taxes, royalties from state lands and the state share of royalties on federal lands, gross receipts tax, and production taxes (including the oil and gas school tax, the oil and gas conservation tax, ad valorem tax, and severance taxes on oil and associated/ dissolved gas).

The largest source of incremental revenue from carbon dioxide flooding projects (the sum of all annual incremental net revenues) is production taxes, followed in descending order of magnitude by royalties on state lands (including the state's share of federal lands), corporate state income tax, gross receipts tax, and personal state income tax (Exhibit IV-3A). The aggregate amount of incremental revenues to the state and localities over the full life of the projects varies considerably with the oil price and required rate of return. At $20/B and a 15% rate of return, state and local treasuries would gain about $90 million whereas at $32/B and a 10% rate, state and local treasuries would gain about $4.6 billion.

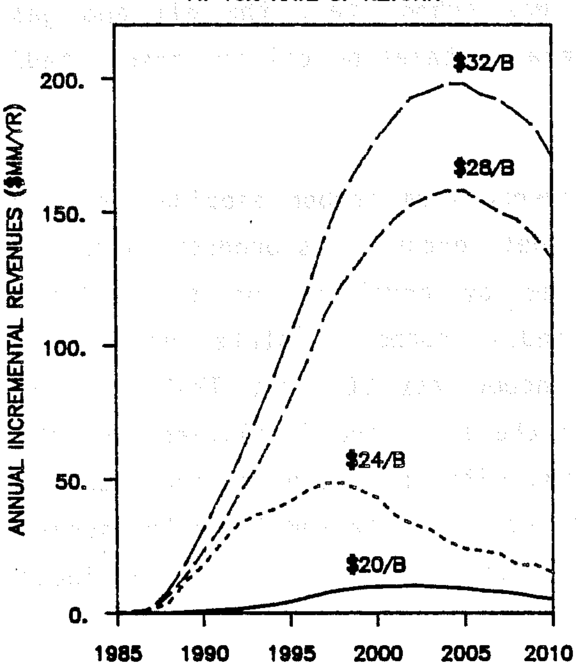
EXHIBIT IV-3

POTENTIAL NEW MEXICO STATE AND LOCAL REVENUES FROM CARBON DIOXIDE FLOODING UNDER CURRENT TAX STRUCTURE

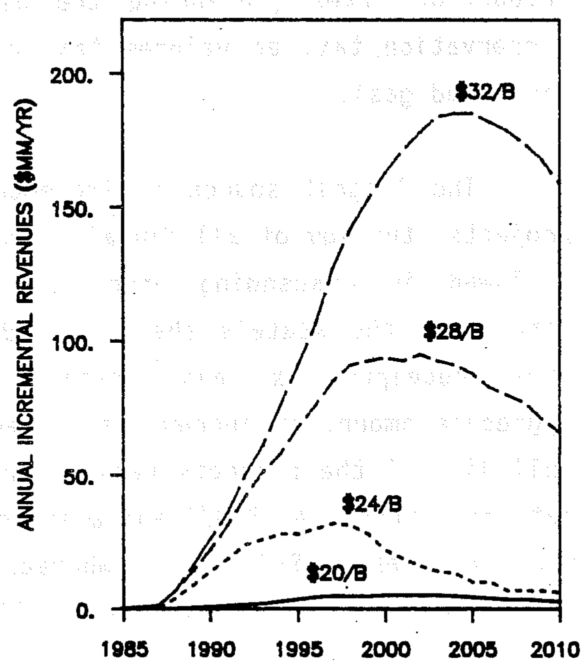
A. AGGREGATED INCREMENTAL REVENUES BY OIL PRICE AND RATE OF RETURN



B. ANNUAL INCREMENTAL REVENUES AT 10% RATE OF RETURN



C. ANNUAL INCREMENTAL REVENUES AT 15% RATE OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

This range of values is also seen in the projected annual rate at which these revenues would be received. The annual incremental revenue rates (Exhibits IV-3B and 3C) demonstrate clearly that both oil price and minimum rate of return have distinct impacts on the timing of projects and the resulting increments to revenues. At $20/B and a 15% rate of return, annual incremental revenues from carbon dioxide flooded reservoirs peak about the year 2002 at slightly over $5 million per year. However, at $32/B and a 10% rate, the peak occurs about two years later, at nearly $200 million per year. As with reserves and production rates, the major sensitivity to both price and rate of return occurs in the $24/B-$28/B range. In 1995, at the $24/B oil price, the 10% rate of return could provide 50% more revenues than the 15% rate. At $28/B, this difference is 18% in 1995, but in the year 2000, the 10% rate case could yield 49% more revenues than the 15% case.

Table IV-2 provides additional detail by tax source and year. The negative quantities that appear in the state income tax in the early years result from the losses in taxable income in the implementation phase of the projects and the assumption that these losses offset taxable income in other operations of the operators. This causes a "negative tax," or positive cashflow, to operators in these early years and a corresponding loss in income taxes to the state. However, in the ensuing years, these early losses are dramatically reversed by incremental income taxes. In no year, however, does this reduced income tax result in an annual loss to the state, as it is more than offset by incremental gains in other taxes. Clearly, the successful application of carbon dioxide flooding holds the promise of major new revenues for the state of New Mexico and its localities.

D. EFFECT ON THE STATE ECONOMY

In addition to the incremental state and local revenues, miscible carbon dioxide flooding will benefit New Mexico through increased direct economic activity and the creation of jobs in the state.

The estimated direct effects of carbon dioxide flooding on the state economy were purposely estimated to be conservative in two ways: (1) only

TABLE IV-2

ESTIMATED INCREMENTAL STATE AND LOCAL REVENUES ATTRIBUTABLE TO CARBON DIOXIDE FLOODING

BY OIL PRICE AND RATE OF RETURN UNDER CURRENT TAX STRUCTURE

(IN MILLIONS OF DOLLARS)*

Price	Source of Revenue	10% Rate of Return					15% Rate of Return				
		1990	1995	2000	2005	2010	1990	1995	2000	2005	2010
$20/B											
	Production Taxes	1	3	5	4	2	1	2	3	2	1
	Royalties (including state share of Federal)	0	0	3	3	2	0	1	1	1	1
	Corporate Income	(0)	(0)	1	1	1	(0)	0	1	1	0
	Gross Receipts	0	1	1	0	0	0	0	0	0	0
	Personal Income	0	0	0	0	0	0	0	0	0	0
	Total Revenue	1	4	10	8	5	1	3	5	4	2
$24/B											
	Production Taxes	7	7	18	10	5	5	11	9	4	2
	Royalties (including state share of Federal)	10	20	18	10	7	8	14	10	4	3
	Corporate Income	(1)	2	4	3	2	(1)	1	2	2	1
	Gross Receipts	2	3	3	1	1	1	2	1	0	0
	Personal Income	0	0	0	0	0	0	0	0	0	0
	Total Revenue	18	42	43	24	15	13	27	22	10	6

* Values in parenthesis are negative in value.

TABLE IV-2 (Continued)

ESTIMATED INCREMENTAL STATE AND LOCAL REVENUES ATTRIBUTABLE TO CARBON DIOXIDE FLOODING

BY OIL PRICE AND RATE OF RETURN UNDER CURRENT TAX STRUCTURE

(IN MILLIONS OF DOLLARS)*

Price	Source of Revenue	10% Rate of Return					15% Rate of Return				
		1990	1995	2000	2005	2010	1990	1995	2000	2005	2010
$28/B											
	Production Taxes	10	38	68	75	62	9	28	40	36	26
	Royalties (including state share of Federal)	13	36	51	52	43	12	32	40	36	28
	Corporate Income	(6)	(4)	9	21	21	(2)	1	7	10	9
	Gross Receipts	5	9	11	9	6	3	6	6	5	3
	Personal Income	1	1	1	1	1	0	1	1	1	0
	Total Revenue	23	80	149	158	133	21	68	94	88	65
$32/B											
	Production Taxes	13	47	83	93	79	11	42	77	87	73
	Royalties (including state share of Federal)	17	47	65	66	56	14	41	59	61	51
	Corporate Income	(6)	(2)	14	27	28	(5)	(3)	13	26	27
	Gross Receipts	6	11	13	11	7	5	10	12	10	7
	Personal Income	1	1	2	1	1	1	1	2	1	1
	Total Revenue	31	102	177	198	171	26	91	163	185	159

* Values in parenthesis are negative in value.

direct effects were considered (i.e., no economic multiplier due to secondary effects); and (2) the direct effects were limited to only those cost elements believed to accrue predominantly to New Mexico's citizens. The included elements were intangible drilling costs, total royalties, state and local taxes (as defined in Section C), and operating costs (exclusive of purchased carbon dioxide). This definition excludes tubular steel products, injection and production equipment, purchased carbon dioxide, carbon dioxide compression plant costs, corporate return on capital, and federal taxes. While the excluded elements undoubtedly benefit New Mexico's citizens, the majority of the benefits will be enjoyed by citizens of other states. However, to the extent that (1) local manufacture or retail pass-throughs of these costs provide economic benefits within New Mexico, (2) carbon dioxide from New Mexico sources is employed, or (3) economic "multipliers" are created, the calculated economic effects are understated.

Exhibit IV-4A displays the aggregated incremental direct economic gains, as defined, to the citizens of New Mexico at the respective oil prices and rates of return. At the most pessimistic level of \$20/B and a 15% minimum rate of return, direct economic activity in New Mexico would increase by approximately \$210 million over the life of the projects. At the most optimistic level presented, \$32/B and a 10% rate of return, incremental economic activity would total around \$11 billion. In essentially all cases, operating costs account for slightly more than half of these direct economic effects, while royalties and state taxes each contribute more than 20%.* Exhibits IV-4B and C show how the estimated incremental economic activity is distributed over time. Even in the most conservative case, increased direct economic activity becomes notable by the year 1990. At a crude oil price of \$20/B and a 15% rate of return, the annual direct economic effects peak in 2000, at over \$12 million per year. This ranges upwards to the 2005 peak of \$400 million per year at \$32/B and a 10% rate of return. These results illustrate the magnitude of impact that carbon dioxide flooding of appropriate reservoirs could have on the New Mexico economy given certain assumptions

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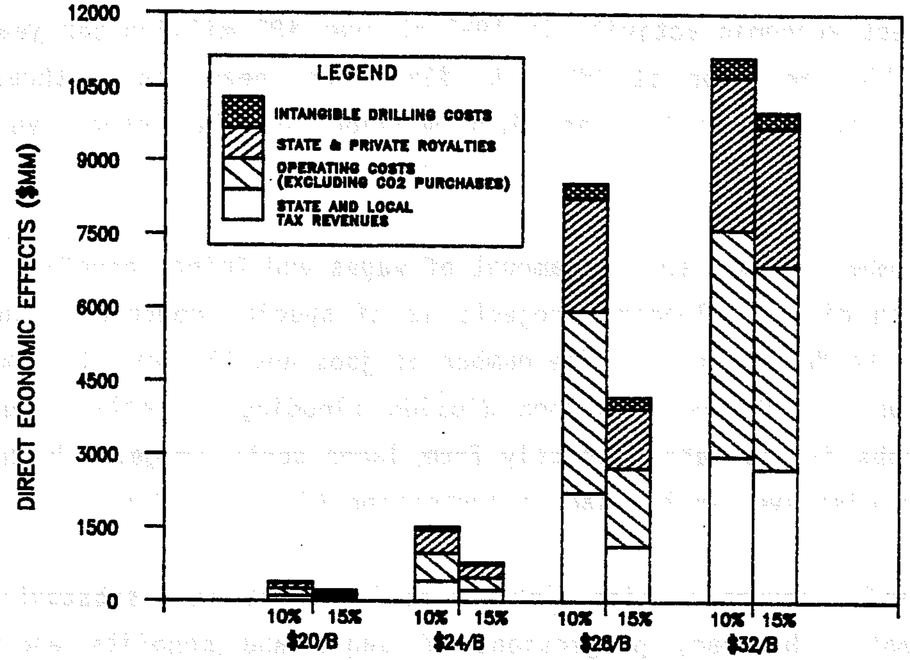
* The royalties shown in this exhibit include those to both public and private sectors. Hence, the difference between this exhibit and Exhibit IV-3, which displayed only the royalties to the state.

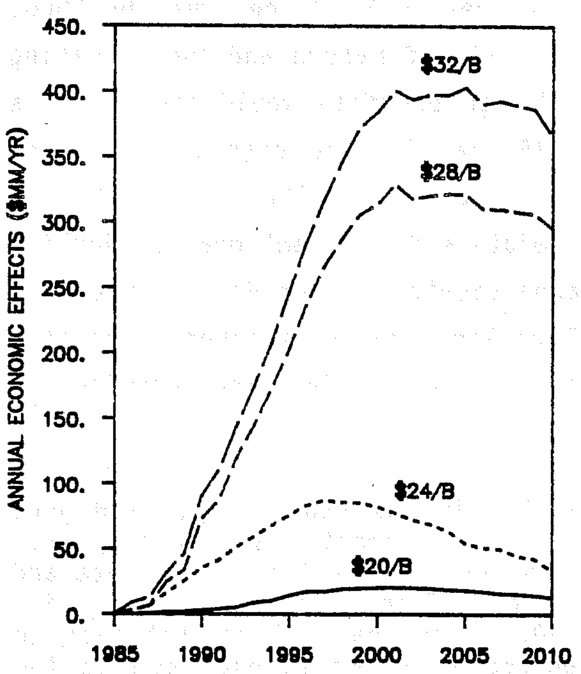
EXHIBIT IV-4

INCREASES IN NEW MEXICO STATE ECONOMIC ACTIVITY DUE TO CARBON DIOXIDE FLOODING UNDER CURRENT TAX STRUCTURE

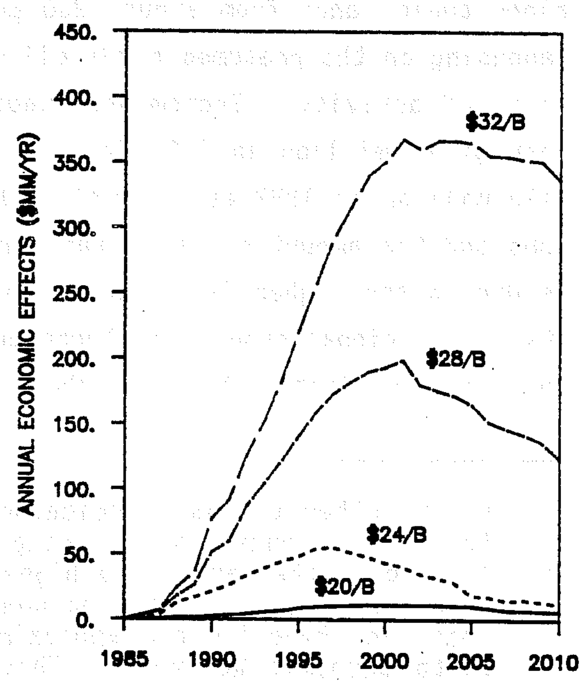
A. AGGREGATED INCREMENTAL DIRECT ECONOMIC ACTIVITY BY OIL PRICE AND RATE OF RETURN



B. ANNUAL INCREMENTAL ECONOMIC ACTIVITY AT 10% RATE OF RETURN



C. ANNUAL INCREMENTAL ECONOMIC ACTIVITY AT 15% RATE OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

about oil prices and corporate investment criteria. Consistent with the estimates presented earlier, the greatest relative sensitivities to price and rate of return lie at the intermediate prices, e.g., \$24-\$28/B. At \$24/B, the peak in direct economic activity is 1997 at over \$85 million per year at 10%, and \$55 million per year at 15%. At \$28/B, the peak occurs three to five years later, at \$330 million and \$200 million for the respective rates of return.

The number of jobs and the amount of wages and fringe benefits generated by the carbon dioxide flooding projects is of special concern in considering the benefits to New Mexicans. The number of jobs and the amount of wages were estimated for all phases of carbon dioxide flooding projects. Because the number of jobs is estimated directly from labor costs (wages), both jobs and wages can be displayed in the same illustration (Exhibit IV-5).

Successful carbon dioxide flooding could result in a substantial amount of employment. However, projections of wages and benefits and new jobs created are highly sensitive to both oil price and required rate of return. In contrast to the 13,400 New Mexicans employed in <u>both</u> oil and gas extraction in 1984, the number of additional jobs attributable to carbon dioxide flooding alone could range from around 200 per year to nearly 8,000 per year by 2000, depending on the presumed crude oil price and rate of return and the resulting level of activity. Incremental wages and fringe benefits would range from a peak of \$7 million in 2000 for the \$20/B, 15% pessimistic case to a peak of \$190 million in 1999 at the \$32/B, 10% optimistic case.* The large number of jobs and the amount of wages and benefits relative to conventional production is due to the higher labor intensity of sophisticated carbon dioxide flooding over conventional production techniques. Recalling that only directly related jobs are estimated here, carbon dioxide flooding holds the promise of

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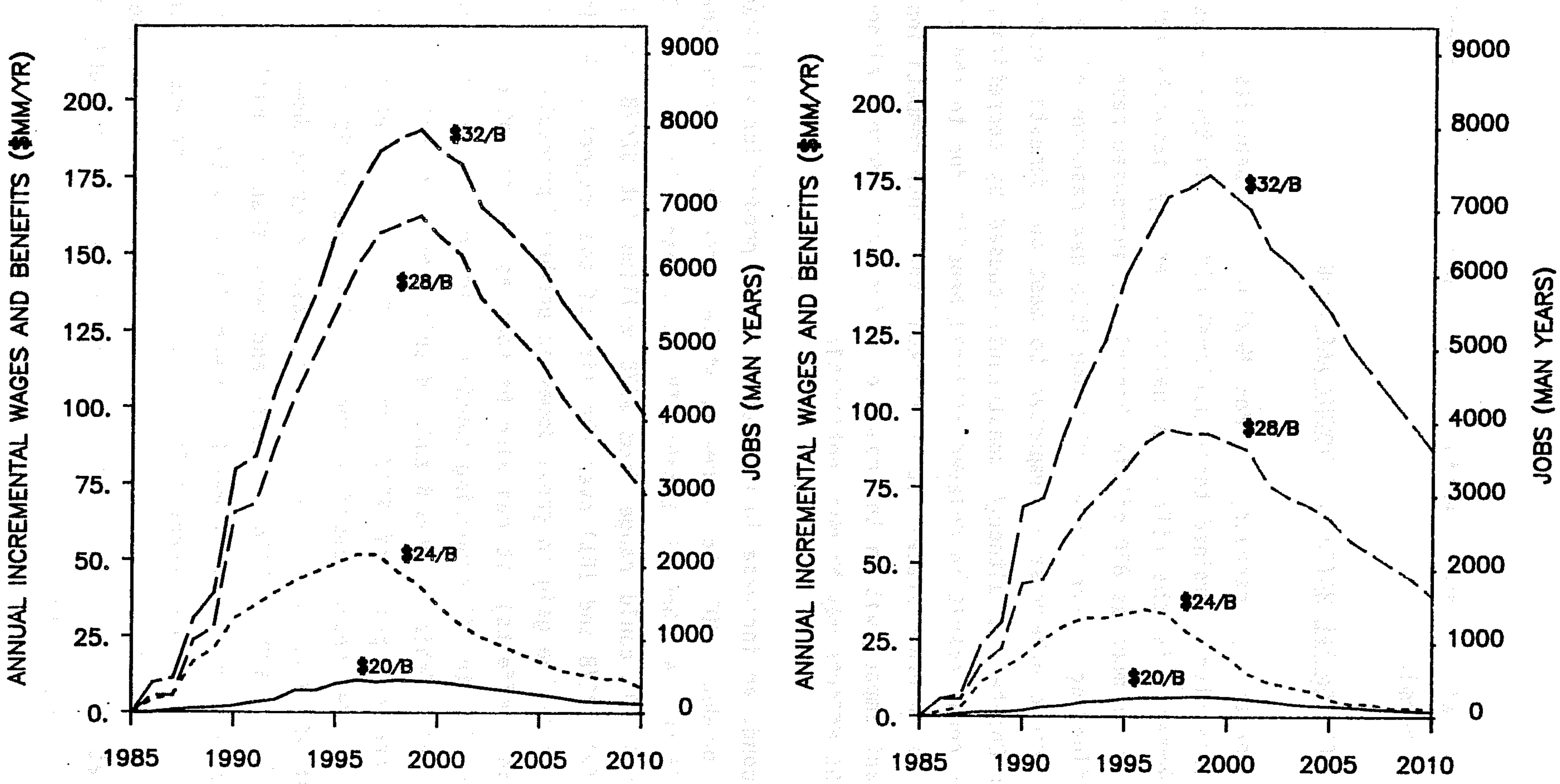
* Unlike other economic indicators estimated in the study, wages and jobs tend to be concentrated during the early development stage of projects. Therefore, they exhibit a higher peak and quicker decline than state and local revenues or direct economic activity. Throughout the project life wages and benefits are approximately 40% of the overall contribution to state economic activity. This percentage is slightly high due to the conservative estimate of direct economic activity, as discussed earlier.

EXHIBIT IV-5

ANNUAL INCREASE IN JOBS AND WAGES AND BENEFITS DUE TO CARBON DIOXIDE FLOODING UNDER CURRENT TAX STRUCTURE

A. 10% RATE OF RETURN

B. 15% RATE OF RETURN



SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

significant direct job creation if oil prices and corporate investment thresholds permit.

E. EFFECTS ON THE NATIONAL ECONOMY AND BUDGET

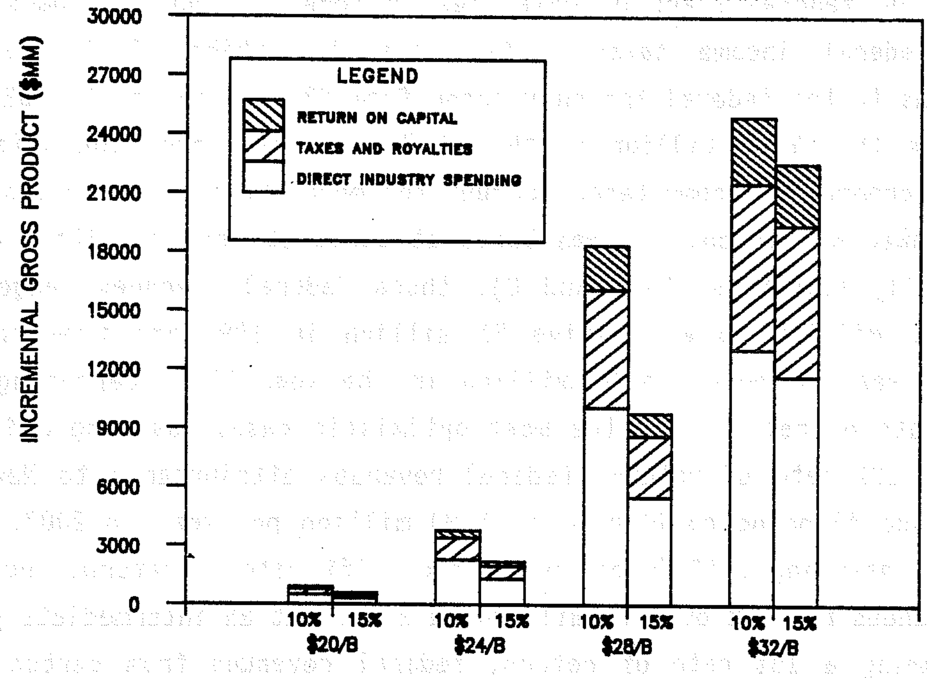
Increased oil recovery in New Mexico also benefits the nation as a whole. This study examined these national effects in three ways. First, and most important, is the effect on national energy security achieved by the addition of as much as 820 million barrels of increased reserves due to carbon dioxide flooding. Each barrel of producible new reserves offsets a barrel of oil that would otherwise be imported to meet our domestic supply needs. As noted in Chapter 3, although constraints caused by competition for limited resources could result in delayed national benefits due to short-term deferral of projects in other states, it is unlikely that such competition would have a significant impact within the range of prices considered, although at higher prices the effects may be more noticeable.

Second, an increase in New Mexico's oil production will cause the gross domestic product (GDP) to increase, while directly reducing the merchandise trade deficit. As shown in Exhibit IV-6A, irrespective of time, the aggregate incremental GDP could range from $570 million (at $20/B and 15%) to $24.9 billion (at $32/B and 10%) over the life of the projects. While this can be interpreted as the gain in gross domestic product (probably incurring economic "multiplier" effects), it can also be seen as the amount of funds that would otherwise flow to oil exporting countries (where few U.S. "multipliers" would be incurred). Exhibits IV-6 B and C display these estimates over time. At an intermediate oil price of $24/B and a 10% rate of return, carbon dioxide flooding in New Mexico could produce an increase in GDP of $250 million in 1997. At $32/B and a 10% rate, the increase in gross domestic product could be as high as $770 million in 1997 and more than $1 billion in 2004, the projected peak year. These may be interpreted as potential direct reductions in the nation's annual trade deficit, as these gross revenues directly reduce the annual cost of oil imports. At a 15% rate of return, the results are similar at the $20/B and $32/B oil prices, but considerably lower at the intermediate oil prices.

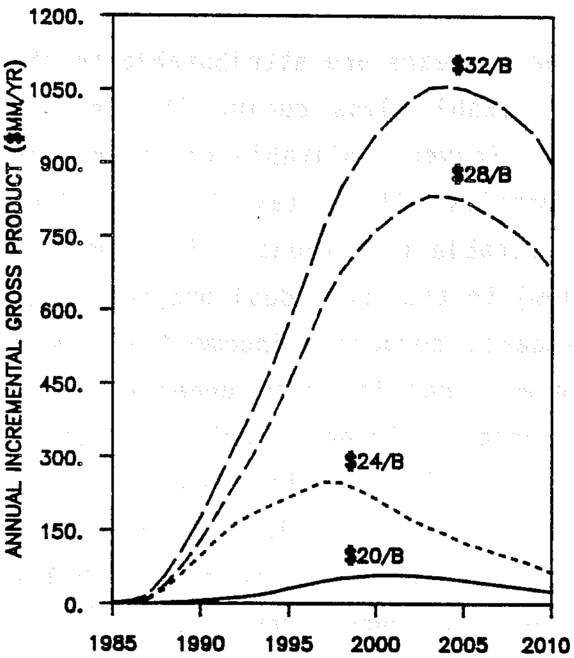
EXHIBIT IV–6

ESTIMATED INCREASE IN GROSS DOMESTIC PRODUCT DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO UNDER CURRENT TAX STRUCTURE

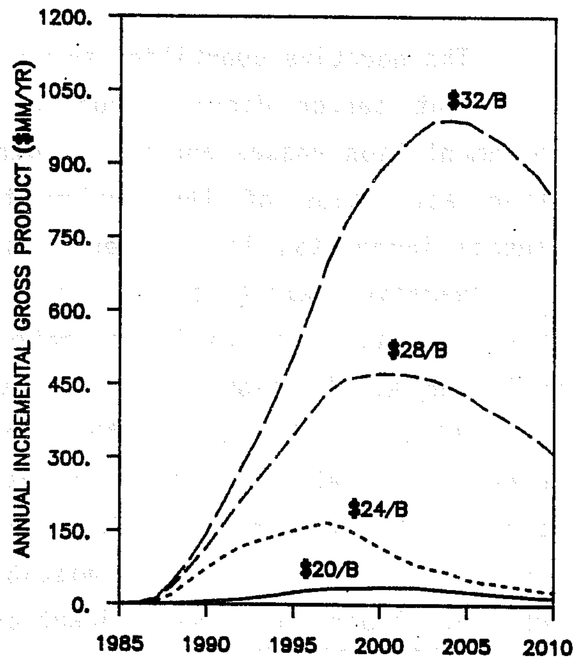
A. AGGREGATED INCREMENTAL GROSS PRODUCT BY OIL PRICE AND RATE OF RETURN



B. ANNUAL INCREMENTAL GROSS PRODUCT AT 10% RATE OF RETURN



C. ANNUAL INCREMENTAL GROSS PRODUCT AT 15% RATE OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

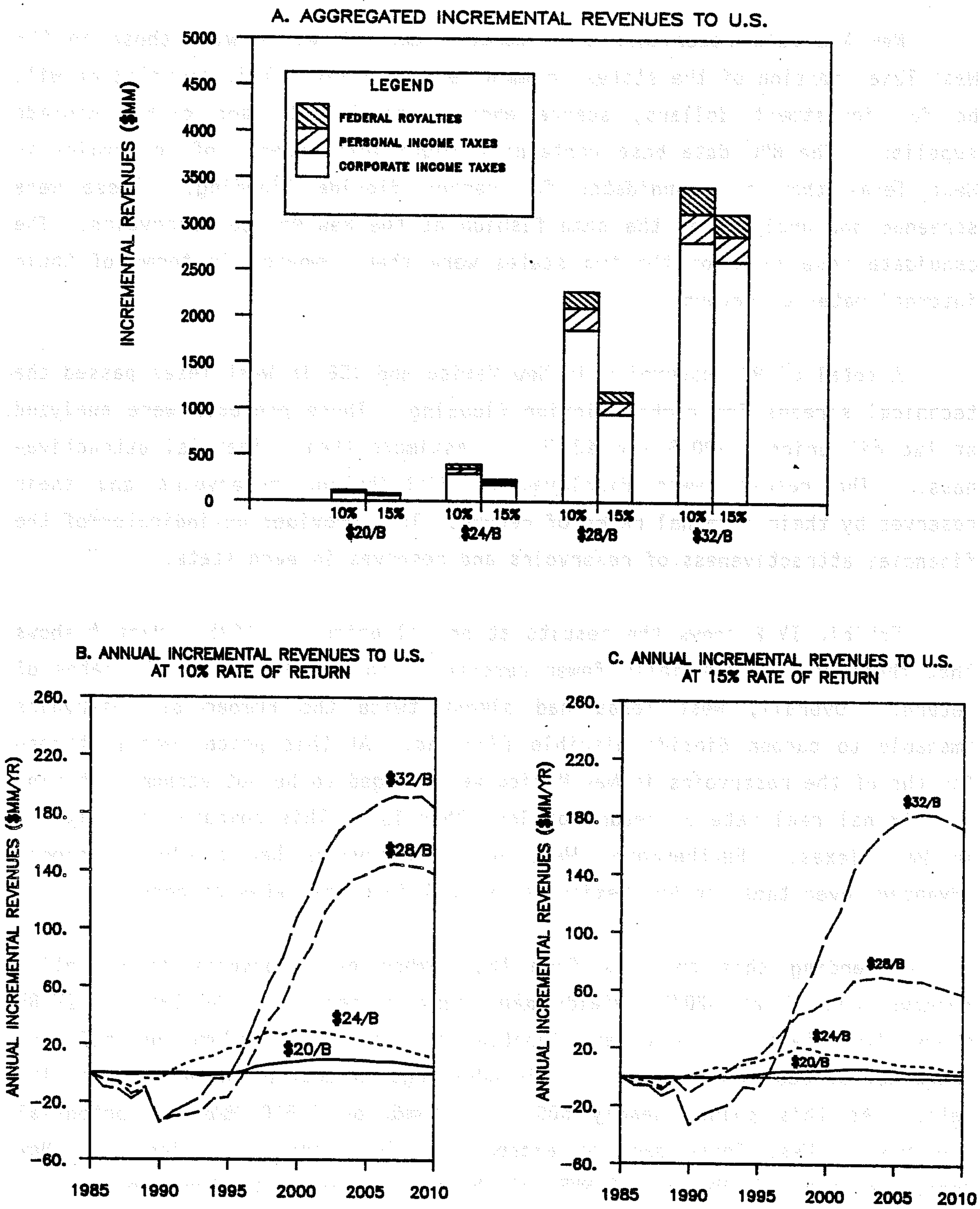
The third impact on the nation is the contribution that New Mexico's carbon dioxide flooding will make to federal revenues. This contribution will consist of the federal share of royalties on federal lands and personal and corporate federal income taxes. As shown in Exhibit IV-7A, aggregate contributions to the federal treasury range from $80 million in the $20/B, 15% case to more than $3.4 billion in the $32/B, 10% case over the life of the projects. Corporate income taxes account for more than three-fourths of this total, followed by personal income taxes at about 13% and royalties at about 9%.* Annually (Exhibits IV-7B and C), these federal revenues range from a negative $30 million to a positive $1 million in 1990 and from around $5 million per year to nearly $110 million in the year 2000, depending on oil price and rate of return. In the most optimistic case, assuming a $32/B oil price and a 10% rate of return, federal revenues attributable to New Mexico carbon dioxide flooding could peak at $190 million per year in 2007. In the lowest case, assuming a $20/B oil price and a 15% rate of return, incremental federal revenues peak at over $6 million in 2003. At an intermediate price of $24/B, assuming a 10% rate of return, federal revenues from carbon dioxide flooding would peak at $30 million in the year 2000; at 15%, they would peak two years earlier at just over $20 million. At $28/B, the comparable estimates are around $145 million at 10% and just over $70 million at 15%.

The negative quantities shown in the early years are attributable to the fact that carbon dioxide projects show a taxable loss during the initial implementation phases and the assumption that (given profitable operations in other activities of the implementing companies) these tax losses offset federal income tax liabilities from the profitable operations. This results in a "negative tax" (i.e., positive cash flow) to the individual projects. In this context, it is useful to note that federal corporate income taxes were evaluated at the highest current corporate marginal tax rate under existing law (46%). To the extent that operators enjoy a lower effective marginal federal corporate rate, both the early negative taxes and the later positive taxes would be reduced. These issues notwithstanding, it is clear that application of carbon dioxide miscible flooding to New Mexico reservoirs holds substantial promise of significant contributions to federal revenues.

* These estimates use the tax regulations in effect as of September 1986.

EXHIBIT IV-7

ESTIMATED INCREMENTAL REVENUES TO U.S. TREASURY DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO UNDER CURRENT TAX STRUCTURE



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

F. RELATIVE PROFITABILITY OF NEW MEXICO AND WEST TEXAS CARBON DIOXIDE PROJECTS

New Mexico's reservoirs will compete most directly with those in the West Texas portion of the states' common Permian Basin. This competition will be for investment dollars, scarce engineering talent, and carbon dioxide supplies. The NPC data base contains a significant number of reservoirs in West Texas that are candidates for carbon dioxide flooding. These were screened and analyzed in the same fashion as the New Mexico reservoirs. The candidate reservoirs of the two states were then compared in terms of their internal rates of return.

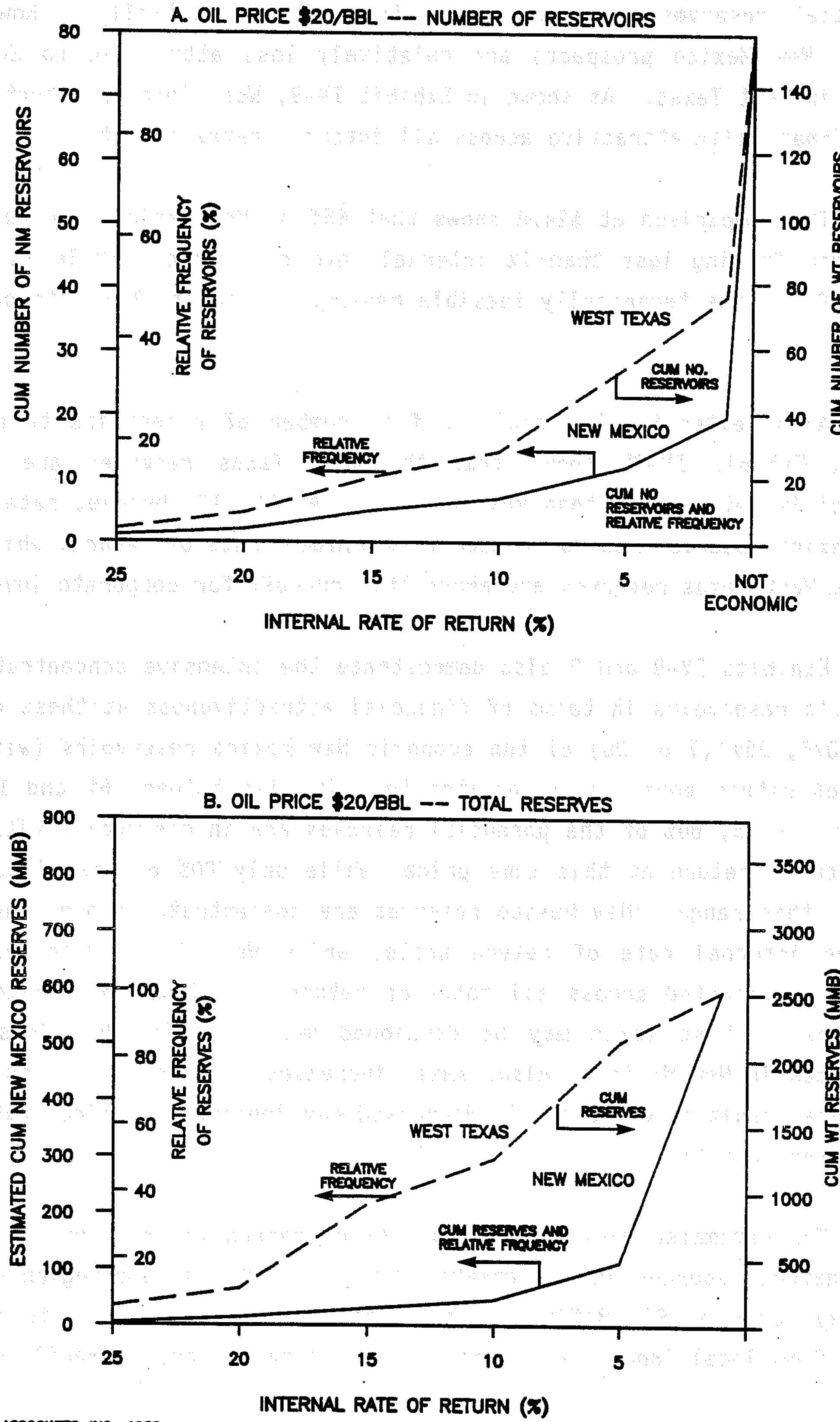
A total of 80 reservoirs in New Mexico and 156 in West Texas passed the technical screens for carbon dioxide flooding. These projects were analyzed at two oil prices, \$20/B and \$24/B, to estimate their financial attractiveness. The results were displayed by distributing reservoirs and their reserves by their internal rates of return. This provides an indicator of the financial attractiveness of reservoirs and reserves in each state.

Exhibit IV-8 shows the results at an oil price of \$20/B. Part A shows that there are substantially fewer reservoirs in New Mexico at all rates of return. Overall, West Texas had almost twice the number of reservoirs amenable to carbon dioxide miscible flooding. At this price, nearly three-fourths of the reservoirs in New Mexico were judged to be not economic (having an internal real rate of return of less than 1%). This compares to only 51% in West Texas. Furthermore, West Texas reservoirs had a clear economic advantage over those in New Mexico across all internal rates of return.

Extending this analysis from the number of reservoirs to potential reserves, still at \$20/B, yields many similar results. As Exhibit IV-8B shows, West Texas has a clear advantage in both total volume and relative frequency of economic reserves. This advantage is most pronounced at the 10% rate. At this point, nearly 50% (1,250 MMB of 2,520 MMB) of potential reserves in West Texas meet or exceed this investment criterion. In New Mexico, only 8% (50 MMB of 595 MMB) of the reserves would be developed.

EXHIBIT IV–8

COMPARISON OF NEW MEXICO AND WEST TEXAS CARBON DIOXIDE FLOODING RESERVOIRS IN TERMS OF FINANCIAL ATTRACTIVENESS



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

At an oil price of $24/B, the number of economic reservoirs and potential reserves in both states increase substantially. However, once again, New Mexico prospects are relatively less attractive to develop than those in West Texas. As shown in Exhibit IV-9, West Texas prospects are still more financially attractive across all internal rates of return.

The comparison at $24/B shows that 65% of New Mexico reservoirs are not economic (having less than 1% internal rate of return), while in West Texas only 38% of the technically feasible reservoirs are in this category (Exhibit IV-9A).

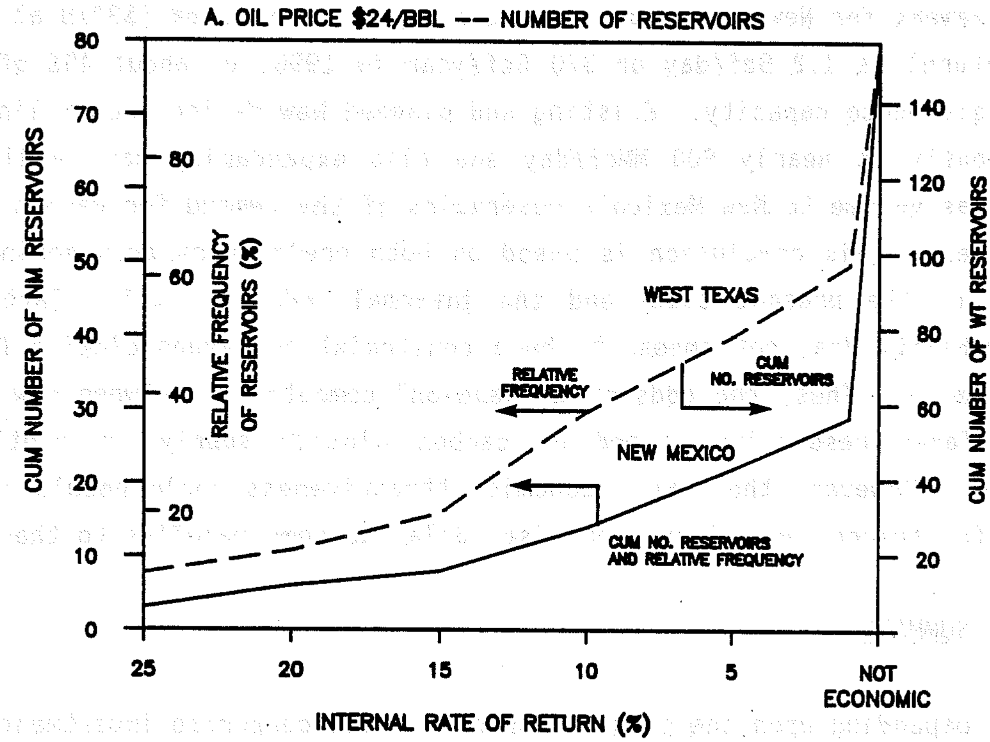
Also, extending the analysis from number of reservoirs to reserves at $24/B, Exhibit IV-9B shows that the West Texas reserves are still more financially attractive than New Mexico's. At the 10% hurdle, rate 22% of the New Mexico reserves meet or exceed this minimum rate of return, while over 65% of the West Texas reserves are above this cut-off for corporate investments.

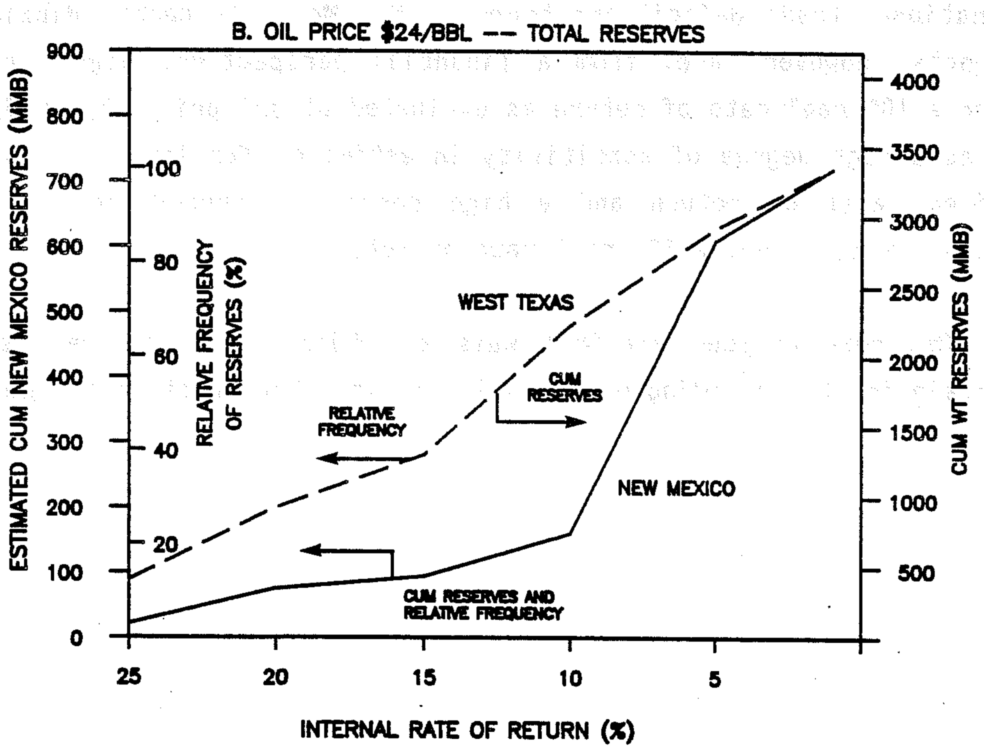
Exhibits IV-8 and 9 also demonstrate the intensive concentration of New Mexico's reservoirs in terms of financial attractiveness at these oil prices. At $20/B, 35% (7 of 20) of the economic New Mexico reservoirs (with internal rate of return equal to or greater than 1%) lie between 6% and 15% rate of return. Also, 80% of the potential reserves are in reservoirs with less than 5% rate of return at this same price, while only 20% of West Texas reserves are in this range. New Mexico reserves are concentrated around the lower end of the internal rate of return scale, while West Texas reserves are more evenly distributed across all rates of return. In times of limited capital, reserves in West Texas may be developed more rapidly than less lucrative prospects in New Mexico. Also, small increases in corporate investment could criteria result in dramatically decreased development, reducing state revenues and economic activity.

The estimated maximum availability of carbon dioxide through trunklines from natural sources in the greater West Texas-New Mexico region exceeds 2.5 Bcf/day, or over 900 Bcf/year, excluding carbon dioxide that is recycled or drawn from local industrial sources. This capacity could readily be expanded

EXHIBIT IV-9

COMPARISON OF NEW MEXICO AND WEST TEXAS CARBON DIOXIDE FLOODING RESERVOIRS IN TERMS OF FINANCIAL ATTRACTIVENESS





SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1988

to meet demand. The maximum purchased (i.e., not recycled) carbon dioxide requirement for New Mexico at the highest price displayed ($32/B at a 10% rate of return) is 1.0 Bcf/day or 370 Bcf/year in 1996, or about 40% of available natural-source capacity. Existing and planned New Mexico branch line capacity (currently at nearly 900 MMcf/day and also expandable) can readily deliver this gas volume to New Mexico's reservoirs if the demand for carbon dioxide is realized. This conclusion is based on both preliminary engineering calculations of the present study and the informal industry poll. Carbon dioxide availability does not appear to be a constraint on carbon dioxide flooding in New Mexico. Thus, the odds of a "head-on" competition between New Mexico and West Texas reservoirs, based on carbon dioxide supply, currently appears remote. However, the lower economic attractiveness could result in competition for scarce capital or expertise, delaying some benefits to the state.

G. SUMMARY

Depending upon the price of crude oil and corporate investment criteria, carbon dioxide miscible flooding could well sustain New Mexico's oil production into the twenty-first century, with corresponding, significant benefits to state and local government revenues, state economic activity, and the national trade deficit and budget. New Mexico's carbon dioxide flooding prospects, however, are, from a financial perspective, highly concentrated around a 10% real rate of return as evaluated at oil prices below $25/B. This creates a high degree of sensitivity in estimates for lower prices and higher required rates of return and a high degree of uncertainty as to whether operators will accept a 10% real rate of return.

The next chapter examines ways by which the state may reduce these uncertainties by providing economic incentives through state tax policy.

V. OIL PRODUCTION AND ECONOMIC EFFECTS OF CARBON DIOXIDE MISCIBLE FLOODING IN NEW MEXICO UNDER SELECTED STATE TAX INCENTIVES

A. INTRODUCTION

New Mexico state officials have defined a need to examine the effects on oil production and economic impacts of state tax incentives to encourage carbon dioxide flooding, such as those proposed in the 1985 legislative session. To meet this need, a series of analyses were conducted, the results of which are reported in this chapter. Two scenarios, in addition to the current tax structure, were developed to analyze the state's options for incentives to promote increased oil production by carbon dioxide flooding. All three tax cases are compared:

- Current taxes -- all state and federal taxes are as currently enacted (reported in Chapter IV), to serve as the principal point of comparison;
- "Incentives-to-Payback" -- state corporate income and production taxes are forgiven until the cumulative (undiscounted) net cashflow exceeds zero dollars, i.e., the "break even" point; and
- "Incentives-for-Life" -- state corporate income and production taxes are forgiven for the life of the eligible project, to be considered here as a maximum realistic state incentive.

These cases were selected to "bracket" the incentive options available to the state while addressing some of the key issues defined in the 1985 legislative session and numerous discussions of the subject over the intervening months. Numerous other options are available, including still more generous tax credits and royalty relief, and less generous variations in production and/or income taxes. The present study was not designed to analyze all available options; rather, its purpose is to provide insight to the legislative and administrative options of New Mexico officials who may choose to design more detailed incentive programs.

The presentation of the selected cases follows the general outline of the analysis of the current tax case, presented in Chapter IV. First, the cases are compared in terms of incremental reserves and production attributable to carbon dioxide flooding. Next, the effects on incremental state and local revenues (after deductions for the costs of the incentives) are contrasted. This is followed by comparisons of the three cases' impacts on New Mexico's economy (including jobs and wages), and their national effects in reducing the trade deficit due to oil imports and in generating revenues to the federal government. Finally, the effects of the incentives on potential competition for capital and expertise with West Texas projects are addressed. While each section draws tentative conclusions, the overall conclusions and recommendations are developed in Chapter VI.

The three cases were analyzed under the same conditions as reported in Chapter IV, i.e., oil prices ranging from $16/B to $40/B in four-dollar increments and at 10% and 15% required minimum rates of return. All analyses are expressed in constant, real (inflation-free) terms. The range of prices, rates of return, and tax structures together were defined to encompass essentially all the circumstances that might be encountered over the 25-year study period.

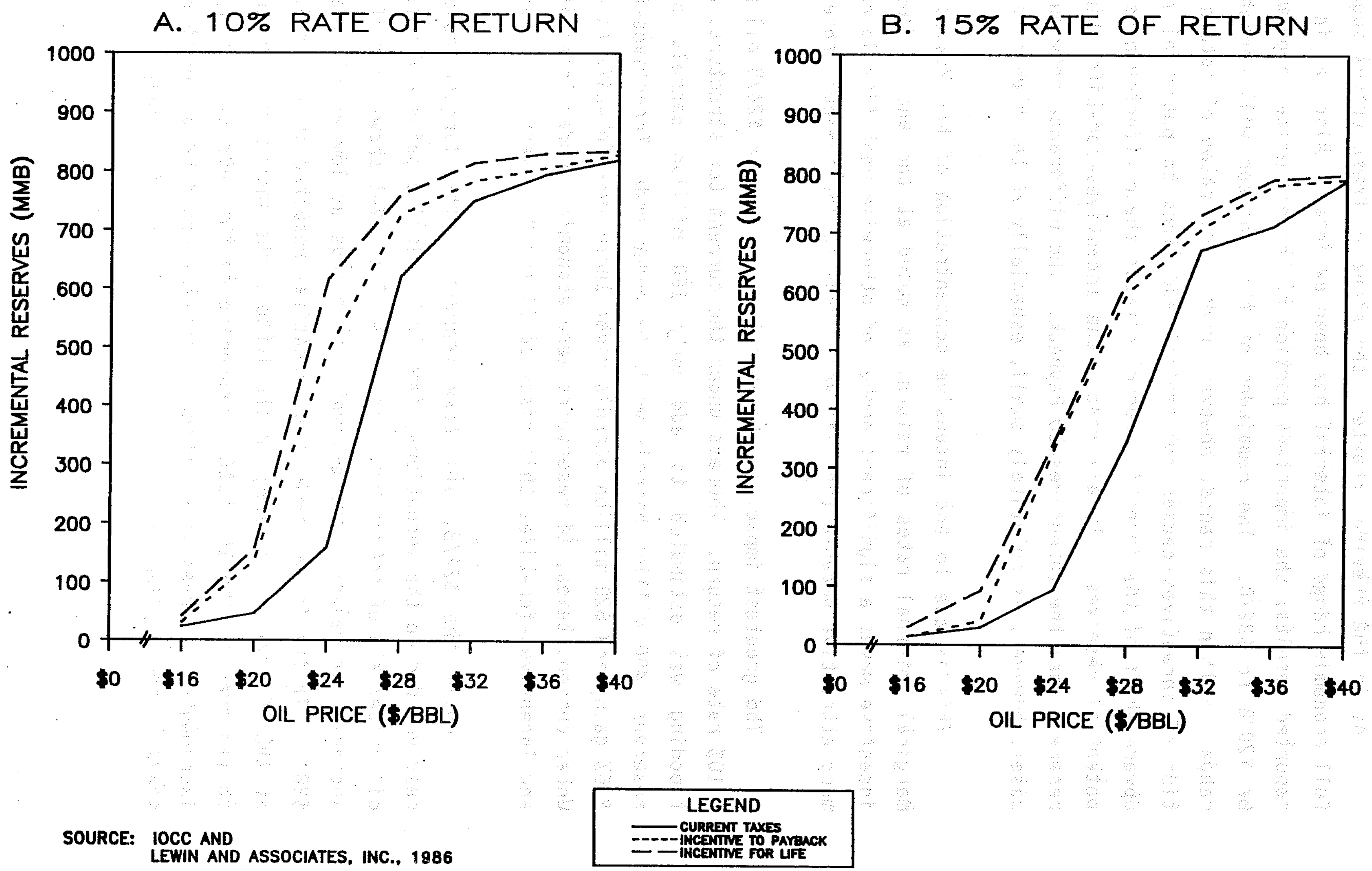
B. RESERVES AND PRODUCTION

As in the case of current taxes, estimates of potential incremental reserves and production were found to be highly sensitive to assumptions about oil price and rate of return. Exhibit V-1 shows the potential reserve additions due to carbon dioxide flooding in New Mexico at prices ranging from $16/B to $40/B and under the three tax cases. Part A illustrates the potential of carbon dioxide flooding under each tax structure at a 10% rate of return, and part B shows the dampened effects of the same price and taxation cases at the 15% rate of return.

These curves can be interpreted in the same way as those in Chapter IV. The very small amount of economic reserves at $16/B under any of the cases can be read as the essential absence of economic carbon dioxide flooding below this price. The flattening of the curves at about $32/B and their convergence by $40/B argues that at prices above about $32/B, the prospects are beginning to become exhausted.

EXHIBIT V–1

POTENTIAL INCREMENTAL RESERVE ADDITIONS DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO UNDER THREE TAX STRUCTURES BY OIL PRICES



SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

As in the previous chapter, the shape of these curves suggests that the full economic range of interest has been explored. Also, as in the previously reported results, the important portion of the oil price range would appear to be \$20/B to \$32/B. The remainder of this chapter will concentrate on this range. Within this range, however, under both rates of return, the application of incentives causes substantial additions to potential reserves. The upward shift of the incentive curves reveals their effectiveness in increasing potential reserves. In all cases, the Incentives-for-Life stimulate greater reserves than the Incentives-to-Payback. The difference between the incentive cases, however, is relatively small, especially at the higher rate of return.

This is due to the intensive concentration of New Mexico reservoirs at marginal internal rates of return, as noted at the end of Chapter IV. The incentive makes a significant number of otherwise unprofitable reservoirs much more attractive because they lie very close to the economic threshold.

The greatest impact of the incentives is at the \$24/B oil price assuming a 10% rate of return. Whereas under the current tax structure, carbon dioxide flooding was estimated to add only 160 million barrels of incremental reserves; 490 million barrels would be added under Incentives-to-Payback; (a 206% gain) and 620 million barrels under Incentives-for-Life (a gain of 288%). Under current taxes, 14 reservoirs were economic. Under Incentives-to-Payback and Incentives-for-Life, this rises to 23 and 26 reservoirs, respectively.

While the \$24/B, 10% case represents the largest absolute gain in reserves due to the incentives, important relative gains are noted at numerous oil price/rate of return conditions. As Table V-1 shows, significant relative increases in reserves are estimated at prices as low as \$20/B and as high as \$28/B. In the former case, the incentives resulted in a tripling of reserves at the 10% rate of return; in the latter, the incentives add nearly 80% more to reserves at the 15% rate. Depending on the rate of return, New Mexico's incremental reserves from enhanced recovery could be at least doubled in the \$24/B to \$28/B price range if incentives are made available.

TABLE V-1

EFFECTS OF INCENTIVES ON POTENTIAL RESERVE ADDITIONS DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO*

Oil Price ($/BBL)	At 10% Rate of Return: Current Taxes (MMB)	Incentives-to-Payback (MMB)	Incentives-to-Payback (%GAIN)	Incentives-for-Life (MMB)	Incentives-for-Life (%GAIN)	At 15% Rate of Return: Current Taxes (MMB)	Incentives-to-Payback (MMB)	Incentives-to-Payback (%GAIN)	Incentives-for-Life (MMB)	Incentives-for-Life (%GAIN)
16	20	30	50	40	100	10	10	0	30	200
20	50	140	180	160	220	30	40	33	90	200
24	160	490	206	620	288	100	330	267	340	278
28	620	730	18	760	23	350	600	71	620	77
32	750	780	4	810	8	670	710	6	730	9
36	790	810	3	830	5	710	780	10	790	11
40	820	830	1	830	1	790	790	0	800	1

* Reserve additions rounded to nearest 10 million barrels.

In interpreting these dramatic shifts, it is important to recall that, because this study uses average properties to characterize highly heterogeneous real reservoirs, individual reservoirs are considered economic or uneconomic as whole units. Undoubtedly, better-than-average portions of reservoirs determined to be uneconomic as a whole would still be amenable to profitable carbon dioxide flooding. To the extent this may be true, these estimates of potential incremental reserves may be understated. Given the concentration of reservoirs near the economic margin, these dramatic shifts are unavoidable using the present methodology. On the other hand, if such understatement is present at the $24/B case, it is also present, although with reduced significance, at the other oil prices.

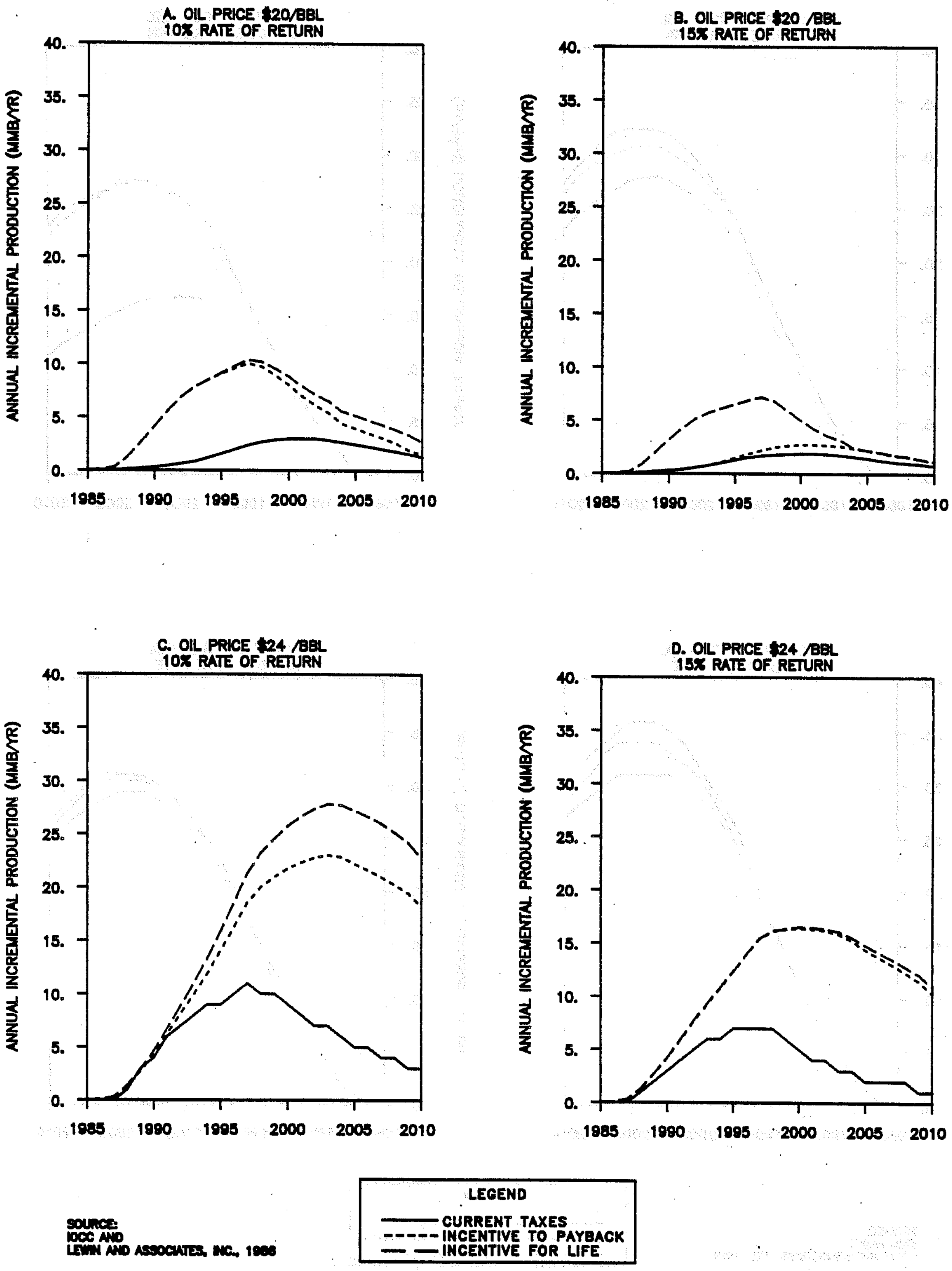
The potential reserve additions at $24/B with the incentives are approximately the same as those at $28/B without the incentives. Similar relative results are notable at $20/B. This argues that, in this highly sensitive price range, the incentives could have an effect on reserve additions comparable to a $4/B increase in oil price, although the actual incentive is less than two dollars per barrel at this price.

While the incentives have a dramatic effect on increasing potential at lower analyzed oil prices, they are substantially less effective at higher prices in stimulating reserve additions due to carbon dioxide flooding. In fact, by the time oil price reaches $32/B at either rate of return, both incentives have essentially lost their ability to stimulate additional reserves over the current tax structure.

Having analyzed the aggregate potential reserve additions from current taxes and incentives, it is important to examine the relative timing of these reserve additions as well. Exhibit V-2 shows projected annual production under the three tax cases at four prices, from $20/B to $32/B, and both rates of return. This exhibit reiterates the trends observed in the estimated reserve additions. In all cases, higher prices, lower rates of return and the availability of incentives result in increased production. The effects of the incentives, however, are not uniform over all conditions. At $20/B and a 10% rate of return, either incentive case would stimulate a three-fold increase in production by the late 1990s, although only the Incentives-for-Life case would

EXHIBIT V-2

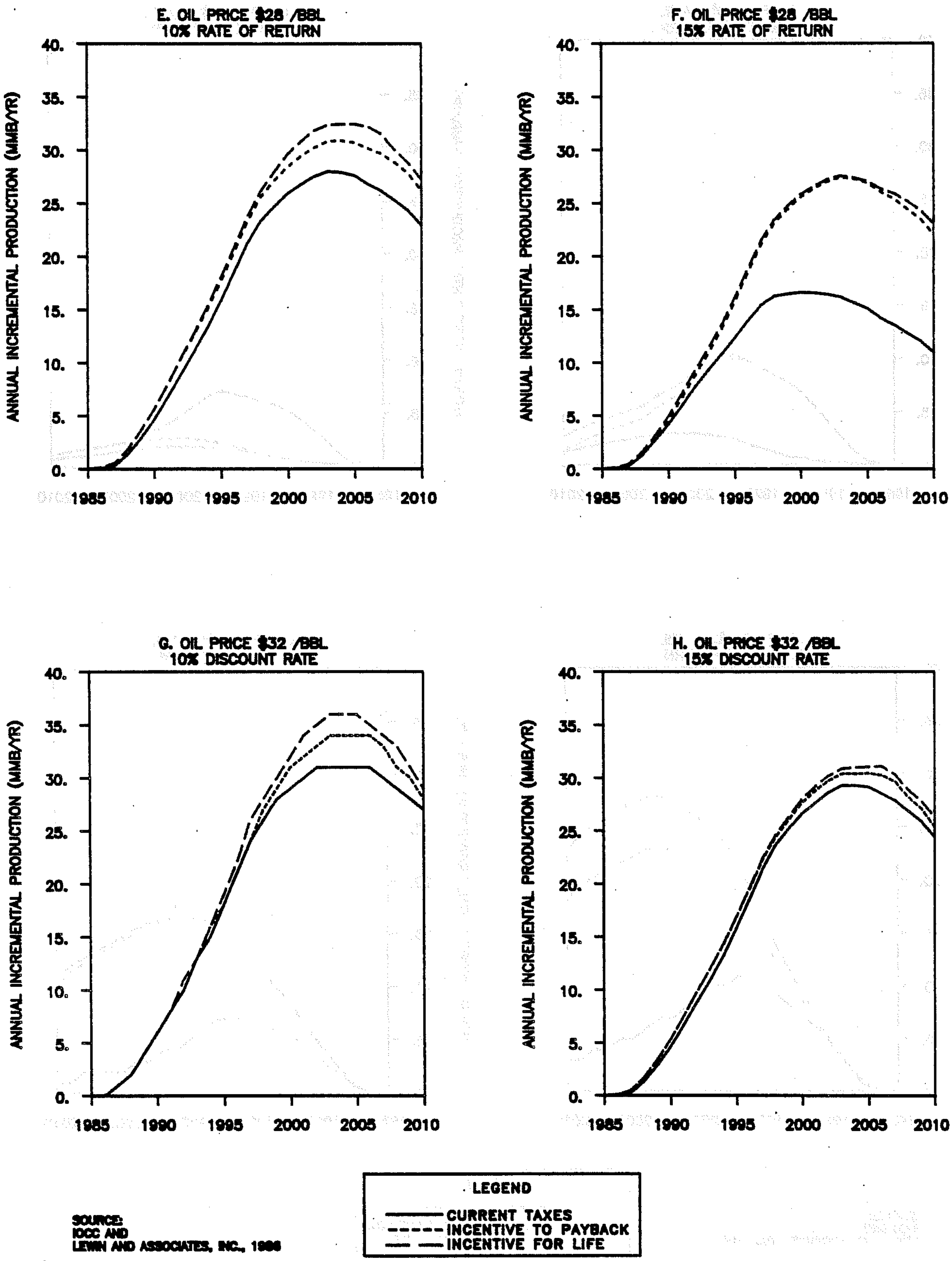
POTENTIAL ANNUAL INCREMENTAL OIL PRODUCTION DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO FOR THREE TAX STRUCTURES AT SELECTED OIL PRICES & RATES OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

EXHIBIT V-2 (CONT.)

POTENTIAL ANNUAL INCREMENTAL OIL PRODUCTION DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO FOR THREE TAX STRUCTURES AT SELECTED OIL PRICES & RATES OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

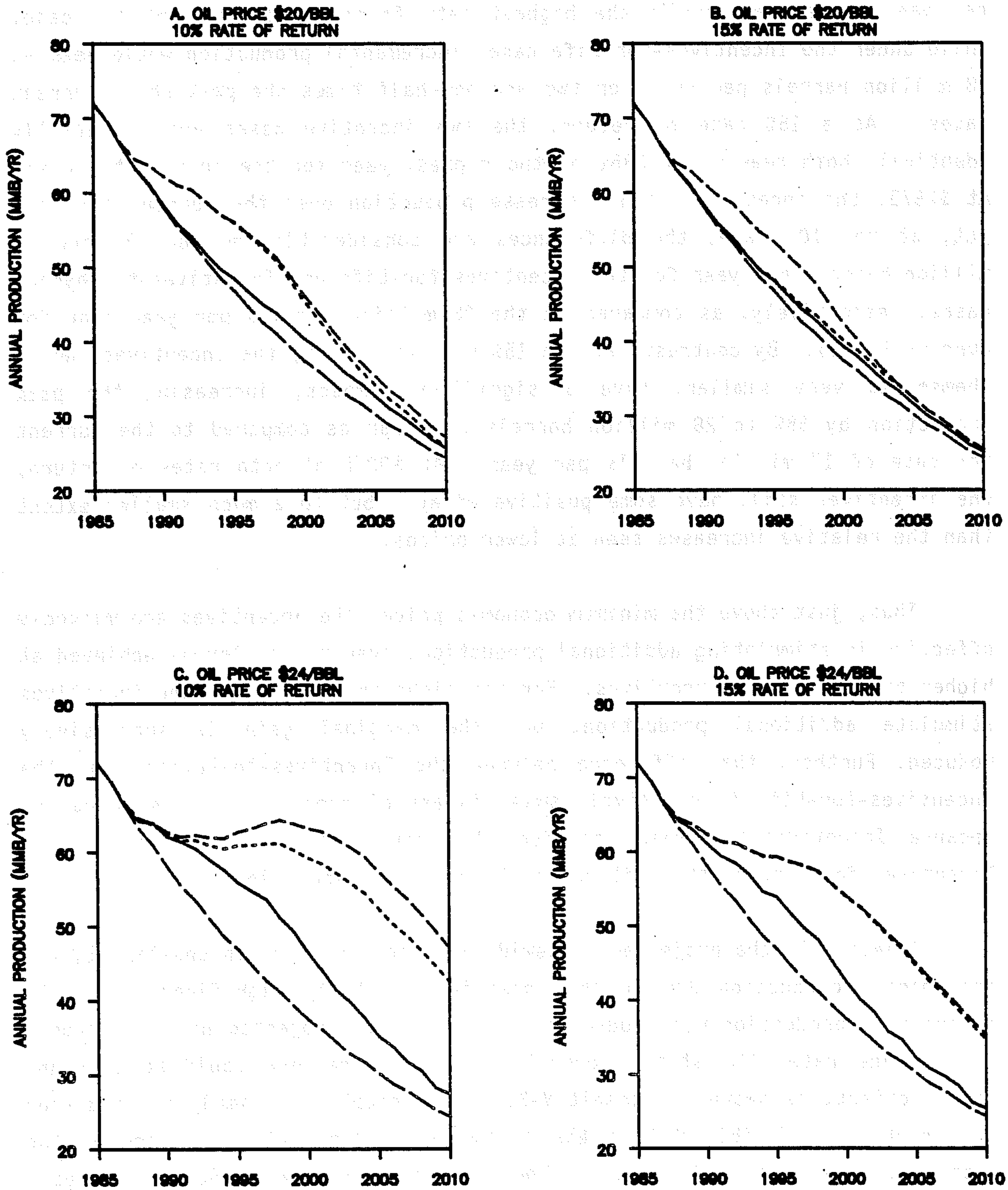
make a significant difference at the 15% rate of return. At $24/B, both incentives stimulate significant increases over the current tax case. Incremental production under Incentives-to-Payback peaks at 23 million barrels per year, more than double the highest rate found in the current tax case, while under the Incentives-for-Life case, incremental production would peak at 28 million barrels per year, or two and one-half times the peak under current taxes. At a 15% rate of return, the two incentive cases are essentially identical, both peaking at 235% of the highest year for the current tax case. At $28/B, the incentives still increase production over the current tax case but, at the 10% rate, the differences are considerably smaller (32 and 31 million barrels per year for the Incentives-for-Life and Incentives-to-Payback cases, respectively, as compared to the 28 million barrels per year peak for current taxes). By contrast, at the 15% rate of return, the incentives, while themselves very similar, have a significant impact, increasing the peak production by 65% to 28 million barrels per year as compared to the current tax case of 17 million barrels per year. At $32/B at both rates of return, the incentives still have some positive effect, but to a much smaller extent than the relative increases seen at lower prices.

Thus, just above the minimum economic price, the incentives are markedly effective in stimulating additional production, even to the levels achieved at higher prices without incentives. For the higher prices shown, the incentives stimulate additional production, but the marginal gain is successively reduced. Further, the difference between the Incentives-to-Payback and the Incentives-for-Life is relatively small in annual production, in most cases, because Incentives-to-Payback provide the same cash flow to operators as Incentives-for-Life in the critical early years of production.

Relative to the projected statewide decline discussed in Chapter II, the incremental production due to the incentives could be significant. If the incremental production were added to the production projected by the historical decline rate, the state's overall production decline could be substantially offset, as shown in Exhibit V-3. These graphs are simply the addition of the data in Exhibit V-2 to the statewide decline rate projected on the historical basis (Exhibit II-3). Even at prices as low as $20/B, the gain in production rates is notable in the overall state context. At the

EXHIBIT V-3

POTENTIAL EFFECTS ON TOTAL PRODUCTION DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO FOR THREE TAX STRUCTURES AT SELECTED OIL PRICES & RATES OF RETURN



LEGEND

PROJECTED CONV. PRODUCTION

TOTAL PRODUCTION W/CO2, ASSUMING

CURRENT TAXES

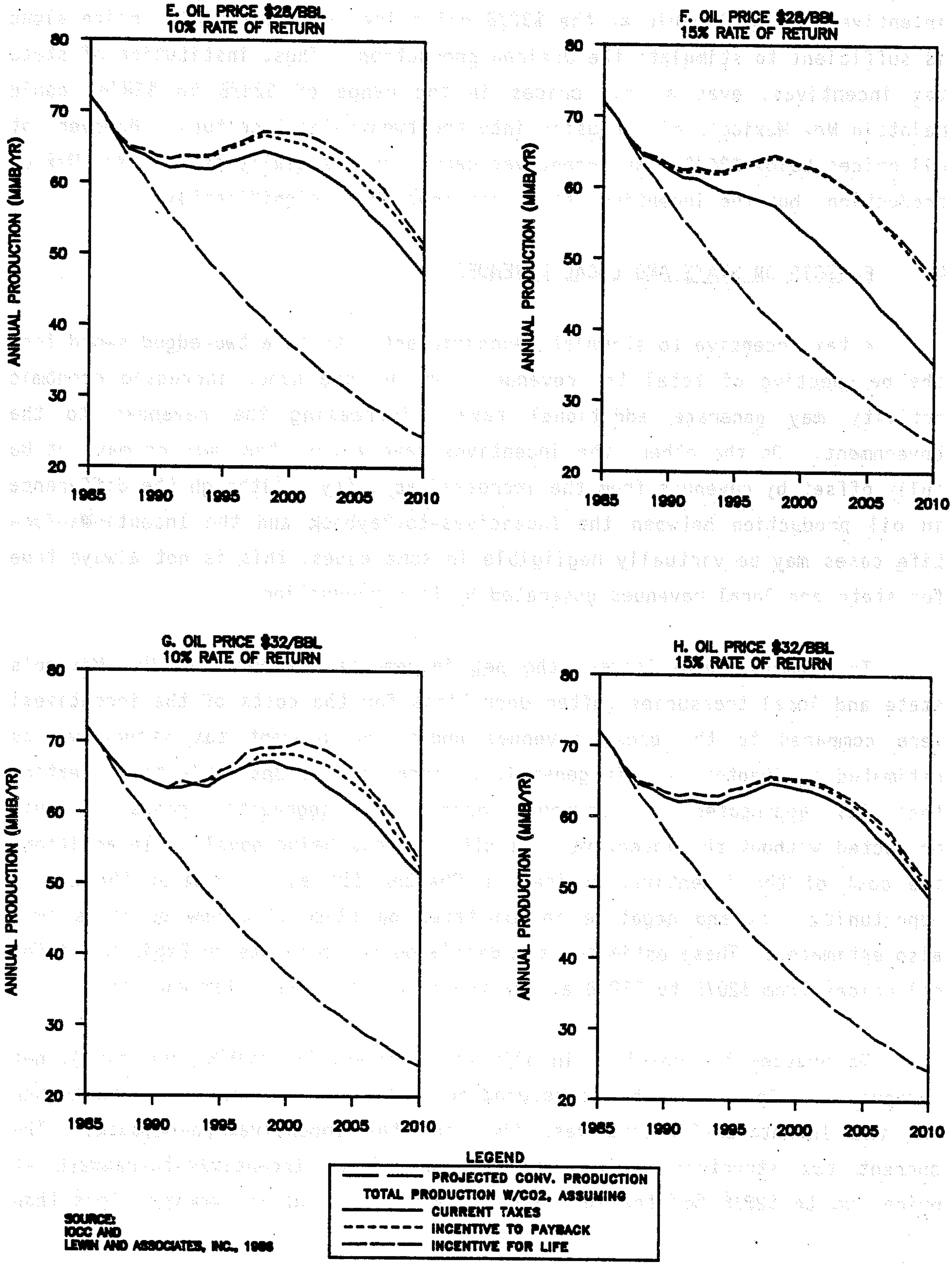
INCENTIVE TO PAYBACK

INCENTIVE FOR LIFE

SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

EXHIBIT V-3 (CONT.)

POTENTIAL EFFECTS ON TOTAL PRODUCTION DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO FOR THREE TAX STRUCTURES AT SELECTED OIL PRICES & DISCOUNT RATES



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

intermediate prices of $24/B and $28/B, the incentives could substantially offset New Mexico's projected decline rate. The additional gains due to the incentives are negligible at the $32/B oil price, as the elevated price alone is sufficient to stimulate the desired production. Thus, institution of state tax incentives, even at oil prices in the range of $24/B to $28/B, could maintain New Mexico's oil industry into the twenty-first century. However, at oil prices below $24/B, the incentives cannot substantially restore New Mexico production, but the incentives still can contribute significantly.

C. EFFECTS ON STATE AND LOCAL REVENUES

A tax incentive to stimulate economic activity is a two-edged sword from the perspective of total tax revenue. On the one hand, increased economic activity may generate additional taxes, increasing the revenues to the government. On the other, the incentives have a cost that may or may not be fully offset by revenues from the increased activity. Although the difference in oil production between the Incentives-to-Payback and the Incentives-for-Life cases may be virtually negligible in some cases, this is not always true for state and local revenues generated by this production.

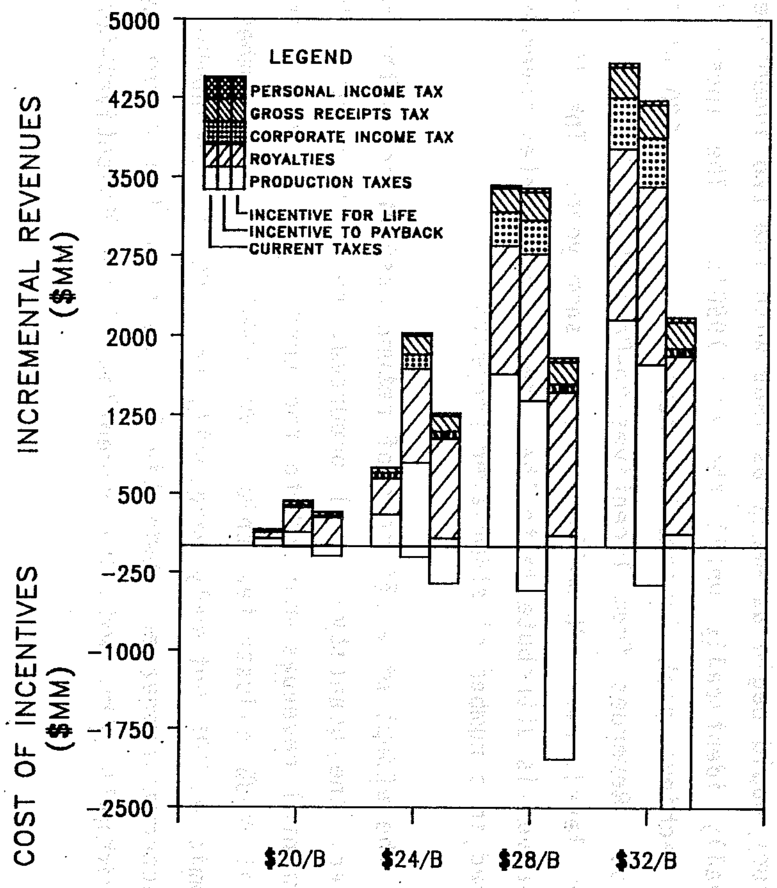
To examine these issues, the net incremental revenues to New Mexico's state and local treasuries (after deductions for the costs of the incentives) were compared to the gross revenues under the current tax structure, as estimated in Chapter IV. In general, an incentive is desirable to the extent that its aggregated net revenues exceed the aggregated gross revenues projected without the incentive (all other things being equal). In addition, the cost of the incentive, defined in Chapter III as the sum of the direct opportunity cost and negative income taxes on stimulated new projects, was also estimated. These estimates are displayed in aggregate in Exhibit V-4 for oil prices from $20/B to $32/B at the two rates of return, 10% and 15%.

To preview the results, in all cases (except the $20/B, 15% case), net revenues are lower and the corresponding costs of the incentives are higher for the Incentives-for-Life case than for the Incentives-to-Payback. The current tax structure yields less revenues than Incentives-to-Payback at prices up to $28/B for the 10% rate of return, and up to somewhat less than

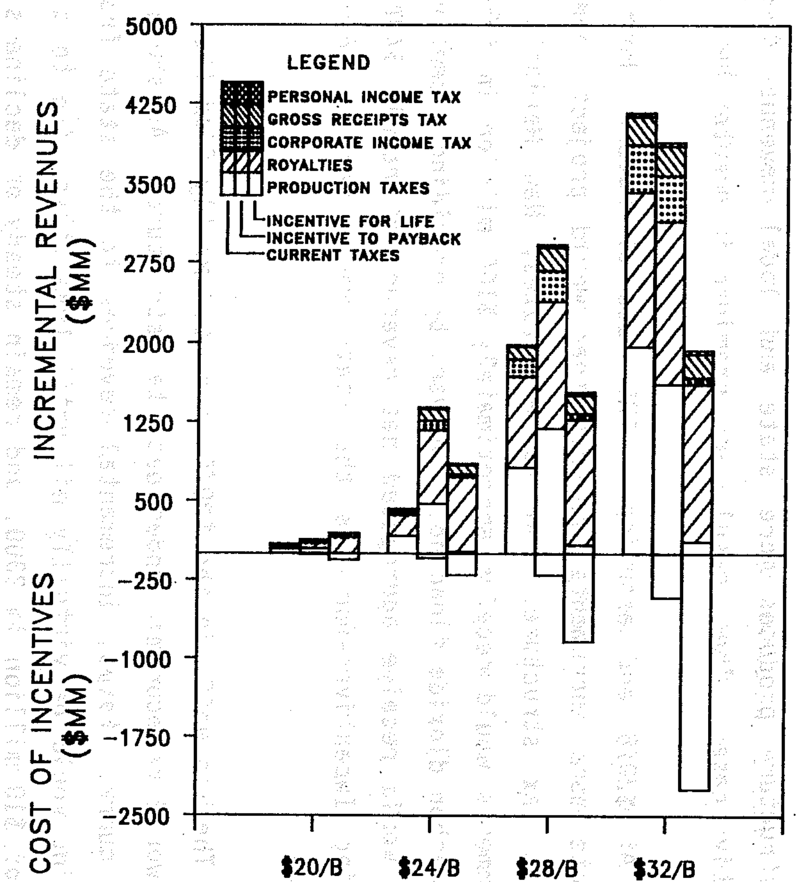
EXHIBIT V–4

POTENTIAL AGGREGATED INCREMENTAL REVENUE AND COST OF INCENTIVES TO STATE AND LOCAL TREASURIES FROM CARBON DIOXIDE FLOODING FOR THREE TAX STRUCTURES AT SELECTED OIL PRICES AND RATES OF RETURN

A. 10% RATE OF RETURN



B. 15% RATE OF RETURN



SOURCE: IOCC AND LEWIN AND ASSOCIATES, INC., 1986

$32/B at the 15% rate. At oil prices higher than these levels, the current tax structure produces more state and local revenues than either of the incentive cases. These results are examined in greater detail below.

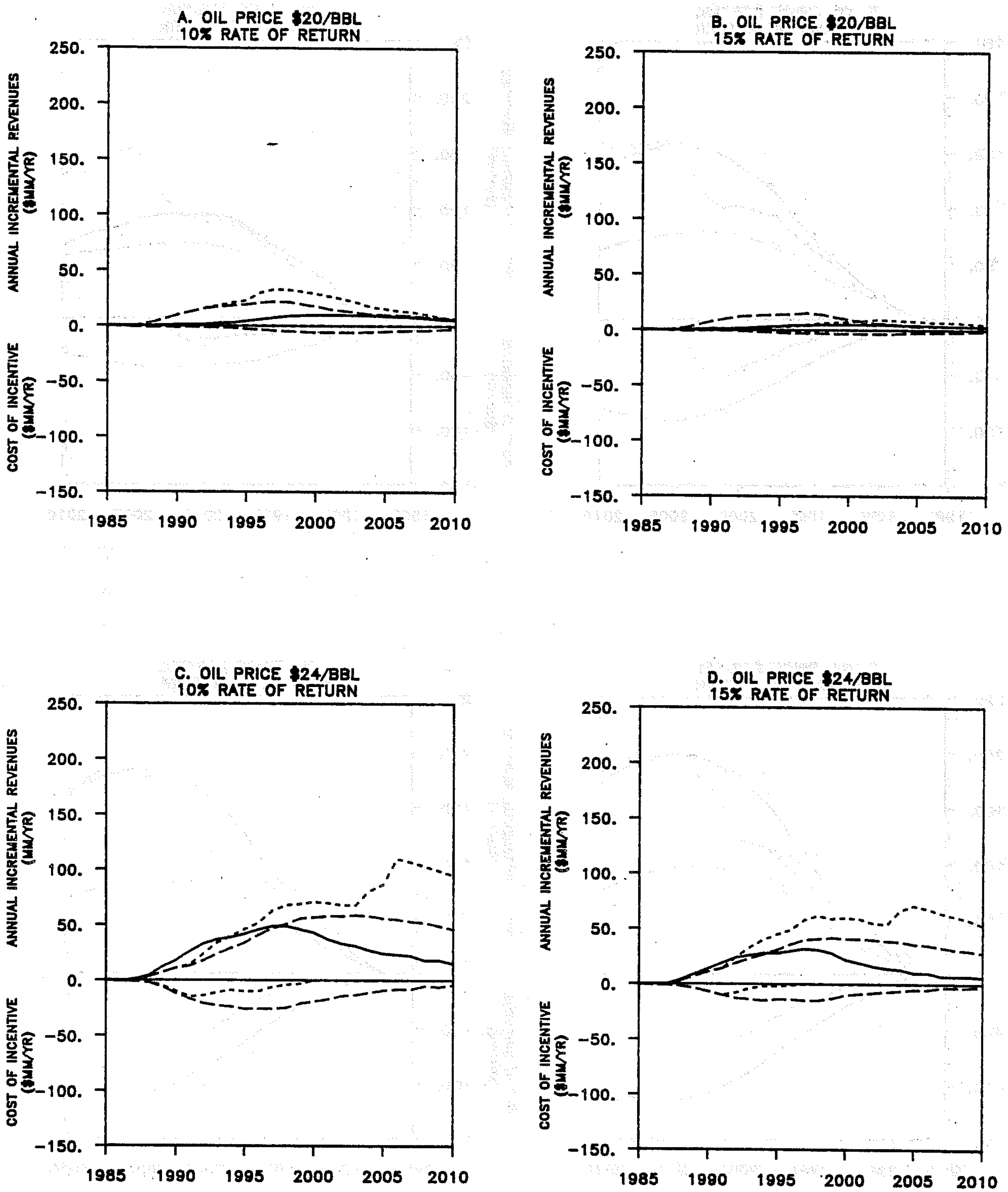
At $20/B and assuming a 10% rate of return, both incentive cases generate more incremental revenue than would projects operating under the current tax structure. At current taxes, New Mexico's state and local governments would receive approximately $160 million in incremental revenues from carbon dioxide flooding. However, by providing Incentives-to-Payback the state would receive aggregated net revenues of nearly $440 million, and by granting Incentives-for-Life the state would gain a total of about $330 million.

The tradeoffs in the $20/B case stem mostly from the timing of projects that would be economic under each tax structure. As shown in Exhibit V-5A, under current taxes, incremental revenues to the state from carbon dioxide flooding would be virtually nil until 1993, then rise to a peak incremental gain of $10 million in 2000, and remain steady or decline slightly each year thereafter. In the incentive cases, however, the situation is quite different. Moderate increases in activity resulting in revenue flows to the treasury would begin as early as 1988 with the two incentives curves tracking virtually identically until the mid 1990's. The Incentives-for-Life case would achieve peak incremental revenues of over $20 million in the late 1990's. Revenues from Incentives-to-Payback would peak at a substantially higher level, over $30 million, in the same year. The difference between the two curves is attributable to the flow of incremental revenues as "payback" is reached in a number of stimulated projects.

The effect of a 15% rate of return assumption on the number of projects started, the quantity of oil produced, and consequently the volume of net incremental revenues accrued to the treasury is dramatic in the $20/B case. Exhibit V-5B illustrates this. At $20/B, a small number of projects are economic at 10% but only marginally so. At 15% the number of projects that are economic decreases substantially. As such, the incremental revenue curves are virtually flat with the exception of the Incentives-for-Life case which

EXHIBIT V-5

POTENTIAL ANNUAL INCREMENTAL REVENUE AND COST OF INCENTIVES TO STATE AND LOCAL TREASURIES FROM CARBON DIOXIDE FLOODING FOR THREE TAX STRUCTURES AT SELECTED OIL PRICES AND RATES OF RETURN



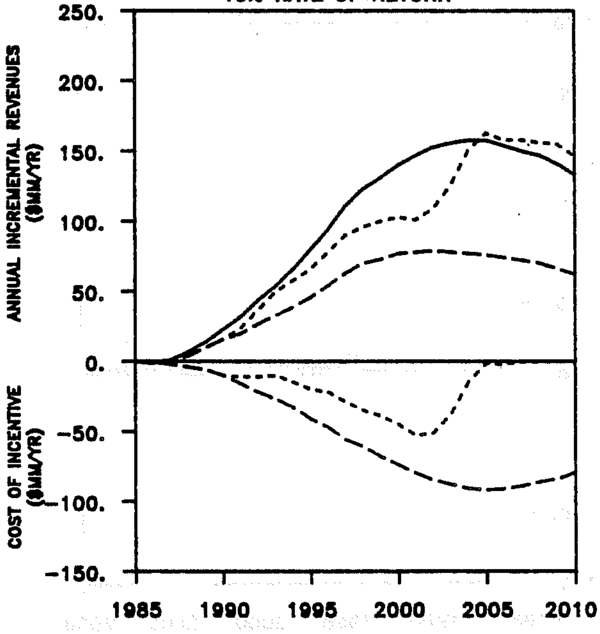
LEGEND
- CURRENT TAXES
- INCENTIVE TO PAYBACK
- INCENTIVE FOR LIFE

SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

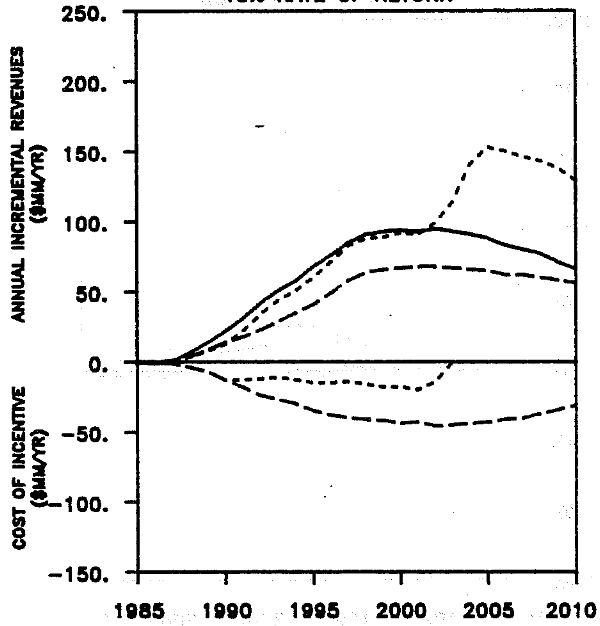
EXHIBIT V-5 (CONT.)

POTENTIAL ANNUAL INCREMENTAL REVENUE AND COST OF INCENTIVES TO STATE AND LOCAL TREASURIES FROM CARBON DIOXIDE FLOODING FOR THREE TAX STRUCTURES AT SELECTED OIL PRICES AND RATES OF RETURN

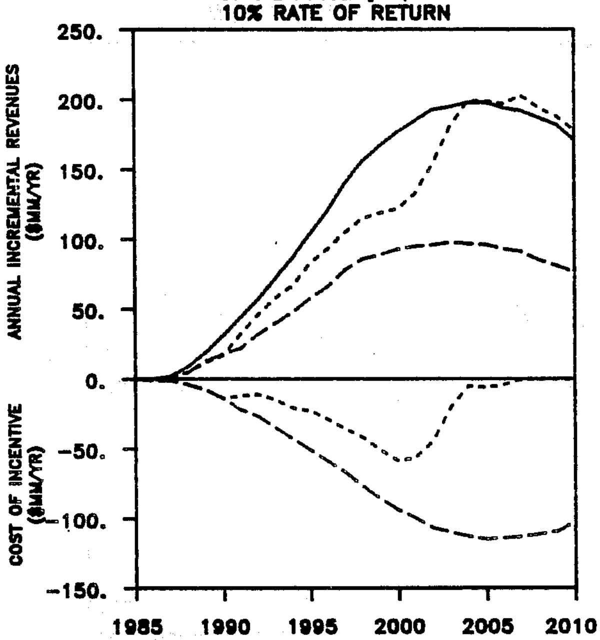
E. OIL PRICE $28/BBL
10% RATE OF RETURN



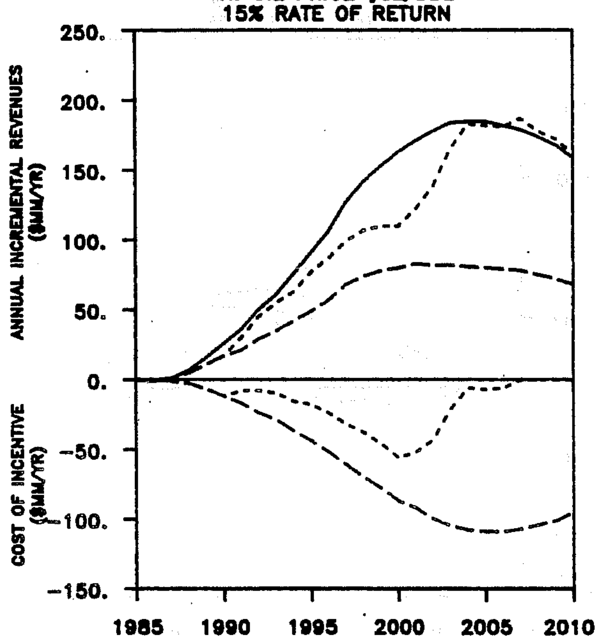
F. OIL PRICE $28/BBL
15% RATE OF RETURN



G. OIL PRICE $32/BBL
10% RATE OF RETURN



H. OIL PRICE $32/BBL
15% RATE OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

LEGEND

- ——— CURRENT TAXES
- - - - - INCENTIVE TO PAYBACK
- — — INCENTIVE FOR LIFE

would yield slightly more than $10 million per year in incremental revenues for a period of ten years, and an overall total of $190 million.

At $24/B, assuming the 10% minimum rate of return, both incentive cases generate more revenues than would current taxes over the full period of the projections. Even under current taxes, the increase in total net revenues to the state is substantial, rising from $160 million (at $20/B) to over $750 million, distributed among the various taxes as shown in Exhibit V-4A. Granting Incentives-to-Payback would increase aggregate incremental net revenues to more than $2 billion (a gain of 266%) due to the significantly increased production. The cost of the Incentives-to-Payback, $100 million, has been subtracted from the gross revenue estimate to arrive at an estimate of net revenues to state and local treasuries. By contrast, under Incentives-for-Life, the sum of incremental revenues to the state and localities is substantially reduced to $1.3 billion for production that is negligibly greater than that which could be achieved under the Incentives-to-Payback. This is a reflection of the higher costs ($350 million) of the incentive program.

The 15% rate of return case follows the same pattern as the 10% case except at a somewhat dampened level that reflects the inability of some projects to become economic at the higher minimum rate of return. The comparable aggregate incremental revenues are $430 million under current taxes, $1.4 billion for Incentives-to-Payback, and $860 million for Incentives-for-Life.

Parts C and D of Exhibit V-5 illustrate the annual potential incremental revenues that would accrue to state and local treasuries at a $24/B oil price and minimum rates of return of 10% and 15%, respectively, for each of the three tax structures. As suggested in the aggregates, the current tax case yields the lowest revenue, Incentives-for-Life the next higher, and Incentives-to-Payback the highest. All three cases are roughly comparable through 1993, after which revenues under the two incentive cases increase rapidly while current tax revenues begin to decline. This results from the phased initiation of several major reservoirs beginning in the early 1990's that are made profitable by the incentives. While revenues due to the

Incentives-for-Life case peak at $60 million per year in 2003, the flow of net revenue from the Incentives-to-Payback case grows more slowly, starting at a moderate pace and escalating rapidly, beginning in 2003, as "payback" is achieved in a number of major reservoirs. Revenues from Incentives-to-Payback peak at $110 million per year.

As suggested in the aggregate incremental revenues, the annual effects of the $24/B case at a 15% rate of return roughly follow the pattern of the 10% case but at a level of about 30 percent less. The effect of the 15% rate is to produce roughly the same amount of revenues as would the 10% rate at an oil price of four dollars less per barrel.

As the oil price rises to $28/B at the 10% rate of return, the revenues under the current tax structure become almost identical to those under the Incentives-to-Payback despite a 18% increase in reserves under the incentive. Both cases would yield about $3.4 billion, while the Incentives-for-Life would produce only $1.8 billion due to the substantially greater costs of the incentive (over $2 billion). At the same price, but at a 15% rate of return, Incentives-to-Payback would yield $2.9 billion, while the current tax structure would only generate $2.0 billion, an increase of 45% due to the incentive. Once again, however, net revenues under Incentives-for-Life are lower than for either current taxes or Incentives-to-Payback due to costs of the incentive.

Exhibits V-5E and F display these incremental net revenues over time. As opposed to the lower price cases, at $28/B the current tax case yields the highest incremental revenues over most of the projected period at a 10% rate of return. Peak annual current tax revenues of over $150 million are achieved in years 2003 through 2006. The Incentives-to-Payback case, peaking in 2005 at $163 million, produces comparable (but about 1% lower) revenues overall, but with a shift in time of about six years until payback is reached by several major reservoirs. The Incentives-for-Life case peaks in 2002 at $80 million. At the 15% rate of return, annual revenues under current taxes peak in 2002 at $95 million, while those for Incentives-to-Payback peak in 2005 at over $150 million, and those for Incentives-for-Life peak at $70 million in the early 2000s.

As oil prices climb further to $32/B, as shown in the final set of the bar charts in Exhibit V-4, the aggregated incremental revenues under the current tax structure are greater than those under either incentive program for both rates of return. At a 10% rate of return, the current tax case yields $4.6 billion, while the incentives produce $4.2 billion (91% of current taxes) and 2.2 billion (48% of current taxes), respectively. At a 15% rate of return, the current tax case generates $4.2 billion, while the incentives would yield $3.9 billion (93%) and $1.9 billion (45%). The annual revenues show these results clearly (Exhibits V-5 G and H). At 10% and 15% rates of return, annual revenues for the current tax structure peak at nearly $200 million and $185 million, respectively, in 2005. Under the Incentives-to-Payback, peak revenues are comparable, but are reached only after a prolonged period of reduced revenues due to the costs of the incentives. Under Incentives-for-Life, the peak revenues are $100 million and $80 million, respectively, for the 10% and 15% rates of return.

Both Exhibits V-4 and V-5 display the costs of the respective incentives. Because they are subtracted from the gross incremental revenues generated by the incentives, they do not warrant detailed discussion. The significant result, however, is that although the incentives may have greater costs, these costs are never high enough to cause a negative cashflow to the state. That is, in all cases, the provision of incentives generates sufficient additional revenues to offset any costs of the incentives themselves. As displayed in Exhibit V-5, for all prices, rates of return, and incentive programs, there is no year in which <u>net</u> revenues to the state are negative. In all cases, the incentives more than "pay for themselves," even in cases with substantial costs of the incentives, e.g., at the higher prices with Incentives-for-Life. However, the costs of the incentives can become quite high where the incentives are not limited at certain higher price cases, resulting in unnecessary lost opportunities for the state. For example, the costs of Incentives-for-Life are estimated to range from $800 million to $2 billion at $28/B, depending on the assumed minimum rate of return, and from $2.3 to $2.5 billion at $32/B.

Table V-2 provides details on specific revenue sources for selected years. The negatives in the row for state corporate income tax are the "negative" tax due to taxable losses in the early years as discussed earlier.

From the perspective of state and local revenues, the desirability of the incentives depends on the oil price. At lower prices, e.g., $20/B, incentives are necessary to make carbon dioxide flooding projects economic. Both of the two incentives analyzed result in higher production and higher revenues, although in most cases Incentives-to-Payback yields substantially greater revenues at lower cost and risk to the state. At $24/B the incentives continue to make a major contribution to revenues, with the additional benefits of Incentives-to-Payback much more apparent than at the $20/B level. As higher oil prices are encountered, e.g., at $28/B and higher and a 10% required rate of return, the incentives begin to cause a loss in incremental net revenue to the state and its localities when compared with the current tax structure. For Incentives-for-Life, the loss is significant -- more than half -- but for Incentives-to-Payback, the loss is small -- only about 1% -- although their receipt is significantly delayed. The same is found for the 15% rate, although the price at which current taxes are clearly preferred to any incentive is somewhat higher (between $28/B and $32/B).

If the policymaker's sole criterion in evaluating such incentives is maximization of state and local revenues, four conclusions might be drawn from these results:

- Incentives are necessary at low oil prices to realize the potential for carbon dioxide miscible flooding in New Mexico.

- Incentives are decreasingly effective in stimulating production and increasingly costly to the state at higher oil prices, so a "ceiling price" for the application of incentives should be established. The "cross-over" point at 10% rate of return is about $28/B; for the 15% rate, it lies between $28/B and $32/B. As these minimum rates of return are expected to bracket corporate investment criteria, the foregoing results suggest that a ceiling price in the range of $30/B to $32/B is appropriate.

- Incentives that are self-limiting and concentrated early in the life of the project (e.g., apply to payback) are more productive and cost-effective to the state and local treasuries than incentives for the life of the project.

TABLE V-2

ESTIMATED ANNUAL STATE AND LOCAL REVENUES ATTRIBUTABLE TO CARBON DIOXIDE FLOODING BY OIL PRICE AND TAX CASE AT TWO RATES OF RETURN

(In Millions of Dollars)

Oil Price: $20/B	10% Rate of Return					15% Rate of Return				
	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010
CURRENT TAX										
Production Taxes	1	3	5	4	2	1	2	3	2	1
Royalties (including state share of Federal)	0	0	3	3	2	0	1	1	1	1
Corporate Income	(0)	(0)	1	1	1	(0)	0	1	1	0
Gross Receipts	0	1	1	0	0	0	0	0	0	0
Personal Income	0	0	0	0	0	0	0	0	0	0
Total Revenue	1	4	10	8	5	1	3	5	4	2
INCENTIVES TO PAYBACK										
Production Taxes	0	3	12	7	3	0	1	3	3	2
Royalties (including state share of Federal)	9	17	13	6	3	0	1	3	3	2
Corporate Income	(1)	0	2	2	1	(0)	(0)	1	1	1
Gross Receipts	1	3	2	1	0	0	1	1	0	0
Personal Income	0	0	0	0	0	0	0	0	0	0
Total Revenue	9	23	29	16	7	0	3	8	7	5
INCENTIVES FOR LIFE										
Production Taxes	0	0	1	0	0	0	0	0	0	0
Royalties (including state share of Federal)	9	17	14	8	5	6	12	8	3	2
Corporate Income	(1)	(1)	(0)	0	0	(0)	(1)	(0)	0	0
Gross Receipts	2	3	2	16	1	1	2	1	0	0
Personal Income	0	0	0	0	0	0	0	0	0	0
Total Revenue	10	19	17	24	6	7	13	9	3	2

TABLE V-2 (Continued)

ESTIMATED ANNUAL STATE AND LOCAL REVENUES ATTRIBUTABLE TO
CARBON DIOXIDE FLOODING BY OIL PRICE AND TAX CASE AT TWO RATES OF RETURN

(In Millions of Dollars)

Oil Price: $24/B	10% Rate of Return					15% Rate of Return				
	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010
CURRENT TAX										
Production Taxes	7	17	18	10	5	5	11	9	4	2
Royalties (including state share of Federal)	10	20	18	10	7	8	14	10	4	3
Corporate Income	(1)	2	4	3	2	(1)	1	2	2	1
Gross Receipts	2	3	3	1	1	1	2	1	0	0
Personal Income	0	0	0	0	0	0	0	0	0	0
Total Revenue	18	42	43	24	16	13	28	22	10	6
INCENTIVES TO PAYBACK										
Production Taxes	0	13	18	34	45	0	13	16	30	22
Royalties (including state share of Federal)	11	29	39	39	32	10	27	33	29	22
Corporate Income	(4)	(4)	4	7	12	(2)	(1)	4	7	6
Gross Receipts	4	7	9	7	5	3	5	6	4	3
Personal Income	0	1	1	1	0	0	1	1	1	0
Total Revenue	11	46	71	88	94	11	45	60	71	53
INCENTIVES FOR LIFE										
Production Taxes	0	1	3	4	3	0	1	1	1	1
Royalties (including state share of Federal)	11	31	43	43	37	10	27	33	30	24
Corporate Income	(6)	(8)	0	0	0	(2)	(3)	0	0	0
Gross Receipts	5	9	10	8	5	3	5	6	4	3
Personal Income	1	1	1	1	1	0	1	1	1	0
Total Revenue	11	34	57	56	46	11	31	41	36	28

TABLE V-2 (Continued)

ESTIMATED ANNUAL STATE AND LOCAL REVENUES ATTRIBUTABLE TO
CARBON DIOXIDE FLOODING BY OIL PRICE AND TAX CASE AT TWO RATES OF RETURN

(In Millions of Dollars)

Oil Price: $28/B	10% Rate of Return					15% Rate of Return				
	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010
CURRENT TAX										
Production Taxes	10	38	68	75	62	9	28	40	36	26
Royalties (including state share of Federal)	13	36	51	52	43	12	32	40	36	28
Corporate Income	(6)	(4)	9	21	21	(2)	1	7	10	9
Gross Receipts	5	9	11	9	6	3	6	6	5	3
Personal Income	1	1	1	1	1	0	1	1	1	0
Total Revenue	23	80	140	158	133	22	68	94	88	66
INCENTIVES TO PAYBACK										
Production Taxes	0	18	26	75	68	0	17	23	73	59
Royalties (including state share of Federal)	15	41	57	57	48	13	36	51	51	43
Corporate Income	(6)	(4)	6	20	22	(6)	(3)	6	20	21
Gross Receipts	6	10	12	10	7	5	9	11	8	5
Personal Income	1	1	2	1	1	1	1	1	1	1
Total Revenue	16	66	103	163	146	13	60	92	153	129
INCENTIVES FOR LIFE										
Production Taxes	0	1	4	5	4	0	1	3	4	4
Royalties (including state share of Federal)	15	41	59	60	50	14	37	52	52	45
Corporate Income	(6)	(8)	(1)	(1)	0	(6)	(7)	0	(1)	0
Gross Receipts	6	11	13	11	7	5	9	11	9	6
Personal Income	1	1	2	1	1	1	1	1	1	1
Total Revenue	16	46	77	76	62	14	41	67	65	56

TABLE V-2 (Continued)

ESTIMATED ANNUAL STATE AND LOCAL REVENUES ATTRIBUTABLE TO CARBON DIOXIDE FLOODING BY OIL PRICE AND TAX CASE AT TWO RATES OF RETURN

(In Millions of Dollars)

Oil Price $32/B	10% Rate of Return					15% Rate of Return				
	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010
CURRENT TAX										
Production Taxes	13	47	83	93	79	11	42	77	87	73
Royalties (including state share of Federal)	17	47	65	66	56	14	41	59	61	51
Corporate Income	(6)	(2)	14	27	28	(5)	(3)	13	26	27
Gross Receipts	6	11	13	11	7	5	10	12	10	7
Personal Income	1	1	2	1	1	1	1	2	1	1
Total Revenue	31	104	177	198	171	26	91	163	185	159
INCENTIVES TO PAYBACK										
Production Taxes	0	24	30	87	81	0	24	27	81	74
Royalties (including state share of Federal)	17	47	68	71	59	16	43	62	64	53
Corporate Income	(7)	(1)	8	27	29	(6)	(1)	7	25	27
Gross Receipts	6	11	14	12	8	6	10	12	11	7
Personal Income	1	2	2	2	1	1	1	2	1	1
Total Revenue	17	83	122	199	178	17	77	110	182	162
INCENTIVES FOR LIFE										
Production Taxes	0	2	4	6	5	0	2	4	5	5
Royalties (including state share of Federal)	18	50	73	76	62	16	43	62	64	55
Corporate Income	(7)	(8)	(1)	(1)	0	(6)	(7)	(1)	(1)	0
Gross Receipts	6	12	15	13	8	6	10	13	11	7
Personal Income	1	2	2	2	1	1	1	2	1	1
Total Revenue	18	58	93	96	76	17	49	80	80	68

- Although incentives that are not self-limiting and/or capped at higher prices may yield less revenue than would be realized under current taxes, none of the cases analyzed resulted in <u>net</u> revenue loss to the state. Because properly designed incentives stimulate projects that would otherwise be unprofitable, resulting in revenues not otherwise available, state and local treasuries have essentially no risk of loss in revenues under the incentive program.

Optimizing state and local revenues, however, may not be the sole criterion for evaluation of possible state incentives. Incentives that are less than optimal in terms of tax receipts may generate other benefits, e.g., employment or state economic activity, that counter-balance relative negative effects on net state and local revenues. These are examined in the next section.

D. EFFECTS ON NEW MEXICO'S ECONOMY

Exhibits V-6 and V-7 summarize the direct impacts on the state economy of the three tax cases for the \$20/B-\$32/B oil price range. Exhibit V-6 illustrates the aggregate gain in direct economic activity in New Mexico that would result from carbon dioxide flooding in each tax case by the component costs, while Exhibit V-7 illustrates the overall impacts on an annual basis.

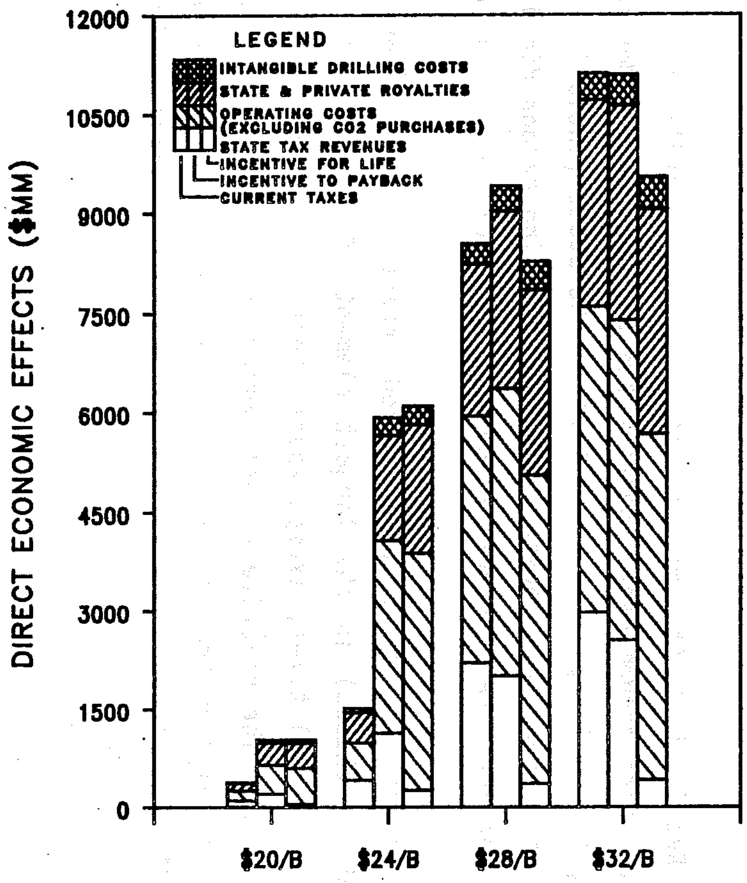
Recall that the measure of economic activity is limited to direct effects which predominantly benefit the citizens of New Mexico. This includes intangible drilling costs, royalties to the state (including the state portion of federal royalties), operating costs excluding carbon dioxide purchases, and state and local tax revenues as defined in Section C of this chapter.

Across all the cases analyzed, operating costs (exclusive of carbon dioxide purchases) is the largest element, followed by total royalties and state and local taxes, except where these are suppressed by the costs of the incentives. The relatively small amount of intangible drilling costs is due to the assumption that all existing wells will be utilized and the fact that waterflood well-spacing is generally adequate to support the carbon dioxide floods.

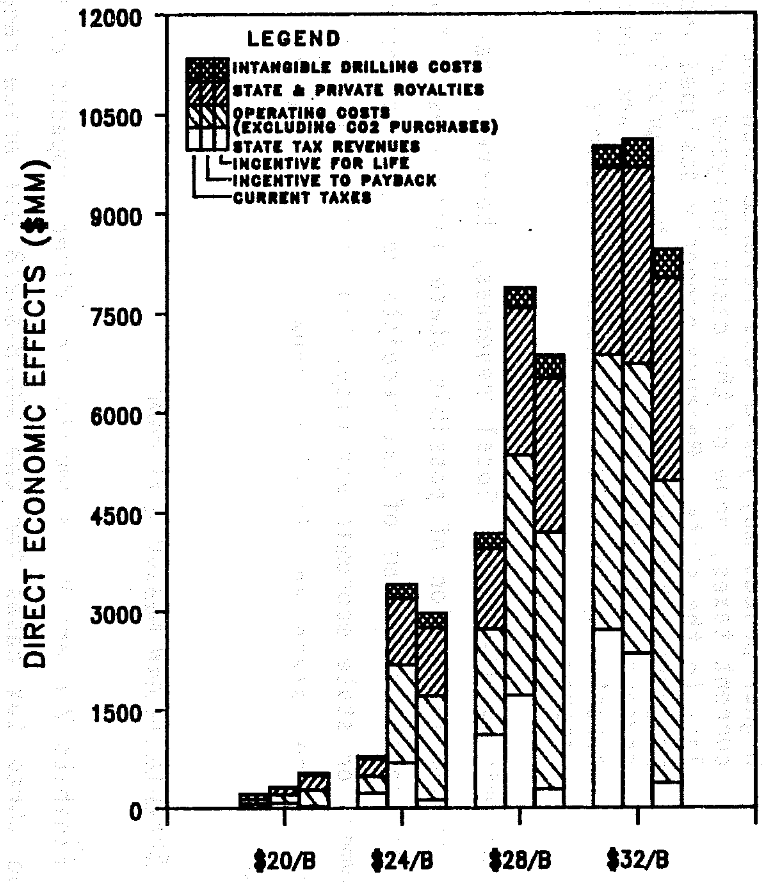
EXHIBIT V–6

POTENTIAL AGGREGATED DIRECT IMPACT ON NEW MEXICO ECONOMY DUE TO CARBON DIOXIDE FLOODING FOR THREE TAX STRUCTURES AT SELECTED OIL PRICES AND RATES OF RETURN

A. 10% RATE OF RETURN



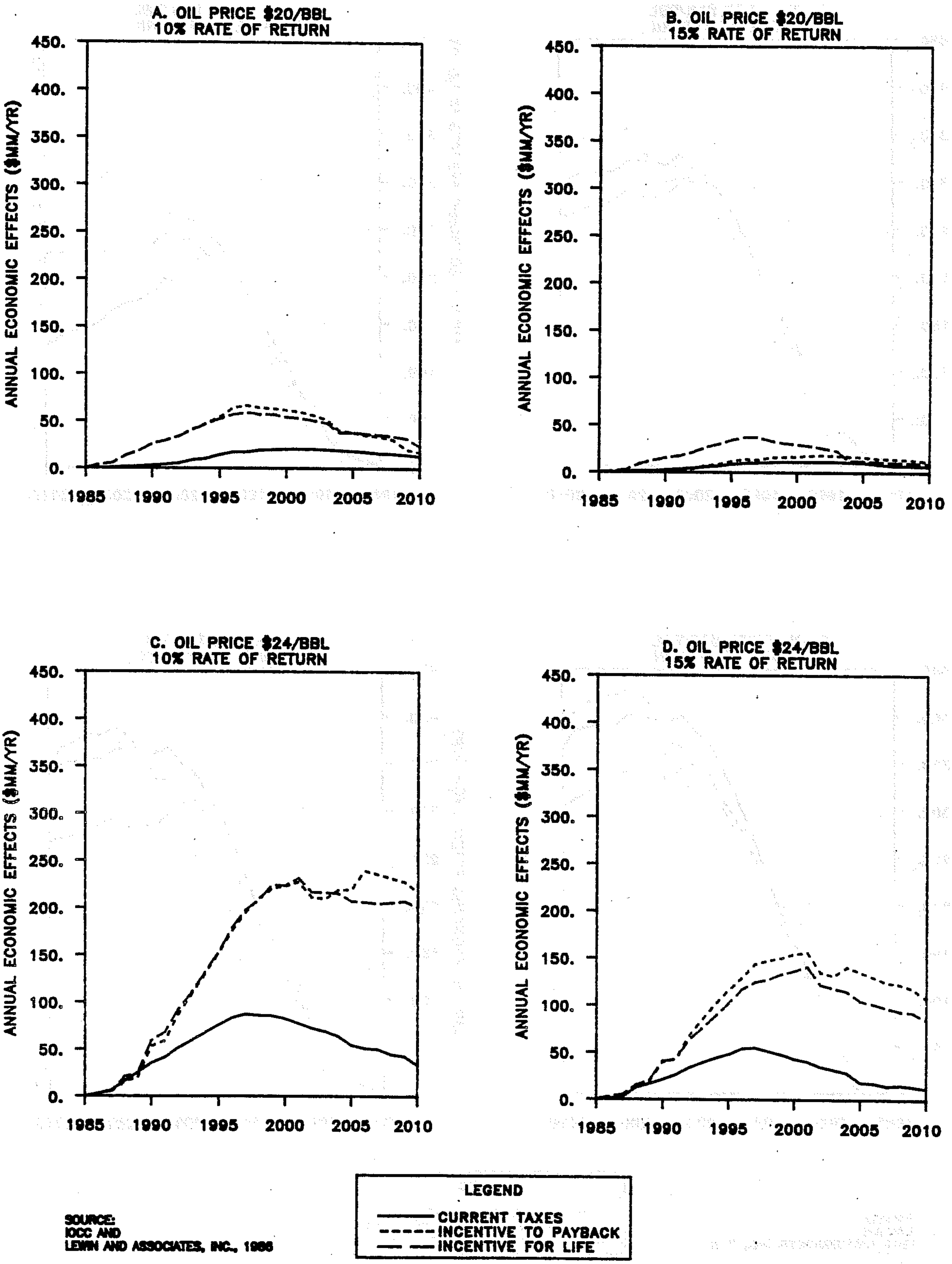
B. 15% RATE OF RETURN



SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

EXHIBIT V-7

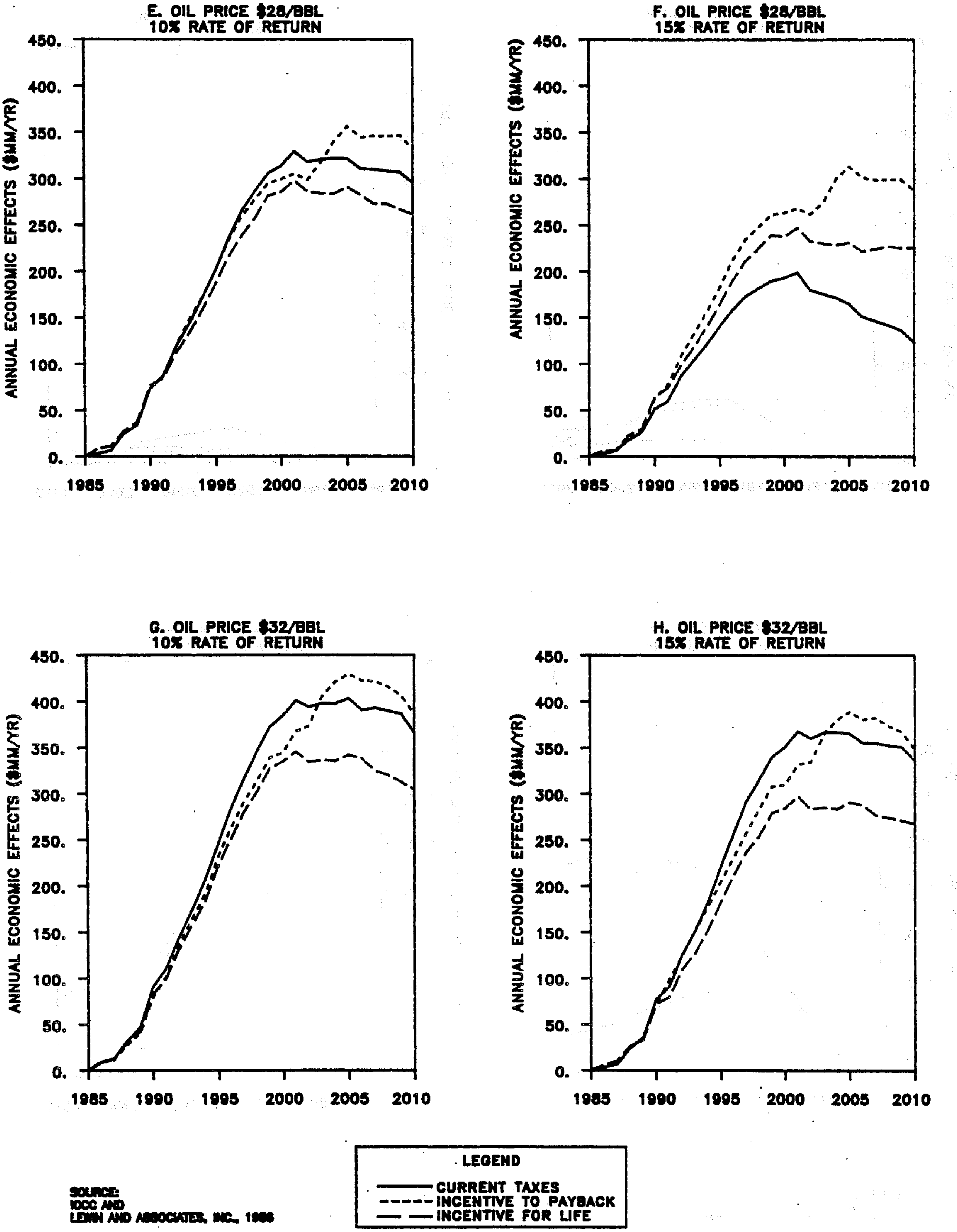
POTENTIAL ANNUAL DIRECT IMPACT ON NEW MEXICO ECONOMY
DUE TO CARBON DIOXIDE FLOODING FOR THREE TAX STRUCTURES
AT SELECTED OIL PRICES AND RATES OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

EXHIBIT V-7 (CONT.)

POTENTIAL ANNUAL DIRECT IMPACT ON NEW MEXICO ECONOMY DUE TO CARBON DIOXIDE FLOODING FOR THREE TAX STRUCTURES AT SELECTED OIL PRICES AND RATES OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

At the lowest price ($20/B), current taxes would yield total direct incremental economic benefits of $370 million at a 10% rate of return. At a 15% rate, current taxes would yield total direct economic benefits of only $210 million. At 10%, these incremental economic benefits would peak at over $20 million per year in 2000; at 15%, they peak at over $12 million per year in the same year.

Both of the incentive cases accelerate and magnify the level of direct economic activity. Assuming the 10% minimum rate of return, the Incentives-for-Life case would yield total incremental direct economic activity of $1 billion, peaking at $59 million per year in 1996, while the Incentives-to-Payback case would yield total incremental economic activity of slightly more than $1 billion, peaking at over $65 million per year in 1995. At the 15% rate of return, the aggregate direct economic activity resulting from the incentives is reduced to $530 million for Incentives-for-Life and $320 million for Incentives-to-Payback, with annual peak levels of $38 million and $18 million, respectively.

As with production and state and local revenues, the incremental economic activity attributable to carbon dioxide flooding increases with a higher oil price. Between $20/B and $24/B, an increase is noticeable under current taxes, but a far greater increase occurs in the total and annual incremental economic activity in both incentive cases. At the $24/B and 10% rate of return the current tax structure would yield aggregate incremental economic gains of $1.5 billion, peaking at over $85 million per year in 1997. However, with Incentives-to-Payback, the aggregate gain in direct economic activity rises to $5.9 billion, peaking at nearly $240 million in 2006. The Incentives-for-Life case would yield aggregate incremental economic activity of $6.1 billion, peaking at over $230 million in 2001. At a 15% rate of return and $24/B, both incentive cases still stimulate more direct economic activity than the current tax case. However, unlike the $20/B case and the $24/B case at a 10% rate of return, Incentives-to-Payback yield greater economic activity than Incentives-for-Life. The reason is that, while Incentives-for-Life stimulate somewhat more production, the cost of the incentives significantly reduces the state and local tax revenues, which are an important component of the direct economic activity as defined. The aggregate values are $0.8 billion for the current tax case (peaking at $55 million in 1996), $3.4 billion for Incentives-to-Payback (peaking at $155 million in 2000), and $3.0 billion for Incentives-for-Life (peaking at $140 million).

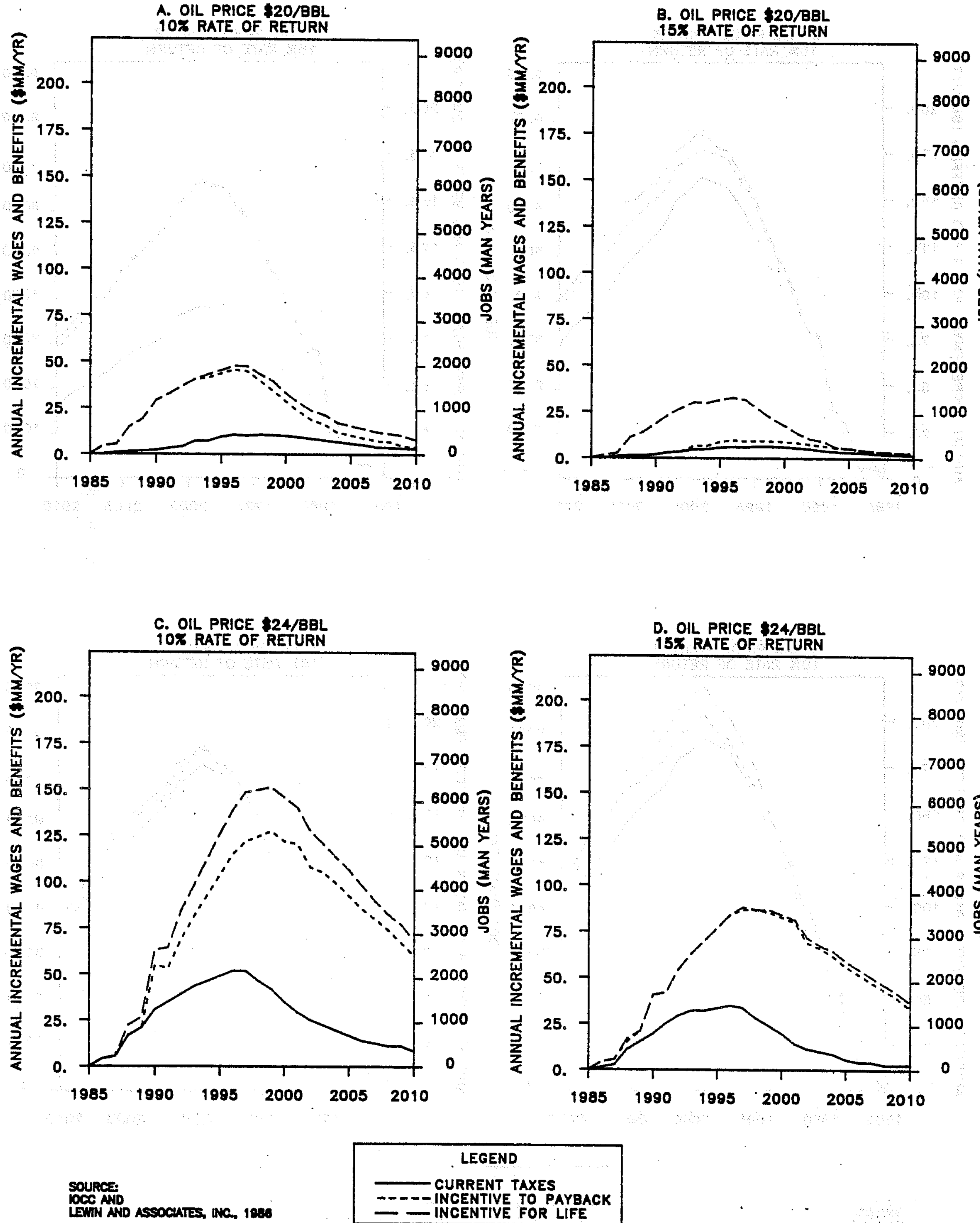
At the higher prices, under both rates of return, as is evident from Exhibit V-6, the higher costs of Incentives-for-Life always cause them to generate less direct New Mexico economic activity than Incentives-to-Payback. At $28/B and a 10% rate, all three tax cases increase significantly over the corresponding $24/B cases. At this point, the current tax structure yields more direct economic activity than Incentives-for-Life ($8.5 billion versus $8.3 billion overall), with Incentives-to-Payback having the highest yield at $9.4 million. Annually (Exhibit V-7E), the current tax case is slightly higher (peaking at $330 million in 2005) than the Incentives-to-Payback until about 2002, when the latter case rises to a peak of $365 million in 2005. Under the 15% rate, both incentives have higher overall and annual rates of incremental direct economic activity than the current tax structure. The current tax case yields a total of $4.2 billion (peaking at $200 million in 2000), Incentives-to-Payback produce $7.9 billion overall (peaking in 2005 at $310 million), and Incentives-for-Life generate $6.9 billion total (with a peak of $230 million in 2005).

At an oil price of $32/B, the current tax structure yields about the same amount of direct economic activity as the Incentives-to-Payback and both are higher then the Incentives-for-Life. At a 10% rate of return, the total is about $11 billion for the two higher cases; at 15%, it is about $10 billion. Moreover, the current tax structure yields this level of economic activity approximately five years sooner (Exhibit V-7, parts G and H), peaking at $400 million at 10% and $370 million at 15%, both shortly after the turn of the century.

Another indication of economic benefit to New Mexico's citizens is the number of jobs and amount of wages and benefits generated, as shown in Exhibit V-8. The exhibit illustrates the incremental wages and benefits in the petroleum extraction industry in New Mexico that would be paid due to increased carbon dioxide flooding on an annual basis. By analyzing the incremental wages and benefits paid, it was possible to approximate the number

EXHIBIT V-8

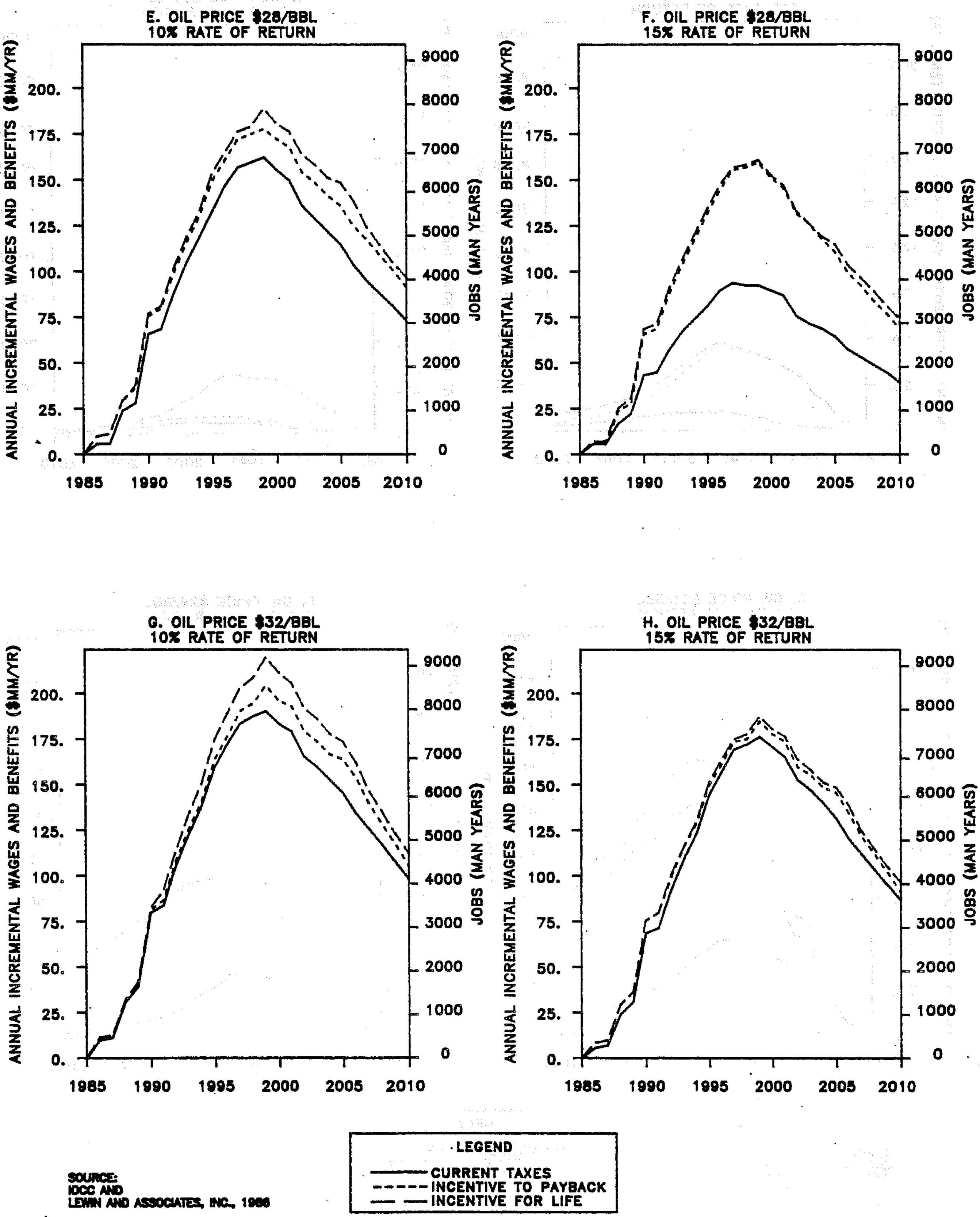
POTENTIAL ANNUAL EFFECT ON WAGES AND JOBS DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO AT SELECTED OIL PRICES AND RATES OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

EXHIBIT V-8 (CONT.)

POTENTIAL ANNUAL EFFECT ON WAGES AND JOBS DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO AT SELECTED OIL PRICES AND RATES OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

of new jobs that will be created as well. These estimates track the same trends that were found in the previous analyses, indicating that, at $20/B and $24/B, incentives could result in a substantial increase in the volume of jobs and wages and benefits paid than would occur under the current tax structure. For example, at $20/B and 10% rate of return, 1995 employment would be 4.5 times higher with the incentives than without (1,800 versus 400 man-years). At $24/B, the comparable gains would be 2.2 times (4,300 versus 2,000) at 10% and 2.3 times (3,200 versus 1,400) at the 15% rate. At higher prices, however, the incremental wages and benefits paid and jobs created would be only moderately higher than would occur under current taxes (as shown in Exhibit V-8, parts E, F, G, and H).

The analysis of direct economic activity and jobs in New Mexico leads to conclusions that are similar to those drawn from the results of the assessment of impacts on state and local treasuries, i.e.:

- Incentives are critically important to realizing the potential for carbon dioxide flooding in New Mexico at lower oil prices (e.g., $20/B to $24/B). As prices rise incentives are decreasingly needed and, at prices as high as $32/B, can begin to be counter-productive, at least in terms of the timing of the benefits to the state economy.

- Self-limiting incentives (e.g., to payback), under nearly all circumstances, are more effective in generating direct economic activity to the state than are open-ended incentives (e.g., for the life of the projects), although open-ended incentives can generate more jobs particularly at lower oil prices.

The next section examines the impact of carbon dioxide flooding in New Mexico on the nation as a whole and on federal revenues.

E. <u>EFFECTS ON THE NATION, ITS ECONOMY, AND FEDERAL REVENUES</u>

The effects on the nation are indicated in terms of three factors: (1) incremental production (reducing vulnerability to import disruption); (2) increases to the gross domestic product (both as increased national economic activity and as direct offsets to the component of the national trade deficit attributable to oil imports); and (3) increases in revenues to the federal treasury.

Additions to reserves and production attributable to tax incentives were reported at length in Section B of this chapter. That section demonstrated that New Mexico's carbon dioxide flooding projects could contribute substantially to U.S. energy security even at prices as low as \$20-\$24/B if the state made appropriate incentives available. In the oil price range of \$24-\$28/B, incentives were shown to add significant reserves and production. In the price range of \$28-\$32/B, the incentives were still found to have a positive, though diminishing effect. Depending on oil prices, rates of return, and state incentives, as much as 800 million barrels of incremental reserves and additional production of more than 30 million barrels per year could be added. These are important contributions to U.S. energy security.

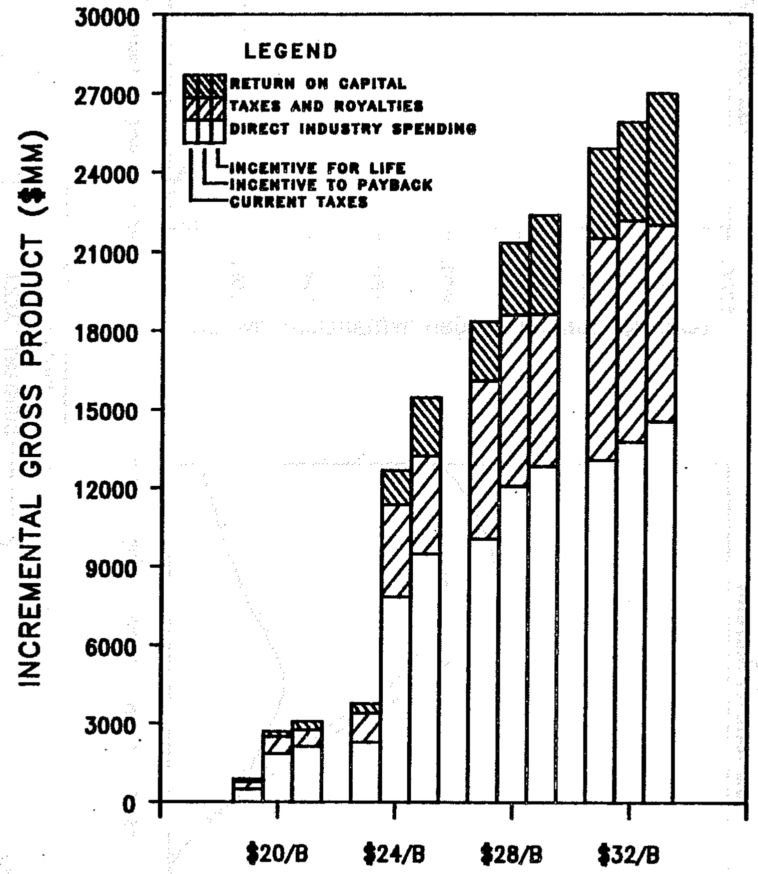
The impact of incremental production by carbon dioxide flooding on gross domestic product -- i.e, on national economic activity added and import costs avoided -- is displayed in the aggregate form in Exhibit V-9 and as annual rates in Exhibit V-10. The overall contributions to gross domestic product are broken down into three components: industry spending, accounting for more than half the total in all cases; taxes and royalties, accounting for about 30%; and return on capital (including debt service and profits), generally about 10-20% of the total across all the cases, being naturally higher at the higher oil prices. Examining only Exhibit V-9, it can be observed that the return on capital is uniformly higher for Incentives-for-Life than for either Incentives-to-Payback or the current tax case and increasingly so at the higher oil prices. This reflects the higher costs of the Incentives-for-Life noted earlier -- in essence, a transfer from the New Mexico state and local treasuries and the local economy to the shareholders of the operating companies. To the extent that the operators are local independents or that New Mexicans are shareholders in multi-state operators, these benefits would be captured in New Mexico, at least in part.

Under current taxes at the lowest price/rate of return case reported (\$20/B at 15%), incremental gross domestic product (GDP) attributable to carbon dioxide flooding would equal only \$570 million in aggregate, peaking at an annual rate of \$36 million in 2001. Incentives-to-Payback would increase

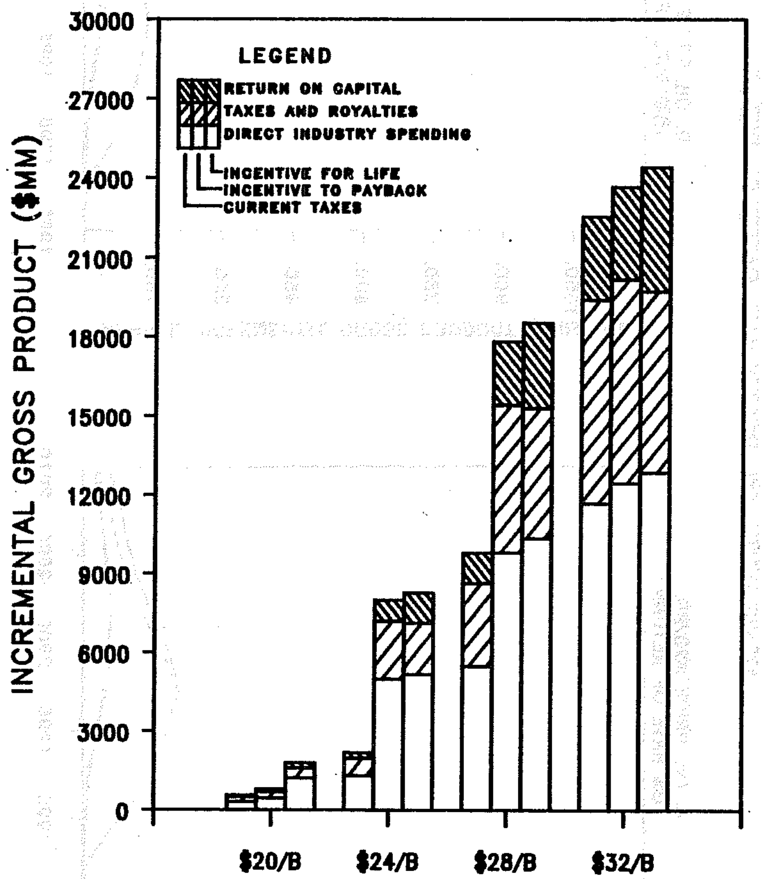
EXHIBIT V–9

POTENTIAL AGGREGATED GROSS DOMESTIC PRODUCT DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO AT SELECTED OIL PRICES AND RATES OF RETURN

A. 10% RATE OF RETURN



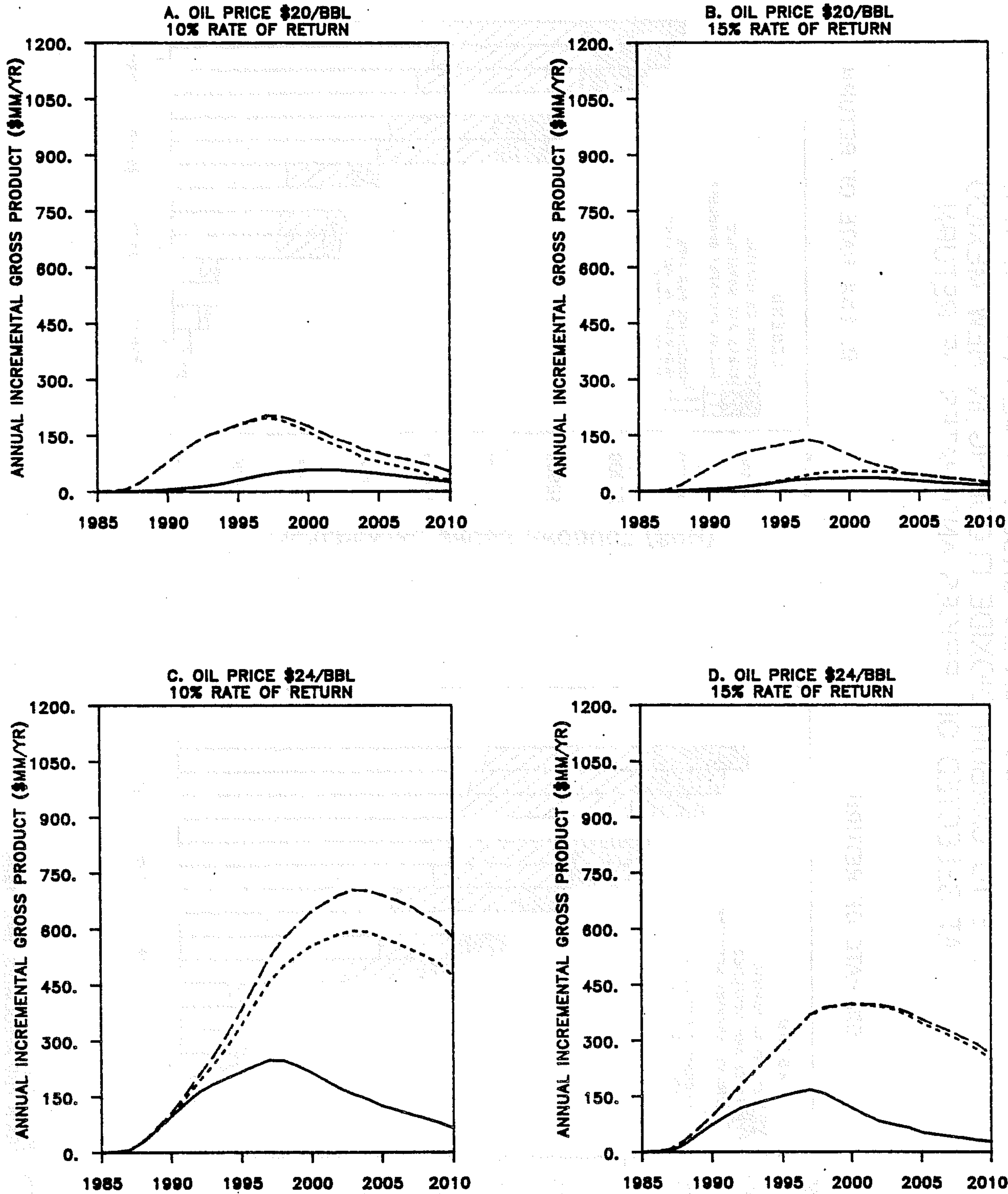
B. 15% RATE OF RETURN



SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

EXHIBIT V-10

POTENTIAL ANNUAL GROSS DOMESTIC PRODUCT
DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO
AT SELECTED OIL PRICES AND RATES OF RETURN

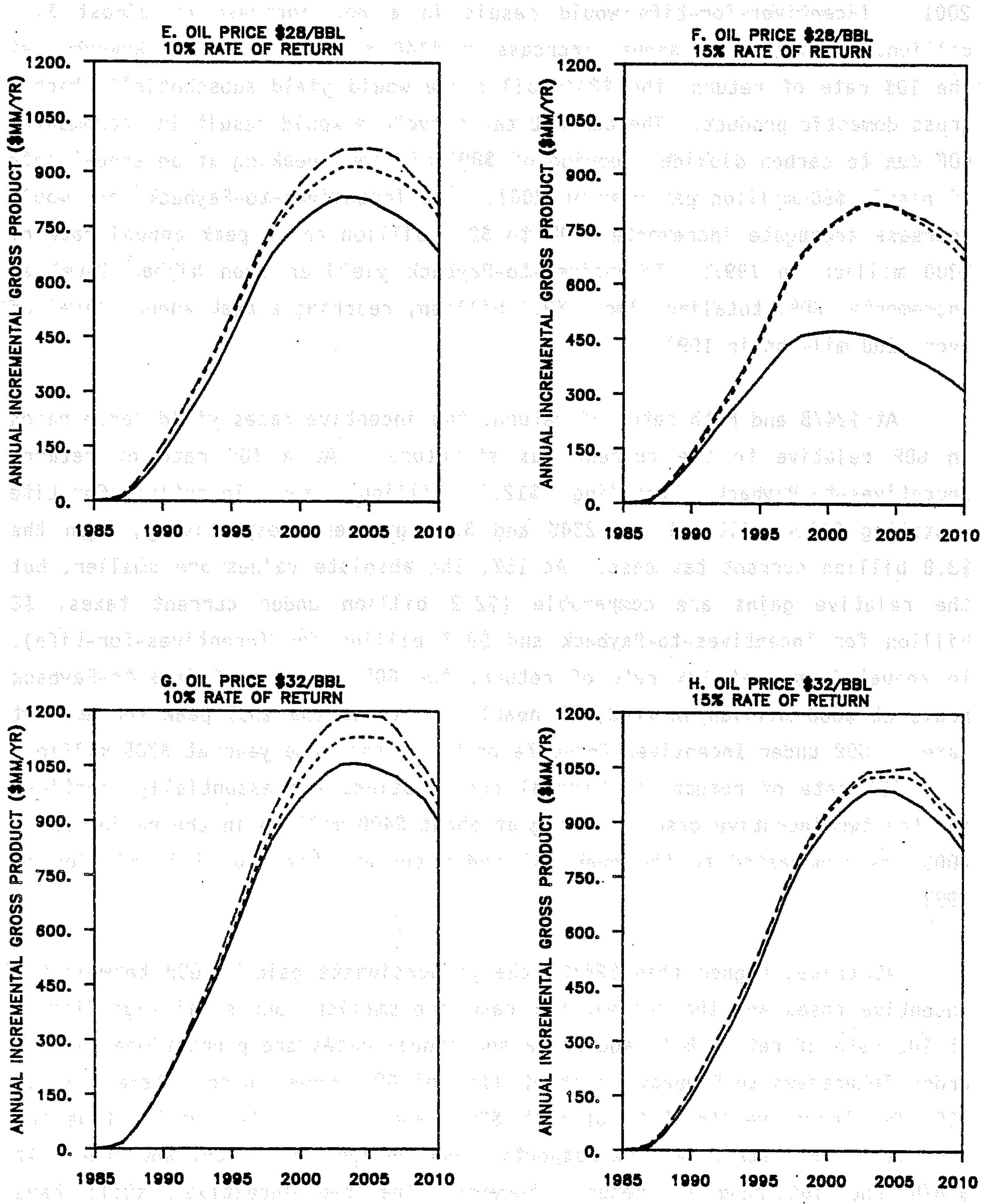


LEGEND
- CURRENT TAXES
- INCENTIVE TO PAYBACK
- INCENTIVE FOR LIFE

SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

EXHIBIT V-10 (CONT.)

POTENTIAL ANNUAL GROSS DOMESTIC PRODUCT DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO AT SELECTED OIL PRICES AND RATES OF RETURN



LEGEND
- CURRENT TAXES
- INCENTIVE TO PAYBACK
- INCENTIVE FOR LIFE

SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

the total incremental GDP to some $810 million, peaking at $54 million also in 2001. Incentives-for-Life would result in a net increase of almost $1.8 billion, peaking at an annual increase of $140 million in 1997. However, at the 10% rate of return, the $20/B oil price would yield substantially higher gross domestic product. The current tax structure would result in incremental GDP due to carbon dioxide flooding of $890 million, peaking at an annual rate of nearly $60 million per year in 2001. The Incentives-to-Payback case would increase aggregate incremental GDP to $2.7 billion and a peak annual rate of $200 million in 1997. Incentives-to-Payback yield an even higher level of incremental GDP, totaling almost $3.1 billion, reaching a peak annual level of over $200 million in 1997.

At $24/B and both rates of return, the incentive cases yield large gains in GDP relative to the current tax structure. At a 10% rate of return, Incentives-to-Payback (totaling $12.7 billion) and Incentives-for-Life (totaling $15.4 billion) are 234% and 305% greater, respectively, than the $3.8 billion current tax case. At 15%, the absolute values are smaller, but the relative gains are comparable ($2.2 billion under current taxes, $8 billion for Incentives-to-Payback and $8.3 billion for Incentives-for-Life). In annual terms, at 10% rate of return, the GDP under Incentives-to-Payback peaks at $600 million in 2003, at nearly 2.5 times the 1997 peak for current taxes. GDP under Incentives-for-Life peaks in the same year at $705 million. At a 15% rate of return, the annual contributions are essentially identical for the two incentive cases, peaking at about $400 million in the period 1997-2003, as contrasted to the peak GDP under current taxes of $170 million in 1997.

At prices higher than $24/B, the proportionate gain in GDP between the incentive cases and the current tax case are smaller, but still significant. At 10% rate of return both aggregate and annual rates are proportional -- GDP under Incentives-to-Payback is about 115% of GDP under current taxes, while 120% for Incentives-for-Life of both $28/B and $32/B. The same is true for the $32/B, 15% rate case, the respective percentages being 105% and 108%. At $28/B and 15% rate of return, however, the two incentives still have significant ability to stimulate gains in GDP, although they are quite similar to one another. Both incentives yield about 75% more in GDP than the current tax case, in aggregate ($18 billion versus $9.8 billion), and annually at their peaks ($820 million versus $470 million).

These results argue that, even while the incentives generate direct benefits to New Mexico in terms of net public revenues and direct economic activity, they also yield significant gains to the overall U.S. economy, increasing the GDP and directly reducing the trade deficit. As noted in Chapter II, the incremental direct New Mexico economic activity may be interpreted as a lower bound. The incremental GDP, on the other hand, can be seen as an upper bound on direct (i.e., no multiplier) economic activity in New Mexico to the extent these benefits are captured within the state. Under this interpretation, the incremental gain in GDP represents a significant benefit to New Mexico as well as to the nation as a whole. By this standard, the incentives are seen as vital at oil prices up to about $28/B. At higher oil prices, the incentives are marginally less effective in stimulating growth in GDP. By the criterion of maximizing GDP, Incentives-for-Life would always be preferred to either Incentives-to-Payback or the current tax structure.

Additional benefits also accrue to the public from incremental revenues to the federal government. Exhibits V-11 and V-12 display estimated incremental federal revenues resulting from carbon dioxide flooding in New Mexico in the aggregate and on an annual basis, respectively, for the four prices and two rates of return being reported in detail.

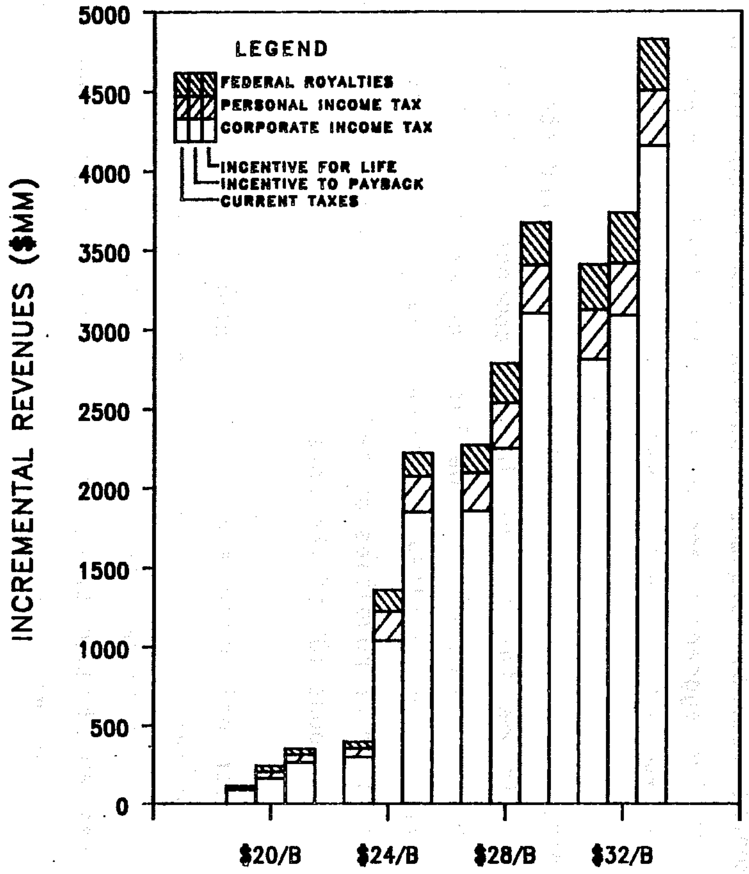
Across all oil prices, rates of return, and state tax incentives, the corporate income tax is the largest component of total federal revenues, accounting for about 80% of the total on average. This is followed by the federal portion of royalties on federal lands (i.e., after deductions for the state's portion of royalties on federal lands) and personal income taxes, each estimated at about 10% of the total.

At each oil price and rate of return, federal revenues are greatest under Incentives-for-Life, next greatest under Incentives-to-Payback, and least under the current tax structure. The reason is clear: the more the incentives and higher prices stimulate incremental production and the more profitable they make that production, the more corporate income there is to

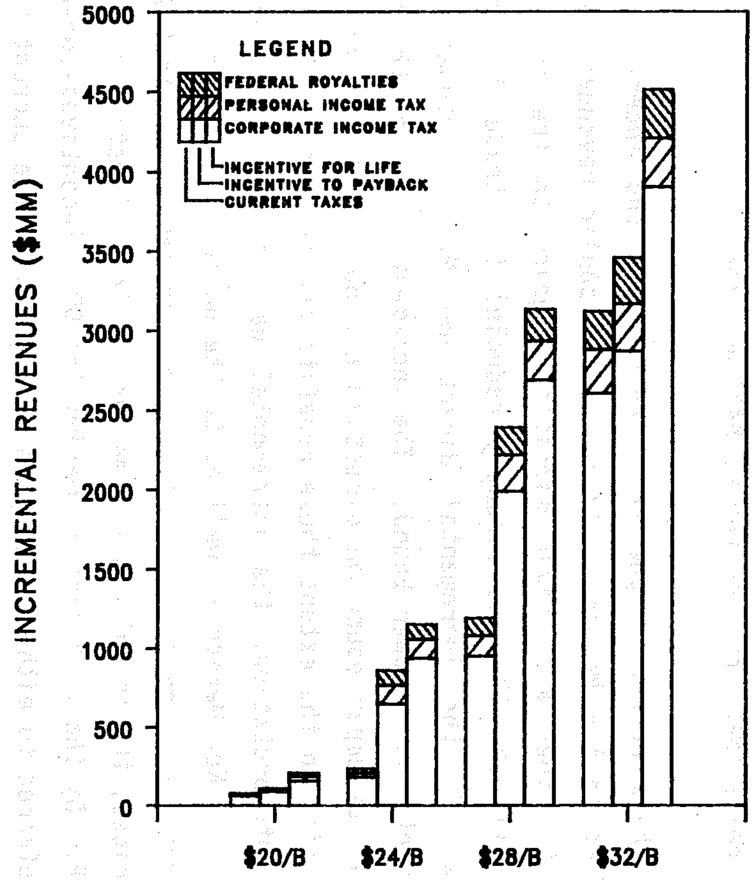
EXHIBIT V–11

POTENTIAL AGGREGATED INCREMENTAL REVENUES TO THE FEDERAL TREASURY DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO AT SELECTED OIL PRICES AND RATES OF RETURN

A. 10% RATE OF RETURN



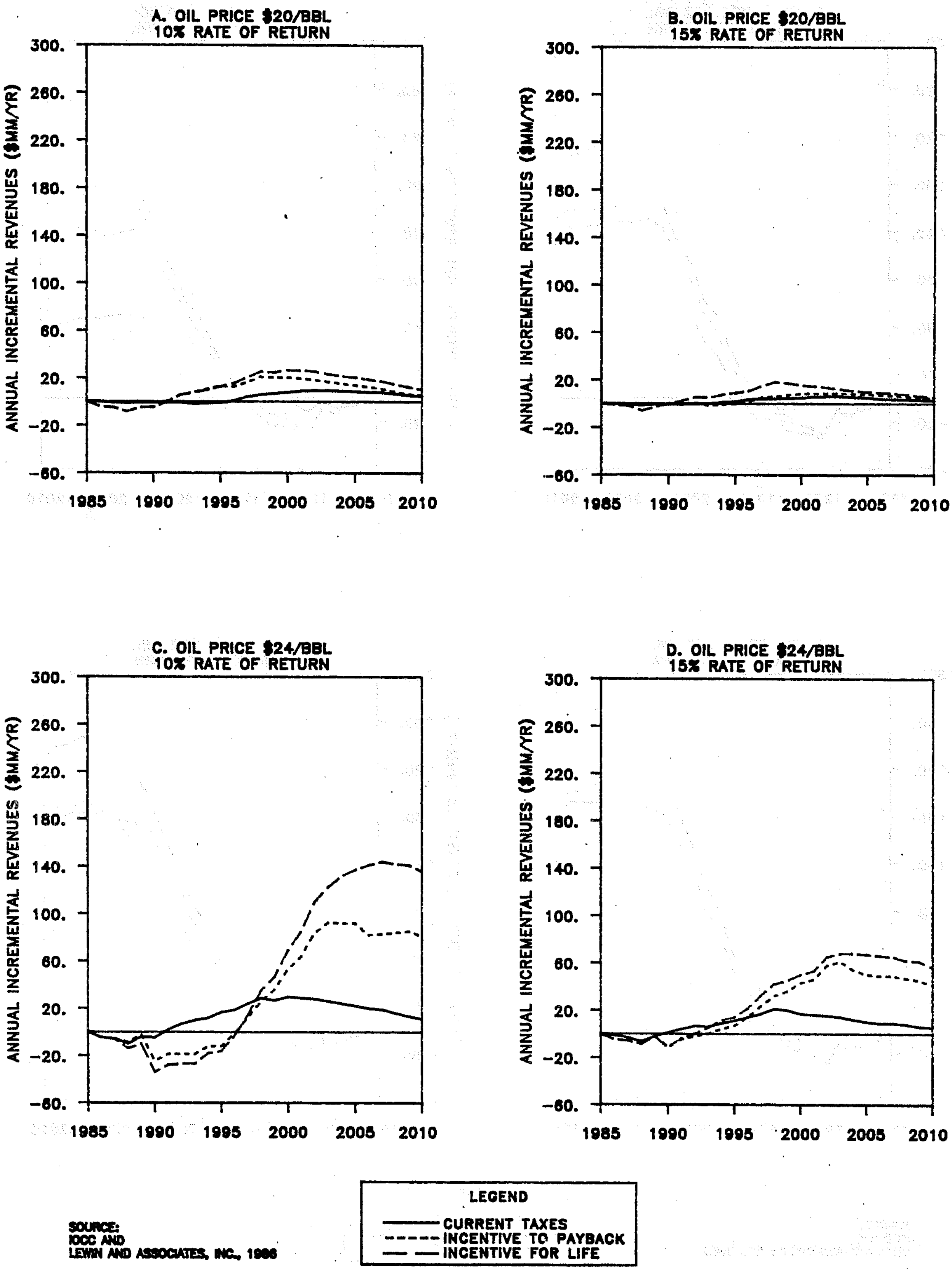
B. 15% RATE OF RETURN



SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

EXHIBIT V-12

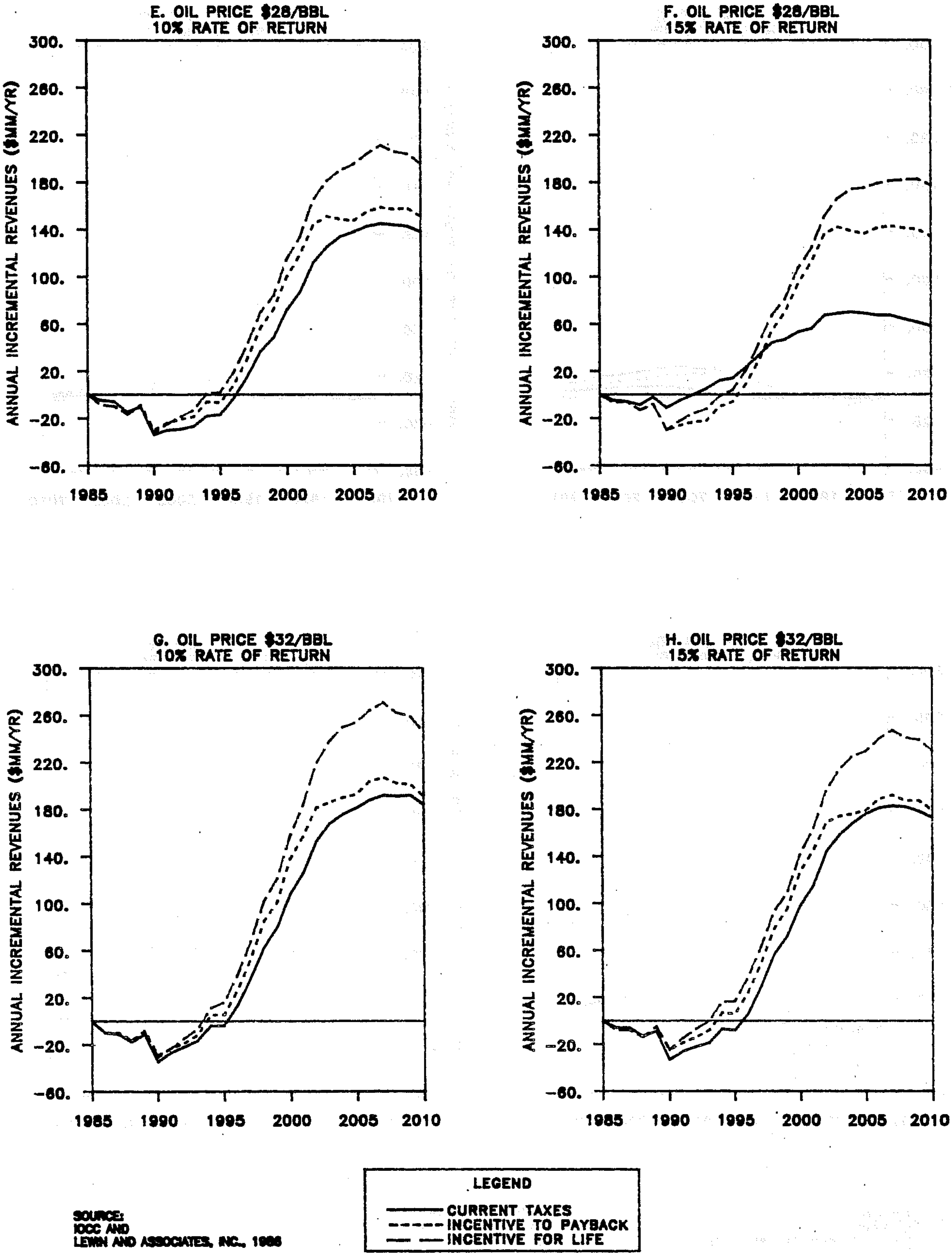
POTENTIAL ANNUAL INCREMENTAL FEDERAL REVENUES
DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO
AT SELECTED OIL PRICES AND RATES OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

EXHIBIT V-12 (CONT.)

POTENTIAL ANNUAL INCREMENTAL FEDERAL REVENUES
DUE TO CARBON DIOXIDE FLOODING IN NEW MEXICO
AT SELECTED OIL PRICES AND RATES OF RETURN



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

tax. Comparison of the results displayed in Exhibit V-11 to those in Exhibit V-4 and V-6 suggests that Incentives-for-Life, especially at oil prices higher than about $24/B, have the effect of transferring revenues from the New Mexico state and local treasuries and citizens to the federal government and corporate stockholders.

While the estimates of federal revenues attributable to carbon dioxide flooding in New Mexico range considerably, they could be significant. At $20/B, aggregate incremental federal revenues range from under $100 million to around $350 million, depending on the state tax treatment and rate of return. At $24/B and 10% rate of return, the range is $0.4 billion to $2.2 billion; at the 15% rate, the range is $0.2 billion to just over $1 billion. At $28/B the comparable ranges are $2.3 to $3.7 billion at 10% and $1.2 billion to $3.1 billion at 15%. At $32/B, federal revenues would range from $3.4 billion to $4.8 billion at 10% and $3.1 billion to $4.5 billion at 15%.

In terms of annual federal revenues (Exhibit V-12), all the cases result in negative taxes in the early years of project implementation. This is due to losses in taxable income during the development phase and the assumption that operators have other profitable ventures against which these losses can be charged, resulting in the "negative taxes" shown in the early years. At $20/B, federal revenues are negligible, although the state tax incentives can more than double them, e.g., $8 million versus over $20 million in 2000, at the 10% rate of return, and $5 million versus almost $9 million for Incentives-to-Payback and over $15 million for Incentives-for-Life at the 15% rate of return. The state incentives start to have a significant effect on federal revenues at $24/B. At the 10% rate of return, Incentives-for-Life yield nearly $70 million in the year 2000, compared with $30 million under the current tax structure. At the 15% rate of return, the corresponding year 2000 estimates are $50 million and $20 million. At $28/B, a significant difference due to required minimum rate of return is noted, with Incentives-for-Life yielding $115 million in 2000, while the current state tax structure produces only $70 million at the 10% rate, as contrasted to $105 million and $50 million, respectively, at a 15% rate of return. At $32/B, the two rates of return cases are more comparable, with $155 million in 2000 for the Incentives-for-Life at 10%, and $140 million at 15%, as compared to $110 million and $100 million, respectively, for the current state tax structure.

While the peaks in estimated federal revenues rise with the higher prices, it is notable that the early-year losses in federal revenues are approximately constant from $24/B at 10% through all higher oil prices and both minimum rates of return. The reason is that a relatively small number of large New Mexico reservoirs become economic at $24/B and 10% and, of course, remain profitable at the higher prices even at the higher minimum rates of return.

Clearly, if the federal government's revenue and gross domestic product were the primary decision criteria, the Incentives-for-Life provisions for New Mexico's tax code would be preferred above all other choices. This conclusion differs from those drawn in earlier sections showing decreased state revenues and economic activity for this incentive.

F. EFFECT OF GRANTING INCENTIVES -- WEST TEXAS COMPARISON

As presented at the end of Chapter IV, New Mexico will compete for potentially limited financial and personnel resources with West Texas. This competition was re-evaluated in light of the potential for state tax incentives to improve New Mexico reservoirs financially as viewed by the operator. Incentives-to-Payback were selected for this comparison because they produced the greatest net revenue to New Mexico. Oil prices of $20/B and $24/B were selected because these are the prices with the greatest relative effect on project economics.

Incentives can have a dramatic effect on the financial attractiveness of New Mexico reservoirs. The comparison in Chapter IV showed that West Texas reservoirs were much more financially attractive than those in New Mexico under current state tax laws. This is due to a larger resource base (more and larger reservoirs), relatively better reservoir quality, and lower state tax rates in Texas when compared to New Mexico. While state tax incentives cannot affect the first two factors, they can dramatically affect the last, making New Mexico reservoirs more comparable with West Texas reservoirs in tax treatment.

Exhibit V-13 shows the results of the comparison at $20/B. In these figures, the arrows indicate that the cumulative number of reservoirs and the cumulative quantity of reserves for New Mexico are read on the left-hand axis, as is the relative frequency for both West Texas and New Mexico. The cumulative number of reservoirs and cumulative quantity of reserves for West Texas is read on the right-hand axis. As previously discussed, the incentives at this price have a relatively small effect on New Mexico's production. However, even at this price, the incentives have an important impact on the financial attractiveness of New Mexico reservoirs. When compared to the large difference between the regions seen under the current tax case, the incentives clearly narrow the gap.

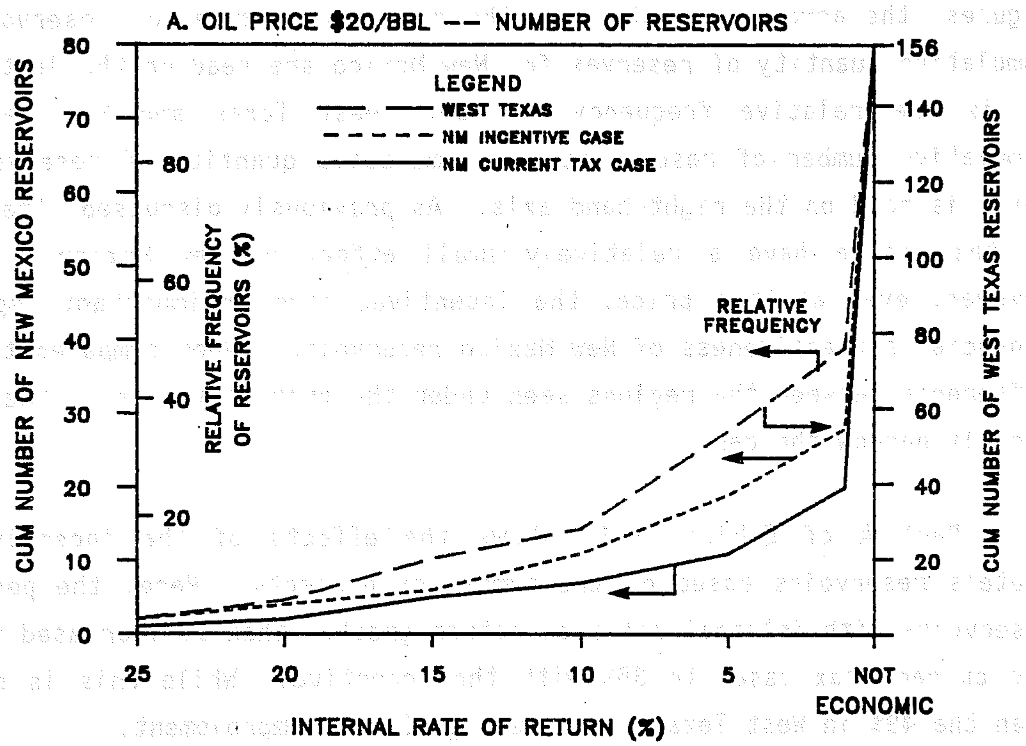
Part A of Exhibit V-13 shows the effects of the incentives on the state's reservoirs based on the number of projects. Here, the percentage of reservoirs with internal rates of return greater than 1% increased from 25% in the current tax case, to 35% with the incentive. While this is still lower than the 49% in West Texas, it is a significant improvement.

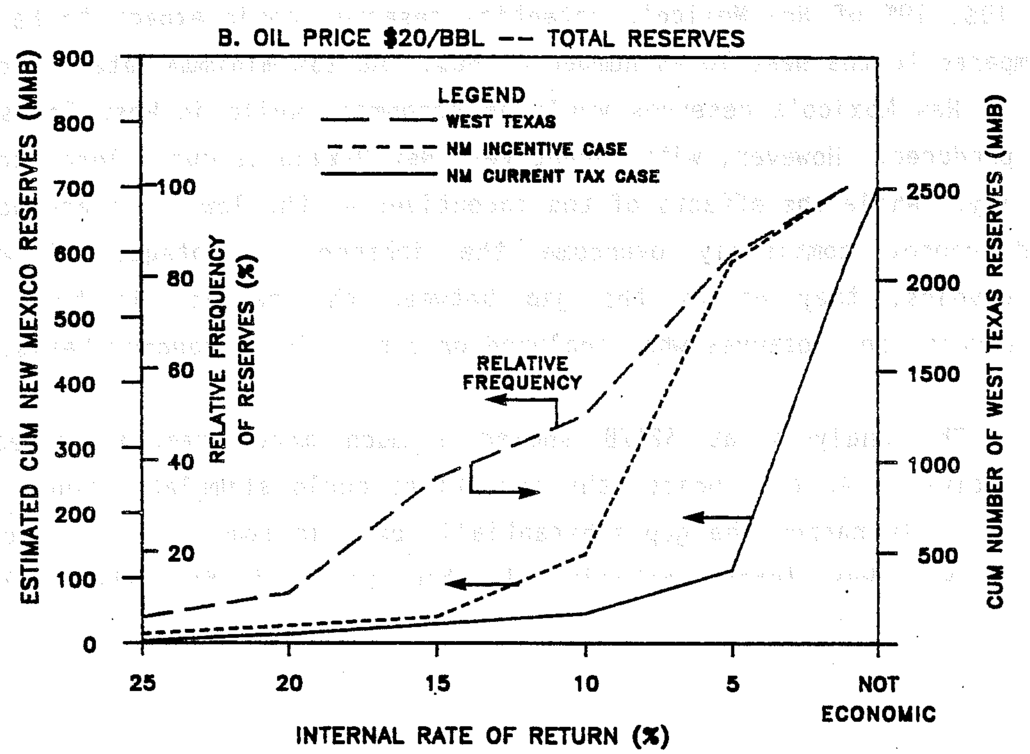
Extending the analysis to reserves (part B of the exhibit) again shows a significant improvement due to the incentives. At the internal rate of return of 10%, 19% of New Mexico's potential reserves could expect to be developed, compared to the West Texas number of 50%. At 15% minimum rate of return, only 6% of New Mexico's reserves would be economic, while in West Texas 40% could be produced. However, with incentives, New Mexico is much closer to achieving parity. While the effects of the incentives at the low price are not dramatic and cannot completely overcome the inherent advantages of West Texas reservoirs, they narrow the gap between the regions in both number of reservoirs and reserves when analyzed on a relative frequency basis.

The analysis at $24/B showed a much more dramatic effect of the incentives. At this price, the incentives could stimulate enough reservoirs to not only narrow the gap substantially but, in some cases, to achieve full parity with West Texas. Exhibit V-14 shows the basis for this conclusion.

EXHIBIT V-13

COMPARISON OF NEW MEXICO AND WEST TEXAS CARBON DIOXIDE FLOODING RESERVOIRS IN TERMS OF FINANCIAL ATTRACTIVENESS

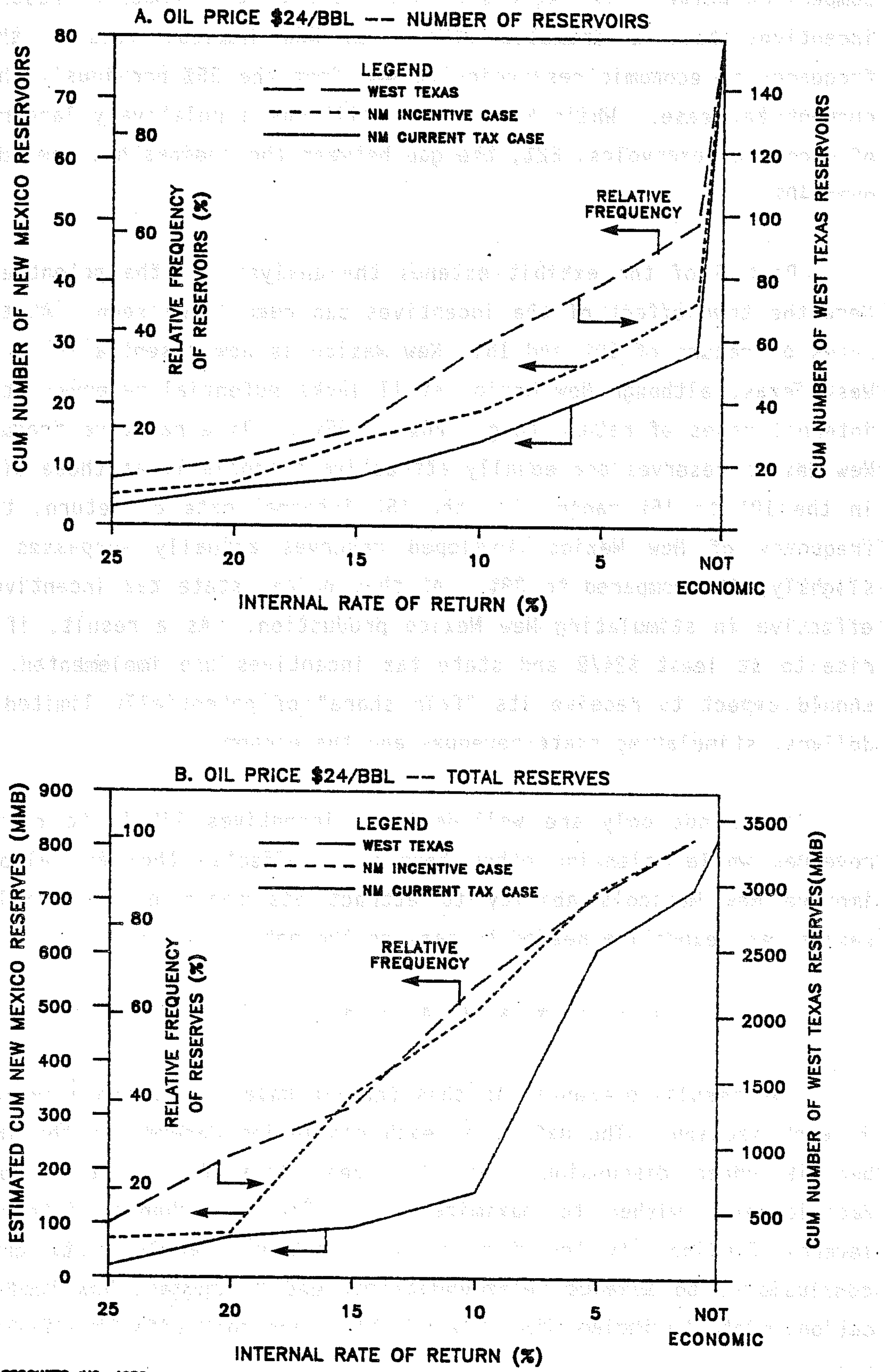




SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

EXHIBIT V-14

COMPARISON OF NEW MEXICO AND WEST TEXAS CARBON DIOXIDE FLOODING RESERVOIRS IN TERMS OF FINANCIAL ATTRACTIVENESS



SOURCE:
IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

As with the preceding analysis, part A of this exhibit shows the comparison between the regions on the basis of the number of reservoirs. The incentives have a dramatic effect in New Mexico, raising the relative frequency of economic reservoirs to 46% from the 35% previously shown for the current tax case. While West Texas still has a relatively larger percentage of economic reservoirs, 62%, the gap between the regions has been decreased by over 40%.

Part B of the exhibit extends the analysis to the potential reserves. Here the true effect of the incentives can readily be seen. At the internal rates of return of 10% and 15%, New Mexico is now essentially in parity with West Texas, although New Mexico still lacks potential reserves at the higher internal rates of return (e.g., 20% to 25%). On a relative frequency basis, New Mexico reserves are equally attractive financially as those of West Texas in the 10% to 15% range. At the 15% internal rate of return, the relative frequency of New Mexico developed reserves actually surpasses West Texas slightly, 41% compared to 39%. At this price, state tax incentives are very effective in stimulating New Mexico production. As a result, if oil prices rise to at least $24/B and state tax incentives are implemented, New Mexico should expect to receive its "fair share" of potentially limited investment dollars, stimulating state revenues and the economy.

Thus, not only are well-designed incentives likely to optimize state revenues while balancing other beneficial effects, they are also likely to improve New Mexico's ability to attract its share of potentially limited capital and expertise needed to realize the potential.

* * * * * * * * * * * * * * * *

The results presented in this chapter have led to tentative conclusions in each section. The nature of each conclusion depends on the indicator of benefit under discussion; each has been presented in terms of "if the decisionmaker wished to maximize..." The new chapter integrates these several findings in the form of a "trade-off" analysis to draw overall conclusions, to advance recommendations, and to suggest how these recommendations might be implemented in a practical and cost-effective fashion.

VI. TRADE-OFFS, CONCLUSIONS, AND POSSIBLE IMPLEMENTATION APPROACHES

A. INTRODUCTION

The previous chapter reported the estimated effects of state tax incentives in terms of a number of relevant indicators of benefit: reserve additions and production rates, net state and local revenues, direct state economic activity and jobs, and national benefits (energy security, gross domestic product, and federal revenues). Preference among the three state tax options considered -- the current structure, Incentives-to-Payback, or Incentives-for-Life -- would vary depending on the relative weight assigned to each of these indicators. This chapter summarizes the estimated benefits to permit direct comparisons and marginal analyses.

Recommending particular tax incentives to encourage carbon dioxide flooding in New Mexico, however, exceeds the scope or purpose of the present study. Specific proposals and their evaluation are the province of the executive and legislative officials of the state government. The tax incentives examined in the present study were designed only to bracket and suggest more fine-grained assessments. Moreover, final selection of specific incentives (if any) must result from the political process in which a variety of incommensurate benefits must be weighed against one another (e.g., treasury effects versus economic activity versus job creation, etc.). For this reason, no formal cost-benefit estimates will be advanced. However, the analyses presented thus far suggest certain conclusions and directions for satisfactory resolution of the issues. The trade-off analyses that follow provide means to fully synthesize the results of this study. An additional analysis of concepts to minimize the administrative burden of the suggested plan is presented at the end of this Chapter.

B. SUMMARY OF POTENTIAL TRADE-OFFS AMONG STATE TAX INCENTIVES

The analysis thus far has shown that state tax incentives, particularly at lower prices, can yield significant benefits to New Mexico, its citizens, and the nation as a whole. However, the two incentives analyzed, Incentives-to-Payback and Incentives-for-Life, affect the respective benefits differently in different price ranges. To fully understand these effects, comparison of the increment of each incentive for each price and discount rate was conducted.

Table VI-1 summarizes the results of the analyses presented in Chapters IV and V for the current tax structure and the two incentive cases at the four oil prices and two rates of return. Table VI-2 displays these same data as the differences in values between the current tax case and each of the incentives; it can be interpreted as the net effects of each incentive case relative to the current structure. Table VI-3 further summarizes these data by displaying the state treasury and economic effects per barrel of incremental oil over the current tax case at each of four oil prices. All the data are undiscounted for time. These three tables, together, permit integrated interpretation of the results of this analysis.

The tables show that in all price rate-of-return combinations analyzed, Incentives-for-Life result in the largest reserve additions, the largest incremental total wages and fringe benefits, the greatest reductions to the trade deficit (increased gross domestic product), and the highest revenues to the federal government. By these criteria, Incentives-for-Life would be preferred to either Incentives-to-Payback or the current tax structure. However, these benefits come at a cost, sometimes substantial, to the state treasury and even to the state economy. These costs vary considerably at different prices and rates of return. At higher oil prices either Incentives-to-Payback or the current tax structure could be preferred on the basis of state and local revenues and direct state economic activity, depending on oil price and rate of return. Closer analysis of these parameters is essential to resolve what the final preferences might be.

At oil prices up to $28/B (for the 10% rate of return) and to $32/B (for the 15% rate), revenues to the state and local treasuries are greatest for Incentives-to-Payback. At prices higher than these, the current tax structure yields the greatest revenues. Only in the $20/B, 15% case would Incentives-for-Life be preferred to Incentives-to-Payback in terms of net state and local

TABLE VI-1

SUMMARY OF TRADE-OFFS AMONG STATE TAX INCENTIVES TO ENCOURAGE CARBON DIOXIDE FLOODING IN NEW MEXICO

	At 10% Minimum Rate of Return						
		State/Local Treasury		State Economy		National Economy	
Oil Price and Tax Case	Potential Reserves* (MMB)	Cost of Incentives ($MM)	Incremental State & Local Revenues** ($MM)	Direct Econ. Gain ($ Bill.)	Total Wages and Fringe Benefits ($ Bill.)	Reduced Trade Deficit ($ Bill.)	Increased Federal Revenues ($ Bill.)
At $20/B							
• Current Taxes	50	--	160	0.4	0.2	0.9	0.1
• Incentives to Payback	140	10	440	1.0	0.6	2.7	0.2
• Incentives for Life	160	90	330	1.0	0.7	3.7	0.4
At $24/B							
• Current Taxes	160	--	760	1.5	0.7	3.8	0.4
• Incentives to Payback	490	100	2,030	5.9	2.4	12.7	1.4
• Incentives for Life	620	350	1,280	6.1	3.0	15.4	2.2
At $28/B							
• Current Taxes	620	--	3,430	8.5	3.2	18.4	2.3
• Incentives to Payback	730	420	3,400	9.4	3.9	21.3	2.8
• Incentives for Life	760	2,040	1,800	8.3	4.0	22.4	3.7
At $32/B							
• Current Taxes	750	--	4,590	11.1	4.1	24.9	3.4
• Incentives to Payback	780	470	4,230	11.1	4.4	25.9	3.7
• Incentives for Life	810	2,590	2,190	9.5	4.6	27.0	4.8

* Potential reserves rounded to the nearest 10 million barrels.
** Net state and local revenues rounded to nearest 10 million dollars.

TABLE VI-1 (CONTINUED)

SUMMARY OF TRADE-OFFS AMONG STATE TAX INCENTIVES TO ENCOURAGE CARBON DIOXIDE FLOODING IN NEW MEXICO

	At 15% Minimum Rate of Return						
		State/Local Treasury		State Economy		National Economy	
Oil Price and Tax Case	Potential Reserves* (MMB)	Cost of Incentives ($MM)	Incremental State & Local Revenues** ($MM)	Direct Econ. Gain ($ Bill.)	Total Wages and Fringe Benefits ($ Bill.)	Reduced Trade Deficit ($ Bill.)	Increased Federal Revenues ($ Bill.)
At $20/B							
• Current Taxes	30	--	90	0.2	0.1	0.6	0.1
• Incentives to Payback	40	10	130	0.3	0.2	0.8	0.2
• Incentives for Life	90	60	200	0.5	0.4	1.8	0.2
At $24/B							
• Current Taxes	100	--	430	0.8	0.4	2.2	0.2
• Incentives to Payback	330	40	1,390	3.4	1.6	8.0	0.9
• Incentives for Life	340	200	860	3.0	1.6	8.3	1.2
At $28/B							
• Current Taxes	350	--	1,990	4.2	1.7	9.8	1.2
• Incentives to Payback	600	200	2,920	7.9	3.1	17.8	2.4
• Incentives for Life	620	840	1,540	6.9	3.2	18.5	3.1
At $32/B							
• Current Taxes	670	--	4,160	10.0	3.7	22.5	3.1
• Incentives to Payback	710	410	3,890	10.1	3.9	23.7	3.5
• Incentives for Life	730	2,250	1,930	8.4	4.0	24.4	4.5

* Potential reserves rounded to the nearest 10 million barrels.
** Net state and local revenues rounded to nearest 10 million dollars.

TABLE VI-2

DIFFERENCES BETWEEN CURRENT TAX CASE AND TWO STATE INCENTIVES TO ENCOURAGE CARBON DIOXIDE FLOODING IN NEW MEXICO

	At 10% Minimum Rate of Return						
		State/Local Treasury		State Economy		National Economy	
Oil Price and Tax Case	Potential Reserves (MMB)	Cost of Incentives ($MM)	Incremental State & Local Revenues ($MM)	Direct Econ. Gain ($ Bill.)	Total Wages and Fringe Benefits ($ Bill.)	Reduced Trade Deficit ($ Bill.)	Increased Federal Revenues ($ Bill.)
At $20/B							
• Incentives to Payback	90	10	280	.6	.4	1.8	.1
• Incentives for Life	110	90	170	.6	.5	2.8	.3
At $24/B							
• Incentives to Payback	330	100	1,270	4.4	1.7	8.9	1.0
• Incentives for Life	460	350	520	4.6	2.3	11.6	1.8
At $28/B							
• Incentives to Payback	110	420	(30)	.9	.7	2.9	.5
• Incentives for Life	140	2,040	(1,630)	(.2)	.8	4.0	1.4
At $32/B							
• Incentives to Payback	30	470	(360)	0	.3	1.0	.3
• Incentives for Life	60	2,590	(2,400)	(1.6)	.5	2.1	1.4

TABLE VI-2 (CONTINUED)

DIFFERENCES BETWEEN CURRENT TAX CASE AND TWO STATE INCENTIVES TO ENCOURAGE CARBON DIOXIDE FLOODING IN NEW MEXICO

	At 15% Minimum Rate of Return						
		State/Local Treasury		State Economy		National Economy	
Oil Price and Tax Case	Potential Reserves (MMB)	Cost of Incentives ($MM)	Incremental State & Local Revenues ($MM)	Direct Econ. Gain ($ Bill.)	Total Wages and Fringe Benefits ($ Bill.)	Reduced Trade Deficit ($ Bill.)	Increased Federal Revenues ($ Bill.)
At $20/B							
• Incentives to Payback	10	10	40	.1	.1	.2	.1
• Incentives for Life	60	60	110	.3	.3	1.2	.1
At $24/B							
• Incentives to Payback	230	40	960	2.6	1.2	5.8	.7
• Incentives for Life	240	200	430	2.2	1.2	6.1	1.0
At $28/B							
• Incentives to Payback	250	200	930	3.7	1.4	8.0	1.2
• Incentives for Life	270	840	(450)	2.7	1.5	8.7	1.9
At $32/B							
• Incentives to Payback	40	410	(270)	.1	.2	1.2	.4
• Incentives for Life	60	2,250	(2,230)	(1.6)	.3	1.9	1.4

TABLE VI-3

PERCENTAGE AND PER BARREL DIFFERENCES BETWEEN
CURRENT TAX CASE AND TWO STATE INCENTIVES
TO ENCOURAGE CARBON DIOXIDE FLOODING IN NEW MEXICO

	At 10% Minimum Rate of Return						
		State/Local Treasury		State Economy		National Economy	
Oil Price and Tax Case	Potential Reserves* (%)	Cost of Incentives ($/B)	Incremental State & Local Revenues* ($/B)	Direct Econ. Gain** ($/B)	Total Wages and Fringe Benefits** ($/B)	Reduced Trade Deficit** ($/B)	Increased Federal Revenues** ($/B.)
At $20/B							
• Incentives to Payback	180	.10	3.10	6.70	4.70	19.90	1.40
• Incentives for Life	220	.80	1.60	5.50	4.60	19.70	2.10
At $24/B							
• Incentives to Payback	206	.30	3.90	13.30	5.10	26.60	2.90
• Incentives for Life	288	.80	1.10	10.00	4.90	25.60	4.00
At $28/B							
• Incentives to Payback	18	3.80	(0.30)	8.20	6.20	28.10	4.80
• Incentives for Life	23	14.60	(11.60)	(1.40)	5.70	28.70	10.00
At $32/B							
• Incentives to Payback	4	15.70	(12.00)	(0)	6.60	29.20	9.60
• Incentives for Life	8	43.20	(40.00)	(26.70)	7.70	32.60	22.10

* Ratios based on rounded numbers.
** Ratios based on actual values then rounded to nearest $.10/B.

TABLE VI-3 (CONTINUED)

PERCENTAGE AND PER BARREL DIFFERENCES BETWEEN
CURRENT TAX CASE AND TWO STATE INCENTIVES
TO ENCOURAGE CARBON DIOXIDE FLOODING IN NEW MEXICO

	At 15% Minimum Rate of Return						
		State/Local Treasury		State Economy		National Economy	
Oil Price and Tax Case	Potential Reserves* (%)	Cost of Incentives ($/B)	Incremental State & Local Revenues* ($/B)	Direct Econ. Gain** ($/B)	Total Wages and Fringe Benefits** ($/B)	Reduced Trade Deficit** ($/B)	Increased Federal Revenues** ($/B.)
At $20/B							
• Incentives to Payback	33	1.00	4.00	10.00	3.90	21.90	2.90
• Incentives for Life	200	1.00	1.80	5.00	4.60	19.50	2.10
At $24/B							
• Incentives to Payback	230	.20	4.20	11.30	4.80	24.40	2.60
• Incentives for Life	240	.80	1.80	9.20	4.80	24.30	3.70
At $28/B							
• Incentives to Payback	71	.80	3.70	14.80	5.20	31.70	4.80
• Incentives for Life	77	3.10	(1.79)	10.00	5.40	31.50	7.00
At $32/B							
• Incentives to Payback	6	10.30	(6.80)	2.50	6.80	31.80	9.70
• Incentives for Life	9	37.50	(37.20)	(26.70)	6.30	31.70	23.60

* Ratios based on rounded numbers.
** Ratios based on actual values then rounded to nearest $.10/B.

revenues. At the lower prices, the Incentives-to-Payback are particularly productive, increasing state and local revenues by as much as $900 million or more in certain cases (c.f., $24/B at 10% and $24/B and $28/B at 15%).

On a per-barrel basis (Table VI-3), the Incentives-to-Payback generate $3 to nearly $4 per barrel in state and local revenues at 10% and oil prices of $20/B and $24/B, while Incentives-for-Life produce only $1.60 and $1.10, respectively. At $28/B, however, the state and local revenues become slightly negative for Incentives-to-Payback and very negative for Incentives-for-Life, indicating state subsidization. At $32/B, the subsidies are significant, $12/B for Incentives-to-Payback and $40/B for Incentives-for-Life. Under the 15% rate of return, the results are similar, although at $28/B, Incentives-to-Payback still generate significant gains in revenues, $3.70/B. At $32/B, however, subsidization for both incentives is again significant, at $6.80/B for Incentives-to-Payback, and over $37/B for Incentives-for-Life.

Relative to direct state economic activity, at the two lower prices, $20/B and $24/B, and a 10% rate of return, the gain to the state economy is highest for Incentives-for-Life and lowest for the current tax case. At the higher prices (e.g., $28/B), Incentives-to-Payback show the largest incremental gain, due to rapidly escalating costs associated with Incentives-for-Life. At this price and higher, Incentives-for-Life begin to detract from the state economic activity due to direct subsidization (see Table VI-3). At the highest price, $32/B, even Incentives-to-Payback begin to lose effectiveness, resulting in no incremental increase in economic activity, assuming a 10% rate of return.

At the 15% minimum rate of return, similar trends are seen, although Incentives-for-Life are less attractive than Incentives-to-Payback, even at $24/B. Incentives-to-Payback are more attractive at the higher prices, showing small but important incremental gains even when viewed on a per-barrel basis. At $28/B, the incremental gain in economic activity per additional barrel is $14.80, assuming a 15% rate of return, and around $8/B, at 10%. At $32/B the incremental gain drops at both rates of return but is still a positive $2.50/B at the 15% rate, while zero at 10%.

Table VI-3 also demonstrates a significant factor in evaluating the incentives analyzed here. At all prices and both rates of return the incremental gain per barrel for both net state and local revenues and direct economic activity are lower for Incentives-for-Life than for Incentives-to-Payback, due to the higher costs of the Incentives-for-Life. This occurs even at the lowest price, where the total incremental gain for Incentives-for-Life is substantially higher for both indicators.

This table* further suggests who benefits when the incentives are poorly designed. In every case where net state and local revenues or direct economic benefits per barrel become negative, estimated federal revenues escalate rapidly. Because these are predominantly corporate income taxes, one can deduce that funds lost to New Mexico through improperly designed incentives will flow to the operators and partially to the federal government. Proper design of the incentives can avoid this loss.

These analyses suggest the following principal conclusions:

1. At lower oil prices, incentives of some form are necessary to realize the potential of carbon dioxide flooding in New Mexico. Only with incentives can oil production and its corresponding benefits to state and local revenues, economic activity, and employment be sustained near their present levels.

2. As oil prices rise, the incremental benefits of the incentives decrease while their costs increase. In the case of Incentives-for-Life, there is little benefit but significant cost by $28/B (in 1985 dollars), while Incentives-to-Payback present a trade-off between lost net revenues and gained economic activity. By $32/B, even Incentives-to-Payback are of questionable cost-effectiveness,

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* The reduced trade deficit in dollars per barrel reflects the gross revenue generated by incremental production oil price in each case. Where it is below the nominal price (left-most column), it reflects the gravity differential which penalizes oils that are heavier than the benchmark oil. Where they are higher, they reflect the higher than average gas-oil ratios of the particular reservoirs that become economic for the respective case.

as the state and local treasuries begin to subsidize incremental production. Thus, incentives that terminate at a specific oil price would appear more cost-effective than incentives without a price-related ceiling. The foregoing analysis suggests that a ceiling of about $30/B (in 1985 dollars) would be appropriate.

3. Incentives that are self-limiting (e.g., incentives-to-payback) have uniformly lower costs and higher net state and local revenues and direct economic activity benefits than those that do not (e.g., incentives for the life of the project). This conclusion would not appear to be substantially negated by the slightly increased employment and national benefits of the unlimited incentives. Thus, the self-limiting approach appears to have the greater merit.

Overall, these conclusions would suggest implementation of state tax incentives which are self-limiting, with a ceiling based on oil price, tied to either payback or time. The difficulty in limiting the incentive by time (e.g., the 12 years suggested in the original 1985 legislative proposal) would be that operators could accelerate or decelerate their projects to manipulate the tax relief. The issue would center on the identification and inclusion of only the truly "incremental production" attributable to carbon dioxide flooding, a difficult engineering calculation. This problem would be largely obviated by Incentives-to-Payback, in which case any conventional production that is credited would only reduce the time period of the incentive, possibly even accelerating the desired benefits, but would not increase the total amount of the incentive. Moreover, Incentives-to-Payback would automatically scale the size of the incentive to the economic requirements of the individual reservoir.

On the other hand, a self-limitation based on payback could, unless implemented very carefully, result in a substantial accounting paperwork burden for both operators and the implementing agency. It could require project-by-project detailed accounting and auditing, an expensive arrangement for both operators and the state. To overcome this administrative burden, possible "surrogate" indicators of payback, readily measured, routinely reported, and fully verifiable were investigated, as reported in the next section.

C. ANALYSIS OF SURROGATE INDICATORS OF PAYBACK

Incentives for enhanced oil recovery in New Mexico can provide an important economic boost to marginal projects. However, to be cost-effective these incentives must be self-limiting. Incentives granted until project payback were shown to be much more cost-effective than incentives for the life of the project. But in making the incentive self-limiting, the increased administrative burdens could be detrimental to the operators and the state alike and may undermine the attractiveness of the incentive program to operators. It is possible, however, that an easily measured indicator could be found to serve as a surrogate measure of project payback. Once determined, this indicator could allow incentives to be granted over essentially the same period of time (until payback) while dramatically decreasing the reporting burden for operators and the oversight activity required by the state.

Payback occurs when cumulative after-tax revenues reach a level equal to cumulative expenditures to date (i.e., a ratio of 1.0). The analysis thus far has used this definition literally to determine when a project breaks even and when the incentive is terminated. However, both after-tax revenues and expenses have numerous components which are not all reported directly to the state. Consequently, the state is unable to determine when a project has reached payback and incentives should be curtailed. An acceptable surrogate must adequately account for major portions of both revenues and expenses in order to make incentives administrative by the state, while limiting additional reporting requirements on operators.

In attempting to define a suitable surrogate indicator, two major features of carbon dioxide flooding were recognized. First, injected carbon dioxide is generally the largest single cost component in the project and is directly correlated with certain other major costs, e.g., the plant for carbon dioxide compression. Thus, carbon dioxide costs should correlate well with total costs. Second, nearly all carbon dioxide purchase contracts (for enhanced oil recovery) price the carbon dioxide, at least partially, as a function of oil price. Thus, a surrogate that depends on carbon dioxide costs is likely to be effective over a fairly broad range of oil prices. These observations tend to focus the definition of the surrogate on indicators that included both revenues and carbon dioxide costs.

Two possible surrogates were identified and analyzed which could meet these requirements. The first, and simplest, surrogate indicator compares cumulative net (after royalty) oil revenues to cumulative purchased carbon dioxide costs at payback. While simple, this ratio accounts for nearly all of the revenues generated by a given project and roughly two-thirds of the operating costs. Moreover, both quantities rely on invoiced transactions, generally at a point of transfer of custody, that could be readily reported and verified. This potential surrogate was analyzed by an economic analysis of all reservoirs to determine the exact value of the ratio at payback. The ratio was found to be very insensitive to price changes and all projects were found to have ratios in a narrow range from 1.3 to 3.0. The mean ratio for the 40 reservoirs that were economic was 1.85, with a standard deviation of 0.4.

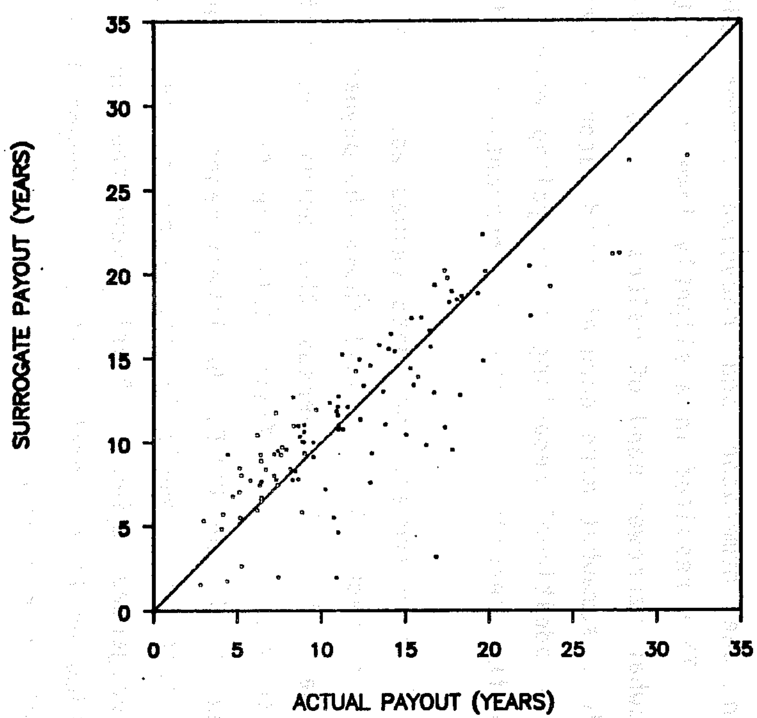
The second surrogate was the same form of this ratio but included gas revenues in the numerator and recycled carbon dioxide costs in the denominator. This resulted in a slightly lower mean ratio statewide of 1.65, with a somewhat narrower band of values, 1.3 to 2.9 (standard deviation of 0.4). While a somewhat more accurate predicator of payback, this surrogate would require additional reporting of recycling expenses for carbon dioxide which are neither readily verifiable nor currently reported.

Each of these average surrogate values was analyzed for reasonableness at projecting payback. Exhibit VI-1 shows the payback projections for each of these surrogate indicators versus the actual estimated payback for the reservoirs in New Mexico. These plots are for all economic reservoirs at prices between \$20/B and \$32/B, the likely range of incentives. The 45-degree line on the scatterplot would indicate a perfect match of the surrogate with the actual projected payback. Points above the line are projects where the length of time until surrogate payback is longer than the actual payback. These projects have a lower than average surrogate ratio at actual payback.

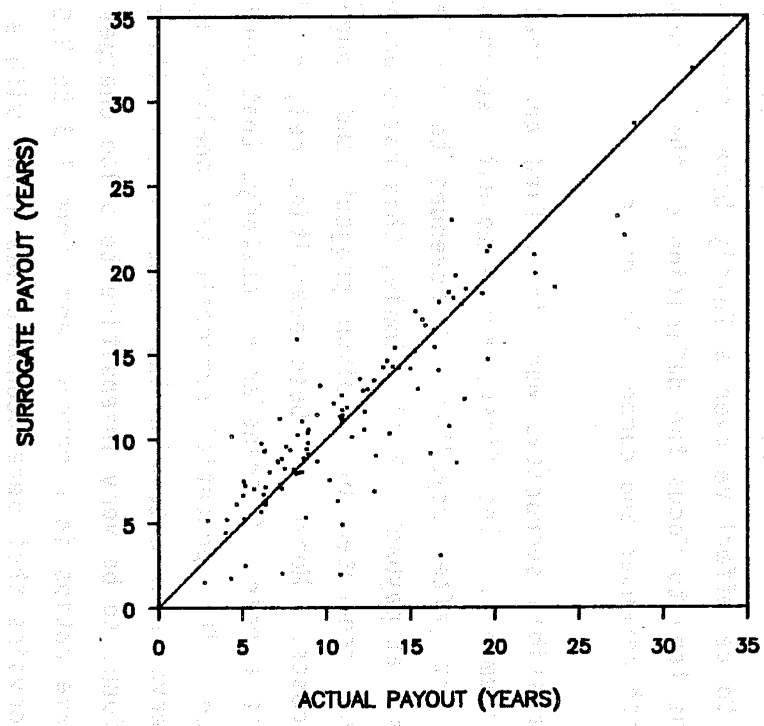
EXHIBIT VI-1

SURROGATE PAYOUT ANALYSIS

A. CUMULATIVE NET OIL REVENUE TO CUMULATIVE CO2 PURCHASE RATIO = 1.85



B. CUMULATIVE NET OIL AND GAS REVENUE TO CUMULATIVE TOTAL CO2 COST RATIO = 1.65



SOURCE: IOCC AND LEWIN AND ASSOCIATES, INC., 1986

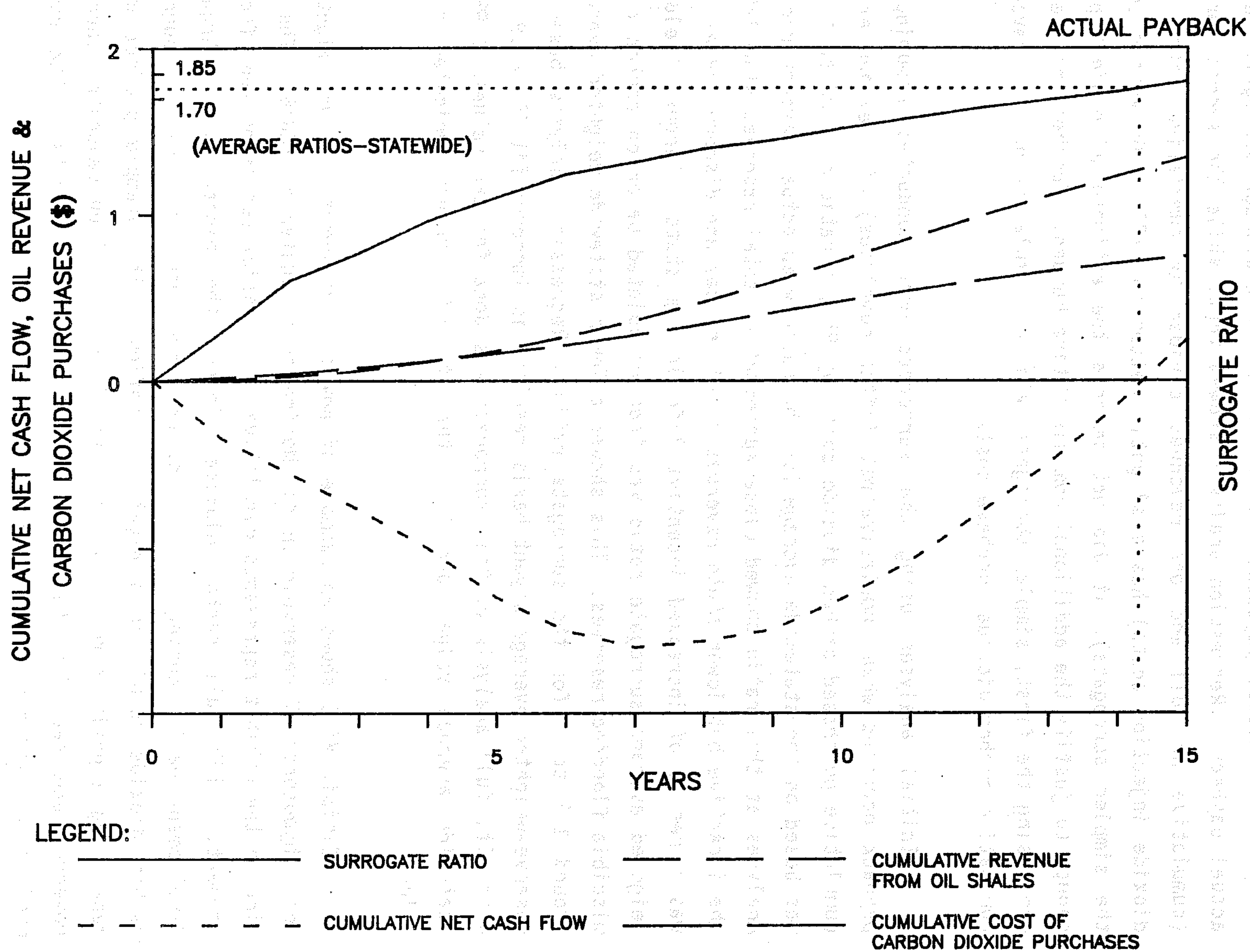
Conversely, points below the line are projects where surrogate payback occurs earlier than actual payback, indicating an above-average surrogate ratio at actual payback. Regression analysis showed that, while the second surrogate (cumulative net oil and gas revenues divided by cumulative total carbon dioxide injection costs) has a slightly better fit (R^2 = .68 versus .65 for the simpler surrogate), it did not improve the estimate of project payback enough to justify the additional administrative burden. Further analyses were done using the first, simpler surrogate ratio of cumulative net oil revenue to cumulative carbon dioxide purchase costs.

Initial analyses using the surrogate were conducted assuming that payback occurred when cumulative net (after royalties) oil revenue exceeded cumulative purchased carbon dioxide costs by 85%, a ratio of 1.85 to 1. This was based on the statewide average for the ratio when actual payback occurred. Analyses at this ratio showed close agreement on total reserves stimulated by the incentive but lower state revenues at all prices and discount rates. This was a result of increased incentive life in the state's largest fields. A weighted average surrogate ratio was then calculated based on carbon dioxide miscible flooding reserves. This showed a lower statewide weighted average of around 1.7 to 1 for the surrogate ratio. Regression analysis based on a reserve-weighted average payout basis resulted in improved fit (R^2 = .91). As a result, full analysis of this surrogate was done for two values, 1.85, the statewide average value, and 1.7, the statewide reserve-weighted average value.

Exhibit VI-2 shows an example of how this surrogate measure might work for a hypothetical reservoir in New Mexico as evaluated at $28/B. The lower line in the exhibit represents cumulative net cashflow (undiscounted) from the project. Like all carbon dioxide floods, the project goes through a development period during which front end investment and costs of purchased carbon dioxide result in a negative cashflow. The example project begins generating a positive margin around year 7 as production generates increased revenues and recycling begins to cut carbon dioxide costs. The example project achieves payback during year 14.

EXHIBIT VI–2

SURROGATE ANALYSIS OF PAYBACK
EXAMPLE RESERVOIR AT $28/B OIL PRICE



SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

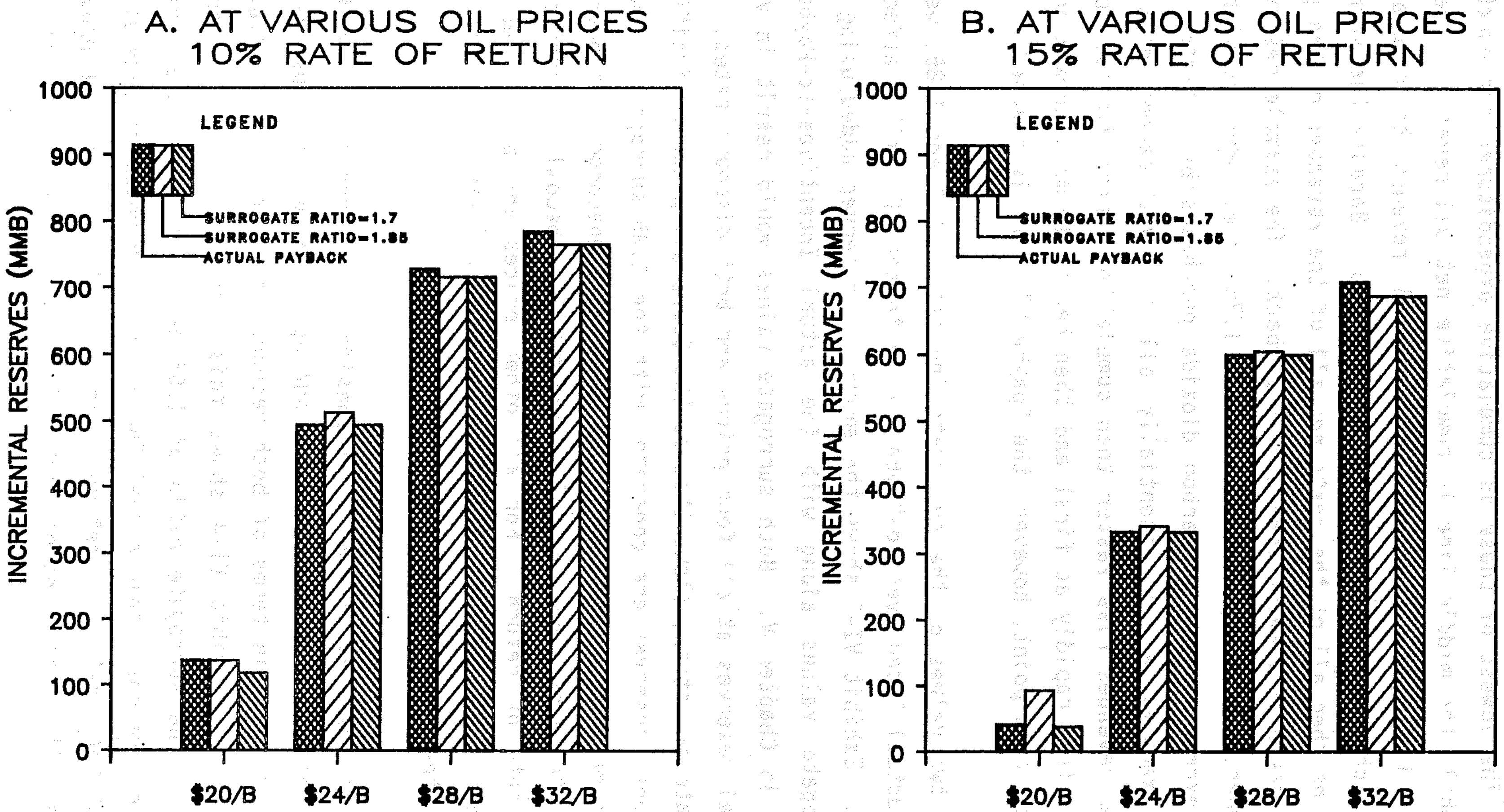
The top three lines represent elements of the surrogate measure for the project. The lowest of these is cumulative expenditures for purchased carbon dioxide while the middle line is cumulative net oil revenue. The upper line represents the ratio of cumulative net oil revenue to cumulative carbon dioxide purchase costs, or the surrogate ratio. Because the surrogate terms represent neither all of the costs nor all of the revenues of the project, the surrogate ratio is greater than 1.0 at payback. The example reservoir reaches payback when the surrogate ratio exceeds 1.76 (i.e., when cumulative net oil revenues exceed cumulative carbon dioxide purchases by a factor of 1.76:1). In this example, as in essentially all economic carbon dioxide floods, cumulative revenues rise faster than cumulative carbon dioxide purchases, so the ratio rises rapidly at first and then begins to move toward an asymptote. Well before this point, however, the "payback" point is reached.

The two values of the surrogate indicator, 1.7 and 1.85, were compared with the actual Incentives-to-Payback case to see if similar effects could be estimated. Exhibit VI-3 shows the amount of reserves added using each of the two surrogate values along with the actual Incentives-to-Payback results presented in Chapter V. Both surrogate values would result in very similar incremental reserves at all four prices and both discount rates. Exhibit VI-3B (15% rate of return) shows that at the $20/B oil price a significant amount of additional reserves are generated with the 1.85 surrogate value. This is due to one major reservoir, which is marginally uneconomic in both the actual Incentives-to-Payback and the 1.7 surrogate case, becoming economic assuming a 15% real rate of return. For all other prices and both rates of return, incremental reserves from the surrogates are within 5% of the actual Incentives-to-Payback values.

The analysis was extended to consider the surrogate incentives on net state and local revenues. A suitable surrogate for payback must closely match the actual payback in terms of both revenues generated to the state and cost of incentives. Exhibit VI-4 shows this comparison for the various cases considered. The surrogate ratio of 1.85 generated lower state revenues and higher incentive costs than actual Incentives-to-Payback results at nearly all prices and both rates of return. This is due to reduced production tax revenues and the corresponding higher incentive costs using this ratio. The

EXHIBIT VI–3

SURROGATE ANALYSIS–COMPARISON OF INCREMENTAL RESERVES
FOR ACTUAL PAYBACK AND TWO SURROGATE VALUES

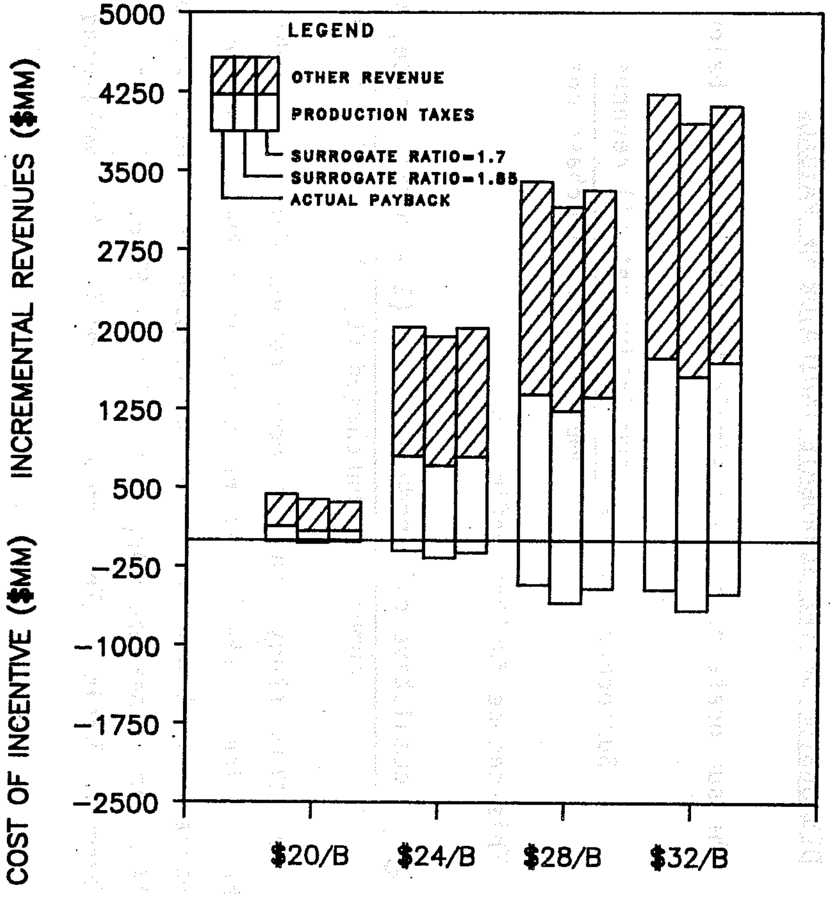


SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

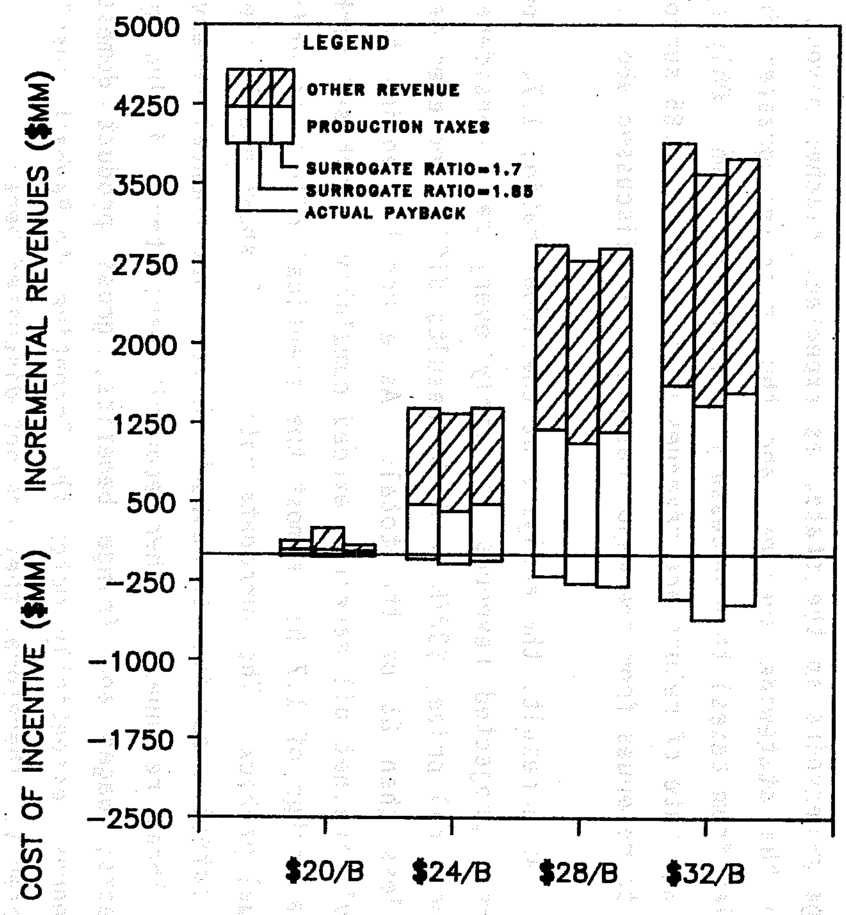
EXHIBIT VI–4

SURROGATE ANALYSIS—COMPARISON OF AGGREGATED INCREMENTAL STATE AND LOCAL REVENUES AND COST OF INCENTIVES FOR ACTUAL PAYBACK AND TWO SURROGATE VALUES

A. AT VARIOUS OIL PRICES
10% RATE OF RETURN



B. AT VARIOUS OIL PRICES
15% RATE OF RETURN



SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

large reservoirs in the state, as expected, reached payout at a ratio lower than the statewide average, and thus received greater incentives (longer relief from taxes) than necessary to stimulate them. Only at the $20/B price and 15% rate of return are revenues higher for the 1.85 surrogate ratio, again due to revenues from one major reservoir, as discussed above.

As a result, the analysis at the lower ratio, 1.7, shows a closer match between projected revenues in nearly every case considered. Only at the highest oil price, $32/B, did the results differ and even here the difference is less than 2% of the total. As a result, ending tax incentives when cumulative net oil revenues exceed cumulative purchased carbon dioxide costs by a factor of 1.7 has almost the identical effect as ending incentives at actual payback. The surrogate ratio of 1.7 shows nearly identical results to the actual Incentives-to-Payback in both incremental reserves and net state and local revenues. Other economic parameters, including direct economic effects, wages and fringe benefits, gross product domestic, and federal revenues, essentially match the Incentives-to-Payback results, presented in Chapter V. Therefore, they are not discussed here.

D. DISCUSSION OF THE SURROGATE INDICATOR OF PAYBACK

The surrogate ratio is a simple formula as shown below:

$$\text{Surrogate ratio} = \frac{\text{cumulative net oil revenue}}{\text{cumulative } CO_2 \text{ purchase cost}}$$

This can be further defined as:

$$SR = \frac{\text{cumulative oil produced (B)} \times \text{(1 - royalty rate)} \times \text{oil price (\$/B)}}{\text{cumulative purchased } CO_2 \text{ (Mcf)} \times CO_2 \text{ price (\$/Mcf)}}$$

For this study, and in most carbon dioxide purchase contracts, the purchase price of the injectant varies with the oil price (see Chapter III). The price of carbon dioxide has two components. The fixed portion is largely pipeline tariff payment roughly equal to $.50 per thousand cubic feet (Mcf) in the Permian Basin. The remainder, mostly the well-head price of carbon dioxide, is tied to the oil price at a rate of \$.02/Mcf per dollar of oil price. Therefore, substituting this equation for carbon dioxide price, the surrogate ratio becomes:

$$SR = \frac{\text{cumulative oil produced} \times (1 - \text{royalty rate}) \times \text{oil price}}{\text{cumulative purchased } CO_2 \times (\$.50 + \$.02 \times \text{oil price})}$$

Simplifying:

$$SR = \frac{(1 - \text{royalty fraction}) \times \text{oil price}}{\dfrac{\text{cumulative purchased } CO_2}{\text{cumulative oil produced}} \times (.5 + .02 \times \text{oil price})}$$

The quantity of purchased carbon dioxide injected divided by the quantity of oil produced is usually referred to as the net (purchased) carbon dioxide to oil ratio. The surrogate ratio is therefore a function of the royalty rate, the oil price, and the net carbon dioxide to oil ratio, three readily definable values. The equation for the surrogate in this form also shows why it is relatively insensitive to price changes, as oil price appears in both the numerator and denominator. By setting the surrogate ratio to 1.7 and using a royalty rate of 12.5%, (as used in this study), the net carbon dioxide to oil ratio at payback can be determined for various oil prices as shown:

Oil Price (\$/B)	Cum CO_2 Purchased (Mcf) / Cum Oil Produced (B)
\$20	11.4
\$24	12.6
\$28	13.5
\$32	14.4

During a miscible carbon dioxide flood, the net carbon dioxide to oil ratio (in Mcf/B) is initially very large as the carbon dioxide is injected and incremental production is very low. Over time, this ratio declines with most projects having an ultimate net ratio of between 8-11 at the end of production. At lower prices, project payback occurs later. The surrogate properly accounts for this, resulting in a lower net ratio at lower prices and a higher net ratio at higher prices.

The surrogate ratio can be adjusted for different royalty rates or different carbon dioxide prices than those used in the analysis by using a simplified equation. If the royalty rate on a given property is higher than 12.5% the payback surrogate ratio should also be higher. Similarly, if the delivered carbon dioxide purchase price is related to oil price by a different relationship the ratio should also be adjusted. This adjustment would be in the form of:

$$SR_{adj} = 1.7 \times \frac{.875}{(1 - \text{actual royalty rate})} \times \frac{\text{actual } CO_2 \text{ price factor}}{(.5 + .02 \times \text{oil price})}$$

Adjustment for royalty will not effect state severance tax revenues since incentives are only on the operator's share of production taxes. Private royalty owners will still pay normal taxes on their revenues. Adjustments due to carbon dioxide price changes should be limited to a reasonable range of price factors (based on current markets for carbon dioxide) to insure proper credit for the true cost of the injectant.

The surrogate ratio as defined is, therefore, a flexible measure of actual payback, valid over the range of prices where incentives would be effective. It can be adjusted prior to project initiation based on operators' presentation of their royalty agreements and carbon dioxide purchase contracts for individual projects. Use of this surrogate should closely approximate actual project payback and the length of incentive period, thereby guarding state interests while limiting administrative burden for operators and the state alike.

This surrogate indicator of payback will provide some attractive side benefits to the state. The use of the surrogate ratio will properly limit the length of the incentive by limiting the amount of oil that can be released from tax burden. As discussed, the surrogate is a function of royalty rate, oil price, and net carbon dioxide to oil ratio. Incentives are intended to be applied only to incremental enhanced recovery, but the increment is difficult to estimate. If incentives are set to a specific time period, an operator may overestimate the increment by including some conventional production, thereby receiving a windfall of tax relief. However, with the surrogate measure, an operator can only release an amount of oil that is in direct proportion to the volume of carbon dioxide he has purchased. As a result, the surrogate measure is self-limiting both in duration of the incentive period and in the volume of oil that will receive the incentive. If some conventional oil is credited, the time period of the incentive is shortened but the dollar amount of the relief is not increased. If incremental production is underestimated, the time period can be extended, but the amount of annual tax relief is reduced because only oil declared by the operator to be incremental receives the tax benefit.

The surrogate should also encourage faster development of fields in order to recover more oil under the incentive. Under current taxes, an operator may delay full development in order to use relatively cheaper recycled carbon dioxide in the later stages of a project. Because he will receive no credit for the recycling costs in the surrogate incentive case, purchased carbon dioxide will be relatively more attractive to inject. An operator may, therefore, choose to develop faster than he otherwise might, using relatively more purchased carbon dioxide. Also, because more oil could be released from taxes, an operator may use a relatively larger carbon dioxide slug in the project than might otherwise be used. While the slug size will still be bounded by sound engineering practices, tax relief on additional oil may make the larger slug attractive, thus improving ultimate recovery and total state revenues.

However, two potential problems should be noted in using the surrogate ratio. Both involve the relationship between carbon dioxide price and oil price for the region. The surrogate ratio is a good indicator of payback across all prices, in part because carbon dioxide prices are a direct function of oil price. First, if oil prices change suddenly and dramatically, the amount of oil subject to incentive treatment may also change. If oil prices rise, the released oil will be relatively higher in price than the previously purchased carbon dioxide and less total oil could be released. On the other hand, if oil prices fall, the carbon dioxide already purchased and injected will be at a higher cost relative to the released oil, resulting in a longer incentive period. This will increase the total volume of oil released from state tax liability and could adversely effect state revenues. This is a risk the state must bear to receive the benefits of the incentive program. However, from the operators' perspective, these features would be seen as "counter-cyclical," somewhat dampening the effects of oil price increases, but buffering the effects of oil price declines. If oil prices decline, significantly after a carbon dioxide flood has been initiated, such incentives may be necessary to make continued operation of marginal projects possible. The operator will receive the incentive for a longer period and on a greater volume of oil, but, due to lower prices, will still receive the incentive approximately until payback.

The second possible problem could arise for project operators who are also owners of carbon dioxide supplies or pipelines. Because the surrogate payback indicator depends heavily on the cost of carbon dioxide, maximum profits could be produced by a high transfer price for the carbon dioxide, benefiting the company both on the carbon dioxide sales and the tax relief on the project. This problem can be mitigated by the state's review and acceptance of the carbon dioxide purchase agreement as part of certifying the project for tax relief and by periodic checks of submitted invoices to assure the carbon dioxide prices being charged are generally in line with the market price being paid by other operators in the region.

Some projects which require higher than average investments, operating costs, or use large volumes of recycled carbon dioxide, may have a higher surrogate ratio at payback than the statewide weighted average. These projects may require larger incentives to stimulate full development. Such unusual projects could be handled through regulatory hearings with appropriate adjustments to the surrogate ratio based on engineering and economic analyses. At project certification, the operator could accept the average adjusted ratio or present testimony to justify a higher value for the project. The same procedure could be used for carbon dioxide purchase contracts which do not follow the general form of fixed and variable (with oil prices) components.

Using a surrogate value to estimate incentive duration will dramatically limit the administrative burden while protecting state interests. The surrogate ratio of cumulative net oil revenues to cumulative carbon dioxide purchase cost appears to be a good indicator of average payback statewide. This indicator is a simple, yet effective, measure of when incentives should end. It can be adjusted to reflect changes in reservoirs which have unusual characteristics or costs. In addition, it may encourage faster development, larger carbon dioxide slug sizes, and increased ultimate recovery. With safeguards, the surrogate will limit state exposure while encouraging enhanced recovery in the next decades.

E. ADDITIONAL CONSIDERATIONS OF INCENTIVES

In implementing any incentive, it will be necessary to define eligibility requirements. Experience with federal tax incentives for EOR demonstrate that, if eligibility requirements are overly flexible, projects with little incremental recovery potential will be eligible for the incentives, thus unnecessarily increasing the opportunity costs of the program. An eligibility criterion to reduce or eliminate such projects might rely on a minimum quantity of carbon dioxide injection, defined in terms of a fraction of the hydrocarbon pore volume to be injected. Operators who failed to inject the required quantity of carbon dioxide might be required to rebate some or all of the incentives they enjoyed. The exact minimum quantity for eligibility is amenable to engineering analysis and reasonable generalization to the majority of carbon dioxide flooding prospects. An overall quantity, applicable to all reservoirs, subject to exemptions through hearings, could be established. The value should be high enough to discourage ineffectual projects but low enough to qualify all serious projects without unnecessary engineering presentations and hearings. Based on the analyses in the present study, a minimum quantity in the range of 0.2-0.3 hydrocarbon pore volumes might be considered.

Even with an incentive program, additional problems could limit New Mexico's receiving the full benefits of carbon dioxide flooding. Among these are the needed unitization of properties and the right of eminent domain for carbon dioxide branch pipelines. Both of these are areas worthy of future state scrutiny, as either could significantly reduce the benefits of carbon dioxide flooding to the state and its citizens.

Also worthy of further state consideration are incentives beyond those considered in the present study. Partial royalty relief (to payback) and "negative" production taxes (e.g., releasing more than incremental production from production taxes to create an even more generous early incentive) might be promising alternatives or additions to the incentives analyzed in the present study, especially if oil prices persist at the present low rates. Each would require careful appraisal, but either could generate significant benefits.

F. SUMMARY AND CONCLUSIONS OF STUDY

Even with oil prices substantially lower than previously expected, the potential for oil recovery by carbon dioxide flooding in New Mexico is very promising. With carefully drawn incentives, carbon dioxide flooding can sustain New Mexico oil production into the next century (Exhibit VI-5). This incremental production will benefit the state in many direct and indirect ways.

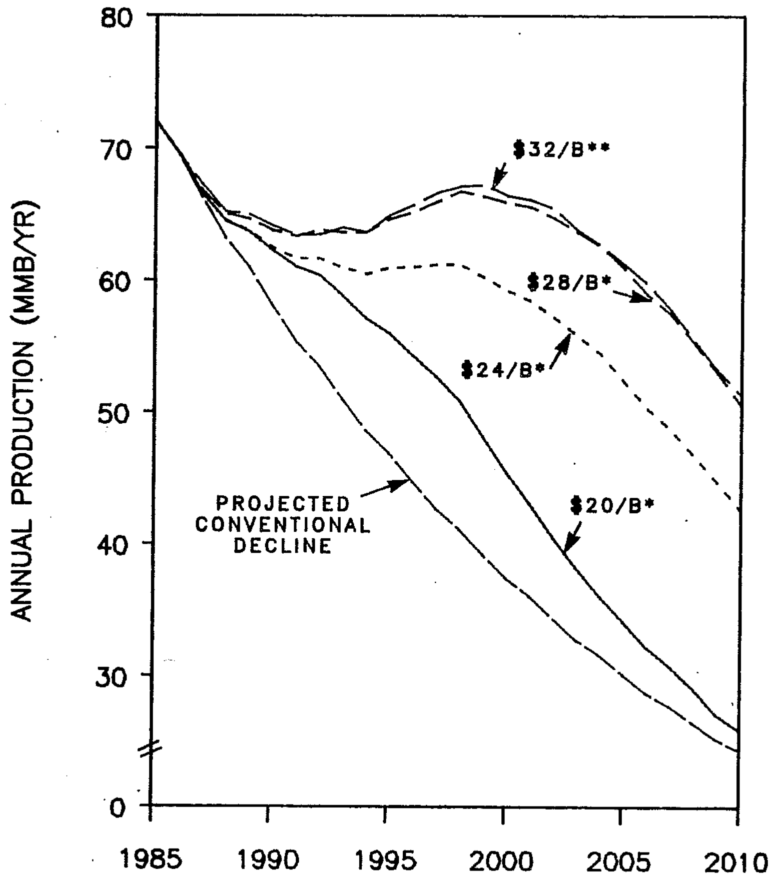
In addition to the substantial incremental reserves and production, the increased activity from carbon dioxide flooding will directly supplement the state and local tax base, while increasing jobs and overall state economic activity. Even without incentives, incremental state and local revenues and economic activity (Exhibits IV-3, IV-4 in Chapter IV) could be substantial. Implementation of incentives, particularly at the intermediate oil prices of \$24/B and \$28/B, should result in even larger increases in these parameters (Table VI-2).

If properly designed, incentives can achieve these dramatic results with a limited amount of risk to the state and without unnecessary administrative burden to either the state or the operators. To limit the state risk, incentives must be self-limiting as projects reach payback, and capped at higher oil prices. To limit paperwork the incentives must be clear, simple, and direct in their language. Potential conflicts could be minimized with a

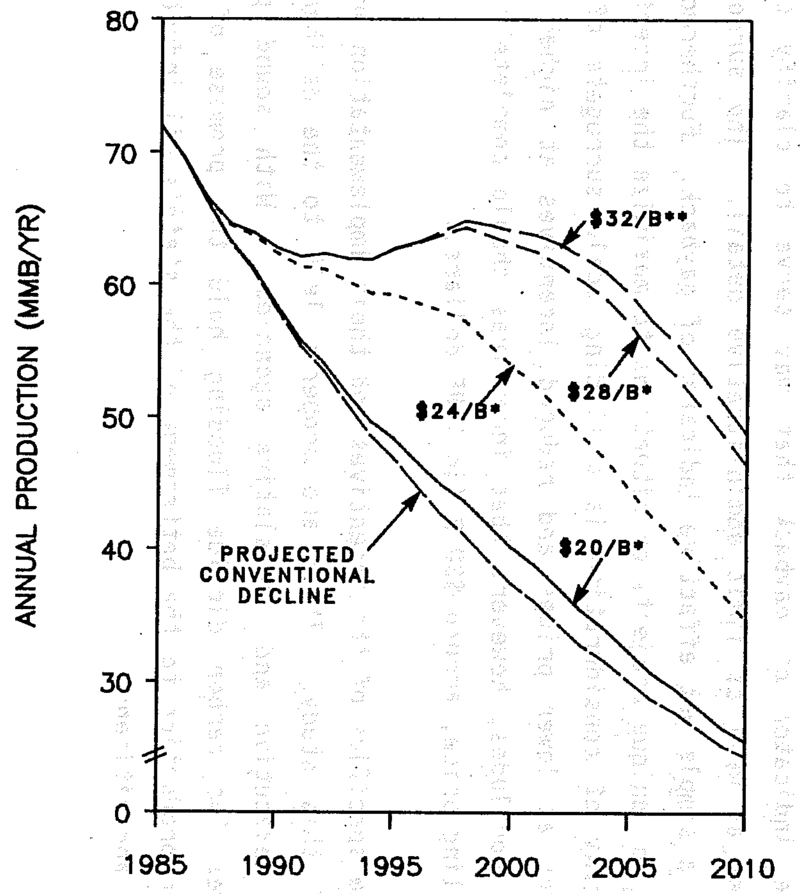
EXHIBIT VI-5

ESTIMATED NEW MEXICO TOTAL PRODUCTION FOR CONVENTIONAL AND CARBON DIOXIDE FLOODING TECHNIQUES AS A FUNCTION OF OIL PRICE WITH INCENTIVES TO PAYBACK* AND AT $32/B WITHOUT INCENTIVES**

A. 10% RATE OF RETURN



B. 15% RATE OF RETURN



SOURCE: IOCC AND
LEWIN AND ASSOCIATES, INC., 1986

surrogate indicator of payback that may serve to clarify the period of incentives as well as limit administrative detail. The surrogate analyzed above is a simple yet effective indicator of payback. Furthermore, it can be adjusted for unique projects or situations to maximize the incentive's impact. Also worthy of consideration is a sliding scale surrogate offering larger incentives at lower prices and reduced incentives at higher prices. The analysis concludes, however, that incentives should completely phase out at some ceiling price, around $30/B (in 1985 dollars).

The specifics of the incentives and their implementation are outside the scope of this study. These are properly left to the deliberation of New Mexico's executive and legislative agencies. With sound planning, tax incentives for carbon dioxide flooding hold the promise of dramatically increased production to the betterment of the state's oil industry, treasury, economy, and citizens.

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APPENDIX

REVIEWER COMMENTS

David F. Boneau, Yates Petroleum Corporation

C. Bremer, Shell Western E&P Inc.

W. L. Fisher, University of Texas

Joe E. King, Texaco USA

Carolyn Lindberg, New Mexico Taxation and Revenue Department

Victor T. Lyon, New Mexico Energy and Minerals Department

Charles J. Mankin, Oklahoma Geological Survey

J. J. Taber, New Mexico Petroleum Recovery Research Center

YATES PETROLEUM CORPORATION

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S. P. YATES
PRESIDENT
JOHN A. YATES
VICE PRESIDENT
B. W. HARPER
SEC. - TREAS.

December 1, 1986

Robert Rea
Assistant Director, Project Development
Suite 358 Pinon Building
1220 South St. Frances Drive
Santa Fe, New Mexico 87501

Dear Sir:

RE: Final Report on CO_2 Potential

I like your final version of the report concerning "The Potential of Enhanced Oil Recovery by Carbon Dioxide Flooding in New Mexico." The material covered and the layout are now excellent. It was a great idea to examine the use of a surrogate indicator for payout.

Here I intend to restrict my final comments to the summary and conclusions since these parts will be examined most closely by most readers:

1. The proposed incentives introduced on page 4 actually apply only to incremental production and not to conventional production. The general reader needs to understand this fact lest he get the idea that the industry is trying to escape taxes it would normally pay on conventional production. It must be clear to the general reader that there is no reduction in taxes on conventional production.

2. The delay in state revenues due to incentives (page 6) should not be glossed over quickly and easily. First, this delay applies to taxes on incremental production and not to taxes on conventional production. Second, a delay of 3 to 5 years may not seem small to a member of the legislature who can lose his job in that time span. The industry needs to acknowledge the costs of these incentives while emphasizing the long-term benefits as has been done in the report.

3. The report mentions "uncertain future oil prices" on page 13 but performs the entire analysis procedure as if the oil price will remain fixed forever at a prescribed level. The instability in oil prices is a complication clearly beyond the scope of the report. However, this problem could be central to an attempt to implement the conclusions of the report. My initial feeling is that no project should be approved for incentives unless the actual oil price exceeds a hurdle of $20 to $22 per barrel, but that an approved project should retain the incentives for each month (prior to payout) that the actual oil price remains below about $35 per barrel.

Robert Rea
December 1, 1986
-2-

Your report is surely super when I can only write about how the public may perceive it. Thank you for listening to my thoughts.

Sincerely,

Dave Boneau

DAVID F. BONEAU
Engineering Manager

DFB/cvg

Shell Western E&P Inc.
A Subsidiary of Shell Oil Company

P.O. Box 576
Houston, TX 77001

October 2, 1986

Mr. Robert H. Rea
Assistant Director
New Mexico Energy Research
and Development Institute
Pinon Building, Room 358
1220 South St. Francis Drive
Santa Fe, New Mexico 87501

Dear Bob:

SUBJECT: COMMENTS ON DRAFT OF "THE POTENTIAL OF ENHANCED OIL RECOVERY BY CARBON DIOXIDE FLOODING IN NEW MEXICO"

I have reviewed the subject report and I am favorably impressed with the analytical approach and results presented. I think that this analysis can effectively be used by the Industry and the State of New Mexico as a basis for formulating meaningful EOR tax incentives. My comments relate not to the analysis itself, but to the practical utilization of this information to accomplish what we all want, namely to develop effective means of encouraging application of EOR to increase oil reserves in New Mexico.

Firstly, I want to comment on the two discount rates used in the analysis, 10% and 15%. In my judgment, use of the 10% discount rate will result in unrealistic expectations of the EOR potential in New Mexico. I think that this was brought out in the industry advisory committee meeting held in Hobbs on February 26, 1986, where my recollection is that the entire group supported the higher rate of return "hurdle rate" as being more realistic. The reason for this is that the 15% discount rate is more consistent with the industry's perceived risk of CO_2 projects. For example, if we were analyzing waterflood potential, I would agree with the 10% "hurdle rate", since the waterflood technology is well established, and the project risk is low due to the relatively small investments required both for facilities and injected fluid. However, the perceived risk of CO_2 flooding will be higher because of the short performance history of commercial field projects and because of the much higher investments required. Considering the cost of the injectant alone, CO_2 is about 25 times as expensive as water on a reservoir barrel basis. Thus, industry will screen projects using a higher "hurdle rate" for CO_2 projects than for waterfloods.

The magnitude of this impact is clearly demonstrated in Exhibit I-5. For example, using \$24/barrel oil, the potential EOR reserve additions are about 500 million barrels (for incentive to payback) for a 10% discount

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rate compared to 340 million barrels for a 15% discount rate. This is a substantial difference of 160 million barrels. I would recommend that the sensitivity between the 10% and the 15% discount rate be shown, but that only the 15% discount rate data be used for analysis and conclusions. This would also serve the very useful purpose of simplifying the report and making it much easier to comprehend.

Secondly, another problem with using this analysis to project future EOR potential concerns the effect of oil price uncertainty on industry decision-making. This is a very significant factor because oil prices can fluctuate widely, whereas, the calculations in the report assume a certain oil price is constant for the life of the project. In actual decision-making, the uncertainty in future oil prices will tend to slow the development of new projects. The net effect is that the actual results will probably be less than predicted by this study. For example, using the curves in Exhibit I-5, I would expect the general shape to be correct, but the actual curves should lie above these curves so that for any given oil price, the actual reserve additions will be less than predicted. What this means is that either the EOR results will be reduced or additional incentives will have to be provided industry in order to meet these expectations. As an example, I think a $30 oil price cap on the incentives, as suggested in this report, would significantly reduce the potential favorable effects of the incentive. If you will recall, when oil prices were in the $30 range, CO_2 projects were not moving forward in New Mexico.

In summary, I believe that this is a very fine analysis of the problem, but I believe it is going to take considerable practical judgment to relate these results to an incentive program that will effectively stimulate EOR in New Mexico.

Yours very truly,

C. Bremer

C. Bremer
Manager Petroleum Engineering
CO_2 Ventures - Western Division

CB:lc

cc: Jerry Brashear

BNBY8626806

BUREAU OF ECONOMIC GEOLOGY

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December 3, 1986

Mr. Robert H. Rea
Assistant Director
Project Development
New Mexico Research and Development Institute
Pinon Building, Suite 358
1220 South St. Francis Drive
Santa Fe, NM 87501

Dear Mr. Rea:

In response to your request for our comments on "The Potential of Enhanced Oil Recovery by Carbon Dioxide Flooding in New Mexico," I have asked Robert Finley, Jerry Lucia, and Claude Hocott to review such. The following observations seem appropriate. The report benefits from the entire effort that was made as part of the National Petroleum Council's effort to review Enhanced Oil Recovery (EOR) on a national basis. The limitations outlined in Chapter III, Section E, must be kept in mind, however, as regards the averaging of reservoir properties over highly heterogeneous carbonate reservoirs that are the prime candidates for carbon dioxide flooding. Given a better understanding of these heterogeneities, it is likely that increased sweep efficiency and overall better reservoir management outside of EOR activities could also account for significant increases in oil recovery.

Exhibit II-1 shows a reversal in production decline (and increase in the number of producing wells) that occurred under the price structure that prevailed from 1979 to 1984. Infill drilling was certainly a part of this activity. On balance, more new reserves are added by infilling than old reserves are drained more rapidly. It therefore may be premature to assume the kind of continuous, rapid decline illustrated by the production decline curves of figure II-3 and to use these curves as the most likely production decline outcome.

In addition, it should be noted that tax and royalty costs are major considerations when EOR project economics are analyzed. Clearly, reduction of these outlays to the operator can enhance the potential profitability of a project. Since this report was initiated, however, the price of oil has been halved, and oil prices of $24 to $28 are unlikely to return in the near future. Other approaches may therefore be evaluated and implemented to help stabilize production declines until a price structure favorable to EOR returns. The potential of EOR should be stated in these contexts.

I hope these comments will be of value to you in your review. Please contact me if you have additional questions.

Sincerely,

W. L. Fisher
Director

WLF:mk

November 20, 1986

New Mexico Research and Development Institute
Pinon Building, Suite 358
1220 South St. Francis Drive
Santa Fe, NM 87501

Attention: Mr. Bob Rea
Assistant Director
Project Development

RE: IOCC Report on New Mexico EOR

Gentlemen:

I have reviewed the final draft of the subject report and recommend it for publication. I do however feel that the fact that incentives are based on incremental production needs to be clearly stated in Section III. A statement that all tax incentives are for CO_2 incremental production only needs to be included in the report.

It is extremely important that any legislative incentive include incremental production from all EOR processes such as nitrogen or flue gas injection, chemical and thermal enhanced recovery projects. New Mexico has numerous reservoirs that are susceptible to enhanced recovery by these methods which would be equally advantageous to the long term economic progress of the state.

I congratulate Mr. Breshear along with the Lewin & Associates personnel for a well prepared report.

Yours very truly,

JEK/pdh

New Mexico
TAXATION & REVENUE DEPARTMENT

P.O. Box 630 Santa Fe, New Mexico 87509-0630

Oct 23 PM '86

NMRDI

September 29, 1986

Jerry P. Brashear
Vice President
Lewin and Associates
1090 Vermont Ave. N.W., Suite 700
Washington, DC 20005

Dear Dr. Brashear:

We find we have relatively few comments on the draft report entitled The Potential of Enhanced Oil Recovery By Carbon Dioxide Flooding in New Mexico, dated September, 1986. The report provides state policymakers with a very useful take-off point for further deliberations on the issue of state incentives for enhanced oil recovery using carbon dioxide injection techniques. The comments we do have really have no particular bearing upon the conclusions in the report. By and large our comments represent points that jump out at the reader, rather than from a thorough page-by-page review.

On page II-6, you state that oil and gas operations sustain half the state's budget. This is, and was, untrue. A large portion of the state's revenues from oil and gas go into permanent funds and are not used for budgeted expenditures. Since the ins and outs of the state budget are quite complicated, and largely irrelevant to the study, we suggest you strike the sentence; you have already made the point that oil and gas revenues are important. Also the term, "endangers", in the next paragraph seems a bit strong -- especially since EOR only potentially postpones the day when oil production will resume its decline. You could say that the decline is a blow to the state's economy.

On page II-24, the third "conclusion" could be easily misinterpreted if taken out of context. As written, it contradicts one of the important messages of the report which is that improperly structured incentives could result in a revenue loss.

We must take rather strong exception to your presentation of the national benefits. Reserves of up to 820 million barrels are added to the nation's oil supply only if resources are not diverted from other reserve-enhancement efforts. Since subsequent sections of the report discuss our competitive relationship with Texas and point out that technical skills and development capital are in scarce supply, (page IV-19), it seems likely that such a diversion would occur. Likewise, the estimated additions to GDP appear to assume that the resources devoted to EOR in New Mexico have no opportunity costs. At the very least, you should spell out the assumptions underlying your national impact estimates.

Finally, we wonder if the new tax law, especially the loss of the ITC, would have an impact upon your analysis.

Otherwise, we welcome your objective approach to a difficult subject. The report represents a great stride forward in developing a rational basis for exploring the issue of tax incentives for enhanced oil recovery.

Sincerely,

Carolyn Lindberg

Carolyn Lindberg
Tax Research & Statistics Office

Jim O'Neill

Jim O'Neill
Assistant Secretary

CL:JO:jrm

cc: Robert Rea
New Mexico Energy Research & Development Institute

STATE OF NEW MEXICO
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NMRDI

October 6, 1986

Mr. Robert H. Rea
New Mexico Research and
Development Institute
Pinon Building
Suite 358
1220 South St. Francis Drive
Santa Fe, New Mexico 87501

Dear Mr. Rea:

We at NMOCD have reviewed the draft of "The Potential of Enhanced Oil Recovery By Carbon Dioxide Flooding In New Mexico" and find it quite interesting.

Certainly, in these depressed times, an incentive is needed to promote activity of any kind in the oil and gas industry. We find your report to be well planned and a reasonable and rational approach.

Our concerns are evidently the same as yours as discussed on pages IV-22, 23; viz, the moving target of oil prices in a period of uncertainty, and the tailoring of treatment of each project. We would expect cumulative cost/investment and cumulative payback to be adjusted periodically to bring the total tax-exempt revenue to the total payback ratio, whether 1.7 or some other "tailored" ratio. The cost of CO_2 may involve going into producer's cost records in order to prevent the "loading" of costs mentioned in your discussion. We would expect, however, that the oil-related cost you discussed to be representative in most cases whether it represents an "in-house" sale or a sale between two completely unrelated parties. Where operating agreements are involved, and most EOR projects are joint ventures, the furnishing of goods and services by an operator must be on a competitive basis. We thereby have protection in that situation.

We must also be more than casually interested in how the program may be administered and how our agency may be impacted. Of course this arrangement must be established in the enabling legislation and we would hope to be consulted during the process of developing and passing that legislation.

Returning to your surrogate payback ratio, we perceive that the array of possible candidates would need to be fitted for tax exemption treatment as indicated by the graphs, Exhibit VI-1 on page VI-14. The SR of 1.7 could apply unless the applicant can show the need for a different ratio.

We commend you on the study, and recommend its consideration by the legislature as a needed incentive to reduce our nation's dependence on imported crude oil and as a long range plan to enhance the state's revenue.

Sincerely,

VICTOR T. LYON,
Chief Engineer

VTL/dr

OKLAHOMA
GEOLOGICAL SURVEY
Charles J. Mankin, *Director*

December 2, 1986

Mr. Robert H. Rea, Assistant Director
Project Development
New Mexico Research and Development Institute
Pinon Building, Suite 358
1220 South St. Francis Drive
Santa Fe, New Mexico 87501

Dear Mr. Rea:

I have recently completed a review of the report entitled "The Potential of Enhanced Oil Recovery by Carbon Dioxide Flooding in New Mexico." This report, prepared by the Interstate Oil Compact Commission as one of a series of reports in their overall project on enhanced oil recovery in the states, is a comprehensive analysis of the enhanced oil recovery potential for the State of New Mexico. The report provides detailed analysis directed specifically toward those petroleum reservoirs in New Mexico that are amenable to enhanced oil recovery by carbon dioxide flooding. I found the assumptions contained in the report to be identified and well documented. It is unfortunately a rare pleasure to find a thorough documentation of the assumptions that are included in any study, and I was pleased to find them to be clearly and concisely presented in this report.

I found in general the assumptions involved were reasonable and for the most part conservative. For example, the assumption was made that EOR projects would not be initiated in a particular field until that field had reached its economic limit in a waterflood operation. In fact, a strong case could be made for initiating carbon dioxide in a field during waterflooding operations with a corresponding higher rate of production and an overall higher yield from the reservoir. Obviously the assumption used in this particular analysis should be considered a minimum case for carbon dioxide flooding.

The report also indicates that based on other information the supply picture for carbon dioxide is quite bright and that full implementation of the program in New Mexico would not approach the limit of the resource base for carbon dioxide. That assumption probably is correct, but having seen the experience of the Harding Carbon Dioxide Gas Field in northeast New Mexico, I am somewhat less optimistic about the overall supply picture. However, my information is more than 25 years old and was based on very sketchy information at that time. I am sure current information on the carbon dioxide resource base is much more comprehensive today.

In summary, I believe the report is exceedingly well done and can be used effectively to enhance the economic fortunes of the petroleum industry in the State of New Mexico. I am convinced the report will stand the test of time and would certainly recommend that you and your colleagues give this report and its recommendations your most serious consideration.

I hope this information will be of some assistance to you. If I may be of further assistance on this or other matters, please do not hesitate to contact me.

Sincerely yours,

Charles J. Mankin

Charles J. Mankin
Director

THE UNIVERSITY OF OKLAHOMA / 830 VAN VLEET OVAL, ROOM 163 / NORMAN, OKLAHOMA 73019 / PHONE (405) 325-3031

New Mexico
Petroleum Recovery Research Center
A Division of
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December 2, 1986

Mr. Robert H. Rea
Assistant Director
New Mexico Research & Development Institute
Pinon Building, Suite 358
1220 South St. Francis Drive
Santa Fe, NM 87501

Dear Bob:

I am pleased to comment on the recent IOCC Report entitled, "The Potential of EOR by Carbon Dioxide Flooding in New Mexico." Although the PRRC is not a direct contributor to the report, we have provided some information to the authors and participated in several discussions while the project was underway. Bill Weiss, Dave Martin and I have taken a strong interest in the study and we hope that it will be a useful document.

In general, I feel that the report is realistic and that it provides a good conservative estimate for the effect that tax incentives can have to stimulate oil recovery by CO_2 flooding. Naturally, no work of this kind, which is based upon models which extrapolate a relatively small amount of data to very large production figures, can claim to provide an accurate prediction. On the other hand, the methodology is based on knowledgeable engineers and managers in the oil industry. In addition, as more field data on CO_2 flooding accummulate, the concensus is starting to emerge that, when mismatches occur, the NPC model and other reservoir simulators tend to predict oil recovery by CO_2 flooding on the low, instead of the high side. Therefore, I agree with the authors who claim on pages 55-58 that the estimates of economic benefits from increased oil production are probably conservative.

There are other aspects of the study which should ensure that the authors' estimates of economic benefits to the State are conservative and not overstated. For example, they have included no CO_2-immiscible oil recovery even though there are some successful immiscible floods in other states at the present time. They excluded immiscible flooding possibilities because the NPC Report was not explicit enough to estimate the CO_2 recovery in reservoirs where operators could not meet the required minimum miscibility pressure. The authors also point out that they are not including any potential for other enhanced oil recovery methds such as by polymer flooding and they imply that significant additional oil recovery in New Mexico could result from this method. Another conservative "omission" is the fact that 19% of the reservoirs in New Mexico were not included in the study at all because there was insufficient data to apply the model accurately. However, one should assume that it is probable that some CO_2 flooding could be carried out in those reservoir also.

It appears to us that the authors have prepared a document which should be useful to the legislators if they wish to consider tax incentives in order to encourage operators to initiate CO_2 floods which would not be started otherwise. I thought that the inclusion of the surrogate indicators, for determining when pay-back had been achieved, was a very valuable addition to the study. Their analysis of the surrogate indicators appears to be sound, and the use of the indicators should add little burden to the operator's reporting and accounting procedures which are now required. The authors also point out that there are built-in checks and balances which should discourage abuse of the incentives in almost all field CO_2 projects.

I hope that these comments will be helpful as you and Larry Icerman make the results of the study available to those individuals in the State who are interested. If either Dave, Bill, or I can provide more information or be of help in any way, please call.

Sincerely,

Joe Taber

J.J. Taber
Director

JJT:jeg
xc: F.D. Martin
W.W. Weiss