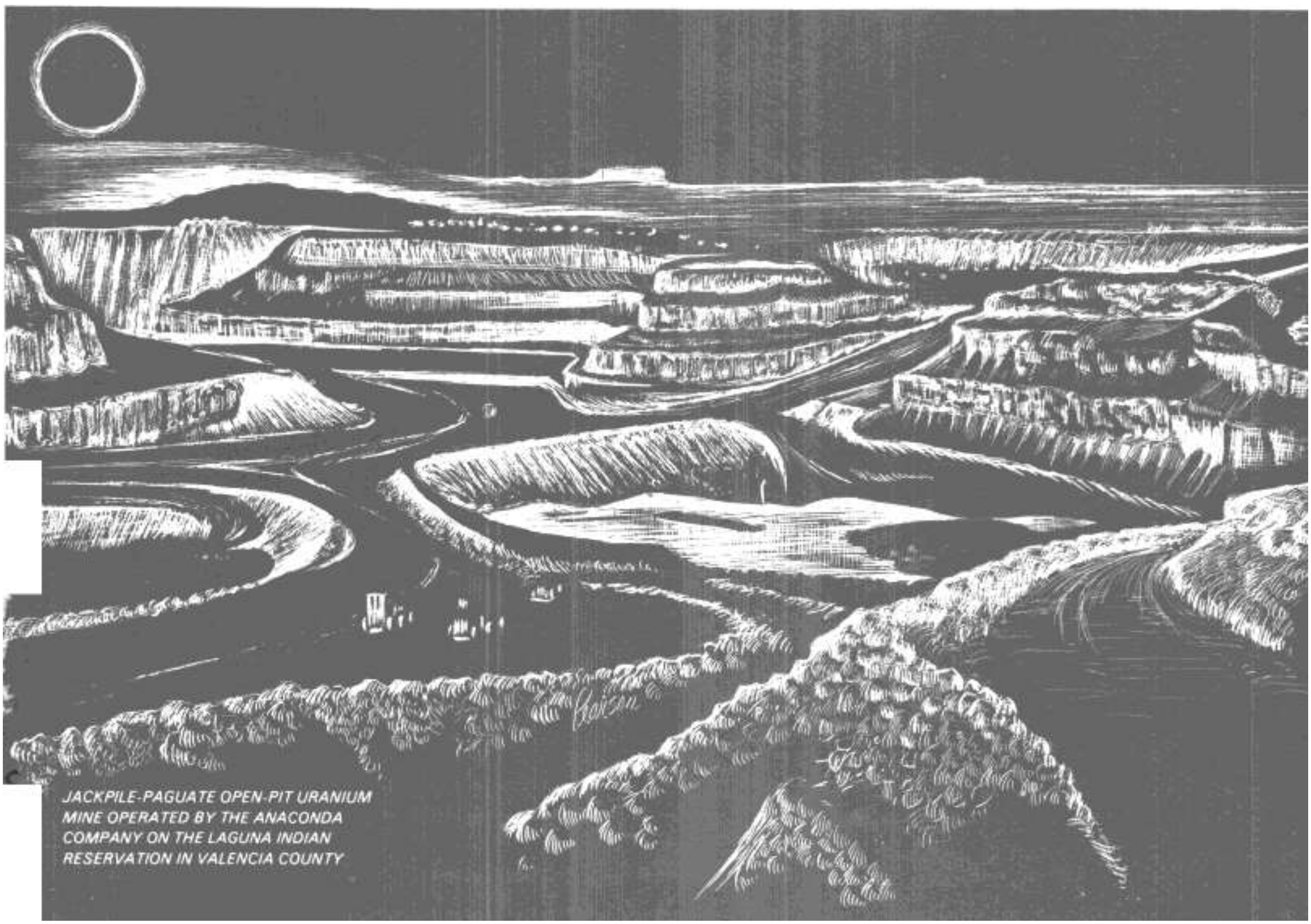
Circular 148 1977

New Mexico's Energy Resources '76

Annual Report of Office of the State Geologist

by
Emery C. Arnold and others

Jerry Apodoca, Governor of New Mexico



New Mexico Bureau of Mines & Mineral Resources

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

Circular 148

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New Mexico's Energy Resources '76
—Annual Report of Office of the State Geologist

compiled by
Emery C. Arnold, State Geologist

with contributions by
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Jerry Apodaca
Governor of New Mexico

SOCORRO 1977

First printing, 1977

Published by Authority of State of New Mexico, NMSA 1953 Sec. 63-1-4
Printed by University of New Mexico Printing Plant, January 1977

Available from New Mexico Bureau of Mines & Mineral Resources, Socorro, NM 87801 Price $1.00

Preface

It is my privilege to present this report to the Governor of New Mexico and to the members of the State Legislature in the hope that it will be of value in aiding them to formulate State energy policy.

The Office of State Geologist was established by Chapter 289 of the laws of 1975. The office was opened in August 1975; permanent quarters are established at No. 2 Jefferson Place in Santa Fe (Post Office Box 2860, 87501; telephone 505/827-2987). The staff consists of the following:

Orin J. Anderson, *Staff Geologist*
Emery C. Arnold, *State Geologist*
David A. Donaldson, *Staff Geologist*
Kay S. Hatton, *Staff Geologist* James
M. Hill, *Deputy State Geologist* Louise
E. Jiron, *Stenographer* Louie B.
Martinez, *Staff Geologist* Ida
Rodriguez, *Administrative Assistant*
Kathleen M. Simmons, *Secretary*

This Office is charged with the responsibility of conducting geological studies aimed at determining reserves of known supplies of energy resources, compiling an inventory of such reserves, and of conducting geological studies of probable and potential supplies. The Office of the State Geologist is also charged with cooperating with the New Mexico Bureau of Mines and Mineral Resources in preparing maps, brochures, and pamphlets on known, probable, and potential sources of energy in New Mexico.

Our first report was issued in January 1976 as New Mexico Bureau of Mines and Mineral Resources Bulletin 107 "New Mexico Energy Resources '75." Circular 148, the second report, contains updated information and is more comprehensive than our first report.

I wish to express my sincere appreciation for the cooperation and assistance received from the New Mexico Bureau of Mines and Mineral Resources, the New Mexico Oil Conservation Commission, the U.S. Bureau of Mines, the U.S. Energy Research and Development Administration, and the many industry personnel who contributed information and advice. Also, in compiling this report a great deal of editorial assistance was provided by Sandra C. Feldman, consulting geologist of Albuquerque.

Emery C. Arnold
State Geologist
Office of the State Geologist

Santa Fe
November 29, 1976

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Abstract

For the last six years the production of **crude oil** and **condensate** in New Mexico has declined from the 1969 high of 129.2 million bbls (barrels). In 1975 production declined to 95.1 million bbls; the decline is expected to continue. Exploration for, and discovery of, oil must increase substantially if further decreases are to be averted. New enhanced recovery projects in older fields may help to slow the decline. Statewide **natural gas** production, which has been increasing since 1969, also experienced a slight decline in 1975. The decline can be attributed to a drop in northwestern New Mexico gas production since the contribution from southeastern New Mexico increased slightly in 1975. The tripling of the price of natural gas at the wellhead will stimulate new exploration and may result in new discoveries. New Mexico **coal production** totaled 9,559,920 tons in 1975, most of it from the Navajo and San Juan mines. The Federal Coal Leasing Act of 1975 made provisions for each state to receive an increased share of the monies generated from mineral extraction on Federal land. New Mexico, with its high percentage of federally owned lands, may expect a substantial increase in benefits under this act. The increasing use of coal as a fuel in electrical generating facilities will be the major factor in the future growth of the coal industry. Coal gasification plants, while still an uncertainty, would cause a huge increase in coal production. New Mexico ranked first in the nation in U_3O_8 production and reserves in 1975, and has contributed 40 percent of the cumulative production of U_3O_8 in the United States to date. Thirty-dollar forward-cost reserves total 302,700 tons of U_3O_8. Potential **geothermal** energy areas occur along the Rio Grande valley, and in the west-central and southwestern portions of the state. As of the fall of 1976, the U.S. Bureau of Land Management had issued a total of 64 geothermal leases in New Mexico.

New Mexico's Energy Position Compared with Selected Energy-Producing States

The Rocky Mountain region, taken here to include the states of Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming, has been characterized as a large producer and exporter of fossil fuel and electricity. In 1974 the consumption in these states was equal to 60 percent of the total production as calculated from table 1. New Mexico was the major energy exporter, shipping out the equivalent of 1,626 trillion Btu (British thermal units) annually, followed by Wyoming at 1,200 trillion Btu. Montana is the only other net exporter of energy, the other five states being net importers.

Other states that are major energy producers in the west but have not been included in table 1 are Texas and Oklahoma. Texas coal, oil, and gas production was 17,098 trillion Btu compared to 2,058 trillion Btu for New Mexico. Texas and Oklahoma, along with Louisiana, comprise an "energy province" that contributed 67 percent of the total domestic crude oil in 1974 and 81 percent of the natural gas. New Mexico contributed 3.1 percent of the total domestic crude oil; the Four Corners states contributed 5.5 percent, whereas the entire Rocky Mountain region contributed 11 percent. Comparing natural gas production statistics, New Mexico accounts for 5.6 percent of the national output, the Four Corners states contributed 6.5 percent, and the Rocky Mountain region (including the Dakotas) contributed 8.0 percent. Only two states in the region, New Mexico and Wyoming, are net exporters of natural gas.

The Rocky Mountain region's petroleum production is significant, but electricity produced from coal is, and will increasingly become, one of the region's most valuable energy contributions. Strippable reserves in Montana, Wyoming, and New Mexico total over 71 billion tons. In addition to the use of coal in electrical generating plants, in the near future the region will also become part of the gas supply as coal gasification plants go on line. Synthetic natural gas will rise to 18 percent of the total gaseous fuel consumption by the year 2000, according to Interior Department projections.

Table 2 shows the position of New Mexico in relation to the immediately adjacent states with respect to production and reserves of oil, gas, coal, and uranium.

New Mexico has led the United States in uranium production for many years. Cumulatively, the state has contributed 40 percent of the U_3O_8 produced nationally to 1974. New Mexico reserves also exceed those of other uranium producing states, including Wyoming, the other major producer. With the rise of nuclear power facilities, uranium in New Mexico will become increasingly important in future years.

TABLE 1—1974 REGIONAL ENERGY BALANCE SHEET; UNITS ARE TRILLION BTU (New Mexico is underlined; from Barrett, R. J., Byer, W. A., and Kolstad, C. D., 1975, *Rocky Mountain Energy 1974;* Flows, Employment, Prices: LASL)

	Coal			Oil & natural gas liquids			Natural gas			Electricity			Total (fossil fuel equivalent)		
STATE	Prod	Cons	Exports (Imports)	Prod	Cons	Exports (Imports)	Prod	Cons	Exports (Imports)	Prod	Cons	Exports (Imports)	Prod[1]	Cons[2]	Exports (Imports)[3]
AZ	141.7	49.6	75.4	4.2	304.0	(300.6)	0.04	163.5	(163.5)	70.1	69.2	(9.5)	222.4	614.5	(417.5)
CO	162.0	130.4	5.5	223.6	281.5	(68.9)	142.6	321.0	(184.4)	53.4	50.8	(5.0)	542.8	749.5	(263.0)
ID	-	10.1	(10.1)	-	99.3	(99.3)	-	50.2	(50.2)	33.1	44.1	(17.6)	100.2	313.1	(212.9)
MT	254.2	14.7	241.1	193.4	115.7	35.1	45.0	79.4	(35.0)	37.7	31.4	1.6	593.3	304.4	246.0
NV	-	100.1	(97.6)	0.8	101.1	(100.3)	-	70.7	(70.7)	47.1	26.5	16.7	17.4	229.9	(218.0)
NM	176.6	141.1	35.5	715.1	169.2	486.7	1165.2	165.9	980.7	68.5	24.2	40.7	2057.7	344.6	1626.2
UT	147.9	98.8	49.5	228.9	149.0	38.5	44.5	121.6	(77.0)	13.5	24.8	(15.0)	431.0	425.3	(34.5)
WY	393.4	110.8	272.2	811.8	92.4	635.4	312.6	73.9	231.7	36.9	14.4	20.3	1532.4	226.2	1200.8
Region	1275.8	655.6	571.5	2177.8	1312.2	626.6	1709.94	1066.2	631.6	360.3	285.4	32.2	5497.2	3207.5	1927.1

1. Total fossil fuel production plus fossil fuel equivalent of hydroelectric production; fossil fuel equivalent of hydroelectric production is obtained by dividing by .33

2. Total fossil fuel consumption plus fossil fuel equivalent of electricity consumption less fuel used for electricity production; fossil fuel equivalent of electricity consumption is obtained by dividing by the product of an average generation efficiency of .33 and transmission efficiency of .87

3. May not equal difference between consumption and production because of losses and fuel used in processing

TABLE 2—NEW MEXICO'S PRODUCTION AND RESERVES OF OIL, GAS, COAL, AND URANIUM COMPARED TO ADJACENT STATES IN 1975 (W means withheld)

	CRUDE OIL				TOTAL GAS				COAL				URANIUM (U_3O_8)			
	Production		Reserves		Production		Reserves		Total Production		Strippable Reserves		Production		Reserves[10]	
STATE	Million Bbls	Nat. Rank	Million Bbls	Nat. Rank	Billion cu ft	Nat. Rank	Billion cu ft	Nat. Rank	Million Tons	Nat. Rank	Million Tons	Nat. Rank	Tons U_3O_8	Nat. Rank	Tons U_3O_8	Nat. Rank
New Mexico	90.39[1]	6	588.1	7	1,120.80[1]	4	11,759.3[1]	6	9.60[3]	12	5,772[5]	7	5,500[10]	1	302,700[10]	1
Texas	1,176.25[1]	1	10,080.0	1	7,041.80[1]	2	71,036.8[1]	1	11.00[4]	11	3,270[6]	11	670[8]	-	43,900[10]	3
Oklahoma	152.77[1]	4	1,239.7	5	1,672.40[1]	3	13,083.0[1]	4	2.77[4]	21	434[6]	19	--	-	--	-
Colorado	37.30[1]	12	276.1	9	165.30[1]	8	1,893.0[1]	-	8.16[4]	14	870[6]	16	W	-	34,200	-
Utah	39.09[1]	11	208.3	12	58.60[1]	17	917.4[1]	-	6.60[4]	17	262[6]	-		-		-
Arizona	.63[2]	-	--	-	.25[2]	-	--	-	6.80[4]	16	350[6]	-	--	-	--	-

1. API Vol. 30, 1976
2. Western Oil Reporter, April, 1976
3. New Mexico State Inspector of Mines, 63rd annual report, December, 1975
4. 1976 Keystone Coal Industry Manual
5. New Mexico Bureau of Mines Bulletin 107, "New Mexico Energy Resources '75"
6. U. S. Bureau of Mines, Mineral Industry Survey, "Coal-Bituminous & Lignite, 1974"
7. ERDA, Grand Junction, March 11, 1976 News Release
8. Texas Railroad Commission, Inter-office Communication, June, 1976
9. Utah Dept. of Natural Resources "Energy Resource Data, March, 1976"
10. ERDA, 1976a

Oil and Gas

by E. C. Arnold, J. M. Hill, and D. A. Donaldson, *Office of the State Geologist, and*
R. W. Foster, *New Mexico Bureau of Mines & Mineral Resources*

In 1975 New Mexico ranked sixth in the nation in the production of crude oil, following Texas, Louisiana, California, Oklahoma, and Wyoming. New Mexico ranked fourth after Louisiana, Texas, and Oklahoma in natural gas production. Of the total area of 77.7 million acres in the state, 36.7 percent has proved productive in terms of oil and gas or is under lease for exploration.

The petroleum industry is the greatest single source of tax revenues for the State of New Mexico. About 95 percent of the revenue that the State received through the Federal Mineral Leasing Act in 1975 was derived from the production of oil and gas on federal lands. The petroleum industry had over 19,000 employees in New Mexico in 1975. The industry continues to be one of the largest non-government employers.

OIL PRODUCTION

SOUTHEAST NEW MEXICO

Crude oil production in southeast New Mexico for 1975 was 86.37 million bbls compared with 88.48 million bbls in 1974, representing a 2.4-percent decline. However, if the Empire Abo Pool had not increased production by 1.84 million bbls for the year, the percentage decline would have been 4.5 percent. A production increase from old well workovers is believed to have also helped to reduce the rate of decline.

Crude oil production for the first 7 months of 1976 was 49.08 million bbls. This is 2.4 percent less than the 50.31 million bbls produced in the first 7 months of 1975. The relatively small percentage of decline is believed to have resulted primarily from increased production from old well workovers and from deeper drilling in existing wells. Condensate production for the first 7 months of 1975 was 1.24 million bbls and 1.40 million bbls in 1976. The 11-percent condensate increase over 1975 is directly related to the increase in natural gas production.

NORTHWEST NEW MEXICO

Oil production in northwest New Mexico continued to decline through 1975. Combined crude oil and condensate production for the year was 6.50 million bbls, a decrease from 1974 by over 1.5 million bbls. The declining production trend is expected to continue through 1976 and will not be reversed unless substantial new reserves are found. The decline can be attributed to a number of factors. The bulk of the oil produced in northwest New Mexico comes from the Gallup Sandstone reservoirs which are now reaching their economic production limits. Secondary recovery methods accounted for 52 percent of the total crude oil produced in this region in 1975; only a limited number of producing pools are left from which additional secondary oil could be recovered.

The outlook for 1976 is not bright; oil production for the first 7 months of 1976 compared with the same 7 months of 1975 was down by 380,000 bbls.

GAS PRODUCTION

SOUTHEAST NEW MEXICO

Dry gas production in southeast New Mexico was 238.5 billion cu ft for the first 7 months of 1976, an increase of 18.6 billion cu ft, or 8 percent above the 219.9 billion cu ft produced in the same period in 1975. The increase was due mainly to the completion and connection of a number of unusually large-capacity Morrow gas wells in the latter part of 1975 and the first 7 months of 1976. The increased compression facilities installed by natural gas transporters and pipeline allowable-production balancing which occurred earlier in 1975 than in 1976 also contributed to the increase.

NORTHWEST NEW MEXICO

Only twice did northwest New Mexico's annual dry gas production exceed 570 billion cu ft of gas. The last time this figure was exceeded was in 1972, during which 574 billion cu ft of gas was produced. Since the 1972 production high, the succeeding years have been marked by an annual production decline. This 3-year decline has ranged from 1 to 5.4 percent with 1975 production registering the largest drop. Table 4 shows the annual production and percent decline for 1972 through 1975.

The Mesaverde, Dakota, and Pictured Cliffs Formations dominate northwest New Mexico dry gas production. In 1975 these formations contributed over 95 percent of the dry gas produced in the San Juan Basin. Two pools within these formations, the Blanco Mesaverde and the Basin Dakota, have accounted for 43 and 32 percent respectively of the region's dry gas production in 1975; these pools will continue to dominate dry gas production in the future. However, they have also largely accounted for the production decline between 1972 and 1975.

Indications are that 1976 production from northwest New Mexico will be slightly higher than 1975 production. Gas production for the first 7 months of 1976 was up 11.2 billion cu ft or 3.6 percent over the same 7-month period in 1975. Production analysis shows that the increase occurred from new infill drilling in the Blanco Mesaverde Pool and from new development in pools in the Pictured Cliffs Formation, primarily the Blanco and South Blanco Pools.

Casinghead gas production for 1975 in northwest New Mexico was 14 billion cu ft and represents only 2.7 percent of the total 518.5 billion cu ft of gas produced in the region for that year. Since casinghead gas production is tied to oil production, any sizable increase in casinghead gas could only come about through the discovery of substantial new oil reserves.

TABLE 3—PRODUCTION OF OIL AND NATURAL GAS IN NEW MEXICO, 1960 TO 1975 (*Source: NMOCC*)

	Barrels				*Thousand cubic feet*		
Year and area	*Oil*	*Condensate*	*Total oil and condensate*	*Water*	*Casinghead gas*	*Dry gas*	*Total gas*
NW	13,430,845	1,374,351	14,805,196	915,768	31,266,992	342,133,828	373,400,820
SE	91,149,978	1,409,974	92,559,952	84,017,567	262,155,625	186,358,171	448,513,796
1960, total	104,580,823	2,784,325	107,365,148	84,933,335	293,422,617	528,491,999	821,914,616
NW	14,210,632	1,525,358	15,735,990	1,862,902	39,954,895	319,541,175	359,496,070
SE	95,596,439	1,220,972	96,817,411	97,512,336	269,373,304	157,725,609	427,098,913
1961, total	109,807,071	2,746,330	112,553,401	99,375,238	309,328,199	477,266,784	786,594,983
NW	9,181,861	1,659,507	10,841,368	3,839,406	35,895,143	304,909,639	340,804,782
SE	97,225,296	1,261,389	98,486,685	113,139,221	275,932,682	170,015,467	445,948,149
1962, total	106,407,157	2,920,896	109,328,053	116,978,627	311,827,825	474,925,106	786,752,931
NW	7,942,818	1,874,934	9,817,752	4,470,887	27,183,166	321,553,533	348,736,699
SE	98,794,993	1,370,312	100,165,305	127,283,521	272,556,376	171,932,132	444,488,508
1963, total	106,737,811	3,245,246	109,983,057	131,754,408	299,739,542	493,485,665	793,225,207
NW	7,443,260	2,550,525	9,993,785	7,131,448	20,991,913	405,718,222	426,710,135
SE	102,508,438	1,361,185	103,869,623	138,760,709	270,538,055	195,430,490	465,968,545
1964, total	109,951,698	3,911,710	113,863,408	145,892,157	291,529,968	601,148,712	892,678,680
NW	8,776,902	2,804,888	11,581,790	10,600,522	18,467,730	441,561,504	460,029,234
SE	105,966,181	1,618,506	107,584,687	150,261,064	276,863,641	208,128,648	484,992,289
1965, total	114,743,083	4,423,394	119,166,477	160,861,586	295,331,371	649,690,152	945,021,523
NW	8,159,673	3,196,280	11,355,953	13,533,781	15,222,739	483,275,803	498,498,542
SE	111,015,456	1,819,342	112,834,798	158,177,814	286,076,861	228,035,560	514,112,421
1966, total	119,175,129	5,015,622	124,190,751	171,711,595	301,299,600	711,311,363	1,012,610,963
NW	7,533,818	3,528,057	11,061,875	16,198,320	13,928,329	523,356,226	537,284,555
SE	113,060,912	1,879,664	114,940,576	167,575,219	281,722,938	236,644,443	518,367,381
1967, total	120,594,730	5,407,721	126,002,451	183,773,539	295,651,267	760,000,669	1,055,651,936
NW	6,732,250	3,673,081	10,405,331	17,020,379	13,140,201	580,374,026	593,514,227
SE	115,700,459	2,505,535	118,205,994	195,073,824	279,612,600	277,239,086	556,851,686
1968, total	122,432,709	6,178,616	128,611,325	212,094,203	292,752,801	857,613,112	1,150,365,913
NW	6,011,237	3,035,489	9,048,726	16,929,938	12,964,592	538,010,671	550,975,263
SE	117,722,236	2,455,899	120,178,135	210,505,804	282,222,689	280,642,531	562,865,220
1969, total	123,735,473	5,491,388	129,226,861	227,435,742	295,187,281	818,653,202	1,113,840,483
NW	5,780,167	2,905,943	8,686,110	18,593,311	11,066,422	513,961,890	525,028,312
SE	117,181,123	2,280,664	119,461,787	226,808,233	292,907,627	305,519,255	598,426,882
1970, total	122,961,290	5,186,607	128,147,897	245,401,544	303,974,049	819,481,145	1,123,455,194
NW	6,012,907	2,801,992	8,814,899	18,860,437	11,573,567	546,546,676	558,120,243
SE	107,708,035	1,887,036	109,595,071	206,386,656	291,253,975	298,056,323	589,310,298
1971, total	113,720,942	4,689,028	118,409,970	225,247,093	302,827,542	844,602,999	1,147,430,541
NW	5,730,714	2,874,298	8,605,012	20,415,149	12,314,515	574,019,873	586,334,388
SE	99,665,888	2,254,324	101,920,212	196,174,211	259,535,532	351,899,738	611,435,270
1972, total	105,396,602	5,128,622	110,525,224	216,589,360	271,850,047	925,919,611	1,197,769,658
NW	5,175,343	2,394,207	7,569,550	20,659,128	12,932,204	537,186,284	550,118,488
SE	91,233,655	2,182,481	93,416,136	199,979,510	250,718,587	398,702,355	649,420,942
1973, total	96,408,998	4,576,688	100,985,686	220,638,638	263,650,791	935,888,639	1,199,539,430
NW	5,599,465	2,401,954	8,001,419	26,544,506	14,612,336	532,780,048	547,392,384
SE	88,483,452	2,210,094	90,693,546	204,598,067	289,089,197	393,191,355	682,280,552
1974, total	94,082,917	4,612,048	98,694,965	231,142,573	303,701,533	925,971,403	1,229,672,936
NW	4,378,951	2,118,324	6,497,275	24,324,927	14,046,453	504,499,980	518,546,433
SE	86,374,571	2,190,689	88,565,260	208,391,779	291,662,510	392,897,887	684,560,397
1975, total	90,753,522	4,309,013	95,062,535	232,716,706	305,708,963	897,397,867	1,203,106,830

TABLE 4—DRY GAS PRODUCTION IN NORTHWEST NEW MEXICO, 1971 TO 1975 (*Source: NMOCC*)

Year	Gas production (billion cubic ft)	% Decline
1972	574.0	
1973	537.2	4.4
1974	532.8	1.0
1975	504.5	5.4

NATURAL GAS LIQUIDS PRODUCTION

Natural gas liquids are recovered from natural gas produced either concurrently with crude oil (casinghead or associated) or independently of crude oil (dry or nonassociated). New Mexico's 1975 natural gas liquid production was converted to gasoline, butane, and propane.

In 1975 there were 38 extraction plants operating in New Mexico. Thirty-one of these were located in southeast New Mexico, and the remaining 7 were in the northwest section of the state. The 38 plants had a total intake of 981 billion cu ft of natural gas. After stripping, 864 billion cu ft of gas was passed on to the interstate or intrastate pipeline system. The 38 plants produced 14,434,531 bbls of gasoline, 8,088,538 bbls of butane, and 9,714,182 bbls of propane. The American Petroleum Institute lists New Mexico gas liquids reserves as of January 1, 1976, as 368,563,000 bbls.

DRILLING AND DEVELOPMENT

SOUTHEAST NEW MEXICO

Gas and oil well completions between 1971 and 1975 in southeast New Mexico have fluctuated. Total well completions and gas well completions reached a peak in 1974, while oil well completions peaked in 1972 and 1975. For the first 8 months of 1975, there were 508 completions, of which 258 were oil, 150 were gas, and 100 were plugged and abandoned. According to the New Mexico Oil Conservation Commission, well completions for the first 8 months of 1976 are up slightly over the same period in 1975. During that period in 1976 there were 534 completions, of which 299 were oil, 128 were gas, and 107 were plugged and abandoned. Although the number of completions was higher, the amount of footage drilled was down from 3,008,843 ft to 2,637,870 ft. Completions are expected to taper off considerably in the remaining months of 1976, since fewer new locations have been filed this year than were filed for the same period last year. The main reason for the decrease in new locations is attributed to fewer new gas well applications being filed in Eddy County.

TABLE 5—OIL AND GAS WELL COMPLETIONS IN SOUTHEAST NEW MEXICO (*Source: NMOCC*)

Year	Oil	Gas	Dry	Total	% Increase or decrease
1971	392	58	158	608	
1972	422	94	150	666	+ 10
1973	240	178	182	600	- 10
1974	382	249	173	804	+ 34
1975	422	224	133	779	- 3
1976 (first 8 mo.)	299	128	107	534	

NORTHWEST NEW MEXICO

Well completions in 1975 were up from 1974 in northwest New Mexico, although the total wells drilled was down by 17 (table 6). The success ratio for 1975 was higher than in previous years, with 26 fewer dry holes being drilled.

Gas well completions for 1975 increased by 8; the largest number of gas completions resulted from extension drilling in the Blanco Pool in the Pictured Cliffs Formation, infill drilling in the Blanco Mesaverde Pool, and discovery and development of the Ojo and Nipp Pictured Cliffs Pools. In the first 8 months of 1976, there were 170 gas well completions. The Pictured Cliffs Formation again received the most interest with 79 new wells completed, representing 46.5 percent of the total gas well completions in northwest New Mexico during this period. The Mesaverde Formation had the second greatest number of completions with 54 new wells, 31.8 percent of the total in the northwestern region.

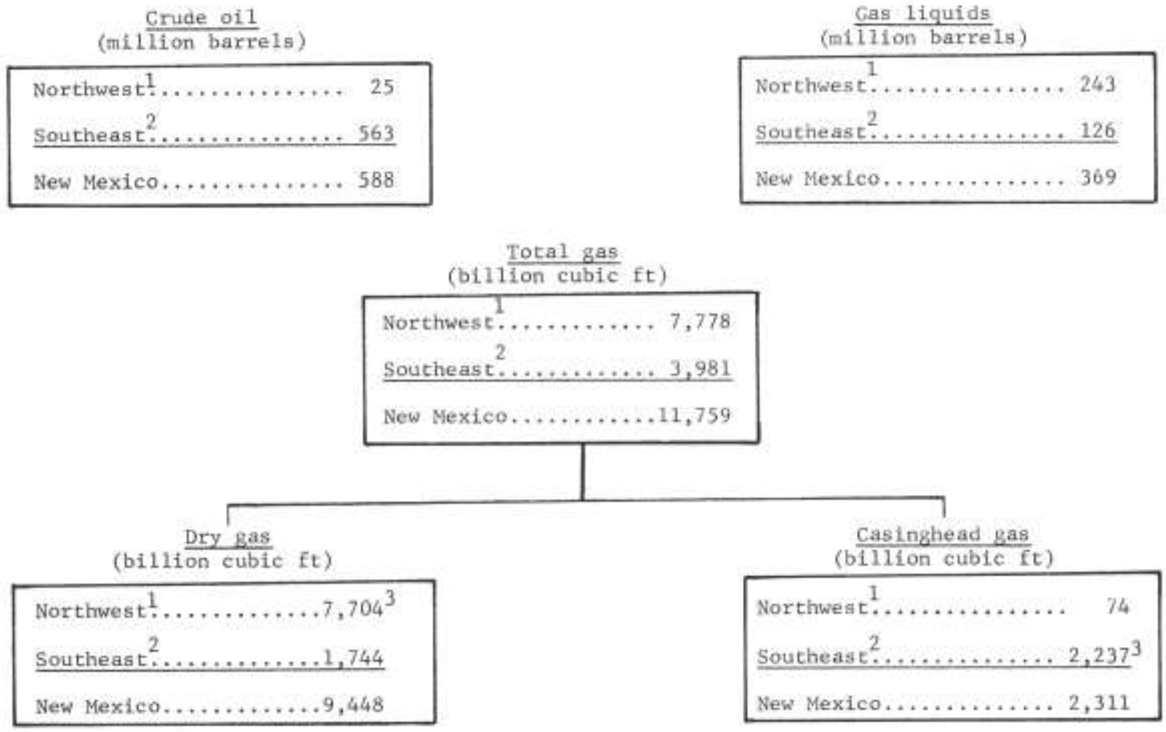
The 63 oil well completions for 1975 kept pace with 1974 with an increase of only one. The total 1976 oil completions is expected to be lower than the 1975 figure.

OIL RESERVES

Crude oil reserves in New Mexico as of the end of 1975 totaled 588.1 million bbls. Of the total, 96 percent is estimated to occur in southeast New Mexico and the remaining 4 percent in northwest New Mexico. American Petroleum Institute sources estimate that 300 billion bbls of oil remains in known fields in the United States which cannot be recovered using known techniques and at current oil prices. Approximately 10.7 billion bbls of this oil is in New Mexico pools. Some sources estimate that by using new high efficiency exotic enhanced techniques, recovery of the original oil in place can be increased 15 percent. A 10-percent increase would add over 1 billion bbls to New Mexico oil reserves. Statistics on proven reserves, cumulative production, and currently unrecoverable oil are depicted in fig. 2.

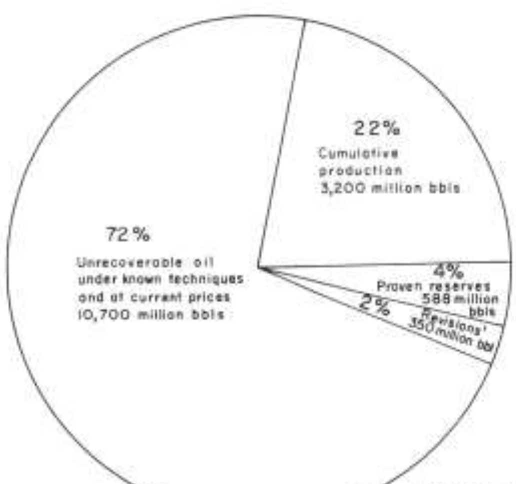
TABLE 6—OIL AND GAS WELL COMPLETIONS IN NORTHWEST NEW MEXICO (*Source: NMOCC*)

Year	Oil	Gas	Dry	Total
1971	49	182	72	303
1972	40	260	105	405
1973	33	434	65	532
1974	62	332	57	451
1975	63	340	31	434
1976 (first 9 mo.)	38	215	58	311



1. Northwest New Mexico includes McKinley, Sandoval, San Juan, and Rio Arriba Counties
2. Southeast New Mexico includes Chaves, Roosevelt, Lea, and Eddy Counties
3. Includes underground storage gas

FIGURE 1—NEW MEXICO'S OIL AND GAS RESERVES AS OF DECEMBER 31, 1975 (*Source: American Petroleum Institute*).



	Million barrels
1975 estimate of original oil-in-place	14,600
Unrecoverable oil under known techniques and at current prices	10,700
Cumulative production	3,200
Proven reserves	588
Revision[1]	350

1. API additional secondary reserves

FIGURE 2—ESTIMATED CRUDE OIL RESERVES IN NEW MEXICO (*Source: American Petroleum Institute*).

GAS RESERVES

New Mexico ranked sixth in the nation in terms of total natural gas reserves. States with greater reserves were (from most to least) Texas, Louisiana, Alaska, Oklahoma, and Kansas. New Mexico gas reserves at the end of 1975, as reported by the American Petroleum Institute, amounted to 11.759 trillion cu ft. Of the total, 66 percent is estimated to occur in northwest New Mexico and the remaining 34 percent in the southeastern part of the state.

The gas reserves referred to in this report for established fields are those reported by the American Petroleum Institute. Independent studies are being conducted by the Office of the State Geologist and the New Mexico Bureau of Mines and Mineral Resources. Estimates of reserve additions in future years are from the Office of the State Geologist and are highly speculative in some instances. However, they are a composite opinion based upon our studies, opinions from individuals and companies operating in the state, as well as opinions from geologists and engineers with other State and Federal agencies.

SOUTHEAST NEW MEXICO—PROBABILITY OF ADDED RESERVES

The best prospect for additions to gas reserves in southeast New Mexico appears to be from lower Pennsylvanian strata (Atokan-Morrowan Series). In 1975, 67.5 percent of the dry gas produced in southeast New Mexico came from the Pennsylvanian, and 65.9 percent of this was from the Atoka and Morrow Formations.

Large areas, particularly in Eddy County, are favorable for additional exploration in the Morrow Formation. These areas are adjacent to producing areas and have a similar geologic setting. Pay zones within the Morrow Formation are lenticular and variable in thickness, generally ranging from 10 to 70 ft. Depths range from 8,500 to 12,000 ft; therefore, exploration and development costs are high. Estimates by reliable geological and engineering firms of possible future discoveries of Morrow gas run as high as 7 trillion cu ft. While this may be realistic, we are forecasting a more conservative estimate of 4 trillion cu ft which may be added to present reserves during the next 15 years. The estimate is a speculative figure and should be treated as such.

NORTHWEST NEW Mexico—PROBABILITY OF ADDED RESERVES

The Cretaceous section in northwest New Mexico has been extensively explored. Over 8,957 gas wells are now producing or have produced. Major discoveries of either oil or gas in Cretaceous rocks are not likely in the future. Exploration has indicated the existence of many thin, marginal, gas-producing zones adjacent to producing areas. With the new gas prices in effect, development of those zones is expected to proceed at an accelerated rate. As many as 200 wells per year for the next 5 years might be completed in marginal zones. The new price should also be sufficient, particularly with future adjustments, to bring on additional development of small capacity Dakota gas wells. Possibly an additional 1,000 wells might be completed in the Dakota Formation at the new price. In the fall of 1974, the New Mexico Oil Conservation Commission approved infill drilling to 160-acre density in the Blanco Mesaverde Gas Pool which had previously been developed on 320-acre tracts. The denser drilling pattern will probably add 15 to 30 percent to original pool reserve estimates. At the new gas price 200 gas wells per year will probably be drilled in this pool during the next 10 years. The drilling rate might exceed 200 if rigs are available. In addition to adding recoverable reserves, development in the Blanco Mesaverde Pool would also substantially increase deliverability from the pool; this additional capacity would go far in slowing the production decline rate from the northwestern region. If all the development mentioned is accomplished over the next 10 or 15 years, 5 trillion cu ft of gas might be added to Cretaceous reserves in the San Juan Basin.

The brightest hope for major new oil or gas development in northwest New Mexico is in the undeveloped 6,000-ft thick Paleozoic section below the Dakota Sandstone. The possibility of major strikes below the Dakota must be classed as speculative for the present. As in southeast New Mexico the future of deep exploration in the San Juan Basin depends upon the oil and gas price structure.

FUTURE CASINGHEAD GAS RESERVES

Casinghead gas production has for years provided a substantial contribution to total gas production in New Mexico. Production has exceeded 250 billion cu ft per year every year since 1960. The high was in 1962 when 311.8 billion cu ft were produced. Production in 1975 was 305.7 billion cu ft, which was 25 percent of total state gas production.

Many of our large oil pools are now declining in production, and waterflooding projects have been instituted in a large number of them. Casinghead gas production from these pools is also declining, and the rate of decline will probably increase. For this reason we have forecast a 10-percent casinghead gas production decline in the years ahead. The decline can only be arrested or reversed by the discovery of significant new oil pools.

The Office of the State Geologist has previously issued a crude oil production projection which indicated that a new oil addition rate of 30 million bbls per year plus additional oil from waterflood projects would be necessary to prevent the crude oil production decline from exceeding 5 percent per year. If this increased discovery rate occurs, and if we use the statewide average gas-oil ratio of 2,650 cu ft of gas per bbl of oil, the addition to casinghead gas reserves would be approximately 80 billion cu ft of gas per year, adding 800 billion cu ft during the next 10 years.

SECONDARY OIL RECOVERY SOUTHEAST NEW MEXICO

The decision to concentrate first on the 50 largest producing pools as of January 1, 1975, was made after a brief study of the oil pools in southeast New Mexico. Each of the 50 pools produced 250,000 bbls or more during 1974. Oil production for these pools in 1975 was 71,172,393 bbls, which was approximately 82 percent of the total production of 86,374,571 bbls in southeast New Mexico for 1975. Horizontal boundaries of the 50 pools were plotted as of December 31, 1975, as well as production curves based on yearly production.

According to the New Mexico Oil Conservation Commission (NMOCC) there were 272 active secondary recovery projects in southeast New Mexico as of December 31, 1975. These projects are located in 74 pools and are operated by 85 operators. Thirty of these pools are included in the 50 largest producing pools and contain 207 (76 percent) of the total projects. Because of time limitations the initial study will be made only on these 207 projects.

The 30 pools, as well as the secondary recovery project injection wells within the pools, were plotted on maps. The total pool acreage was calculated as of December 31, 1975, and by using NMOCC Rule 701, the active and depleted waterflood acreage was calculated and plotted. These pools contained 903,000 acres with 313,000 acres either currently or previously under flood. Cumulative pool production and cumulative secondary production were tabulated yearly from 1965 through 1975. Crude oil production for the 30 pools for 1975 was 55,645,037 bbls (primary and secondary), and for the 207 projects was 24,487,191 bbls (secondary only).

Additional reservoir, reserve, and production information is now being obtained for the 207 projects as well as for the balance of projects in southeast New Mexico. When this information is complete, an analysis of past and present performance of secondary projects will be made on a formation basis. This information will then be projected into other areas not yet under flood so that a more accurate analysis of the production of oil in the future by secondary methods can be made.

NORTHWEST NEW MEXICO

The highest total annual oil production in northwest New Mexico was reached in 1961, approximately 4 years after major oil field development. There was a sharp decline in annual production during the years 1962, 1963, and 1964, with an improvement in 1965. The improvement can partially be attributed to the impact of secondary recovery which was being instituted in the various pools during the early 1960's. Secondary recovery is a method in which fluid, either gas or liquid, is injected into the producing horizon to restore or maintain the reservoir pressure or natural energy lost by primary production.

After 1965 a general decline was experienced in both secondary and primary production in northwest New Mexico. The trend has continued to the present, although erratic fluctuations have occurred. As shown in fig. 3 and table 7, secondary production totaled only 1.9 million bbls in 1975. The 1975 figure represents a decrease in production of over 64 percent from the 1966 high of 5.2 million bbls.

In 1975, with the termination of the Escrito Gallup unit and North Many Rocks Gallup Pressure Maintenance Project #1, 23 secondary recovery units were operating in northwest New Mexico, 2 less than in 1974. Table 7 indicates that the 23 active secondary recovery units were producing from 13 pools. The Gallup Formation, the most prolific of the oil reservoirs, accounted for 78.5 percent of the secondary oil production.

In 1975 secondary production in northwest New Mexico decreased by 455,954 bbls from 1974 levels. Each producing formation showed a decrease with the exception of the Mesaverde, which registered a small increase of 738 bbls. Production from the Dakota Formation experienced the greatest decline, 175,582 bbls lower than the previous year. The only secondary producing unit in the Dakota Formation is the Lone Pine "D" unit.

Fig. 4 is a 4-category classification of the total crude oil production for northwest New Mexico. Groups 1 and 2 denote production from pools that are producing by primary reservoir energies. Group 3 production is from

TABLE 7—SECONDARY OIL RECOVERY PROJECTS IN NORTHWEST NEW MEXICO, 1965 TO 1975 (*Source: NMOCC*)

Date	Number of projects	Number of pools	Secondary production (barrels) Annual	Cumulative
1965	32	17		30,067,661
1966	32	17	5,237,282	35,304,943
1967	30	15	5,029,125	40,334,068
1968	31	17	3,819,997	44,154,065
1969	27	14	2,750,671	46,904,736
1970	28	14	4,296,587[1]	51,201,323
1971	28	14	2,801,752	54,003,075
1972	29	16	3,235,390	57,238,465
1973	26	16	2,874,260	60,112,725
1974	25	15	2,325,501	62,438,226
1975	23	13	1,869,547	64,307,773

1. Puerto Chiquito Adjustment

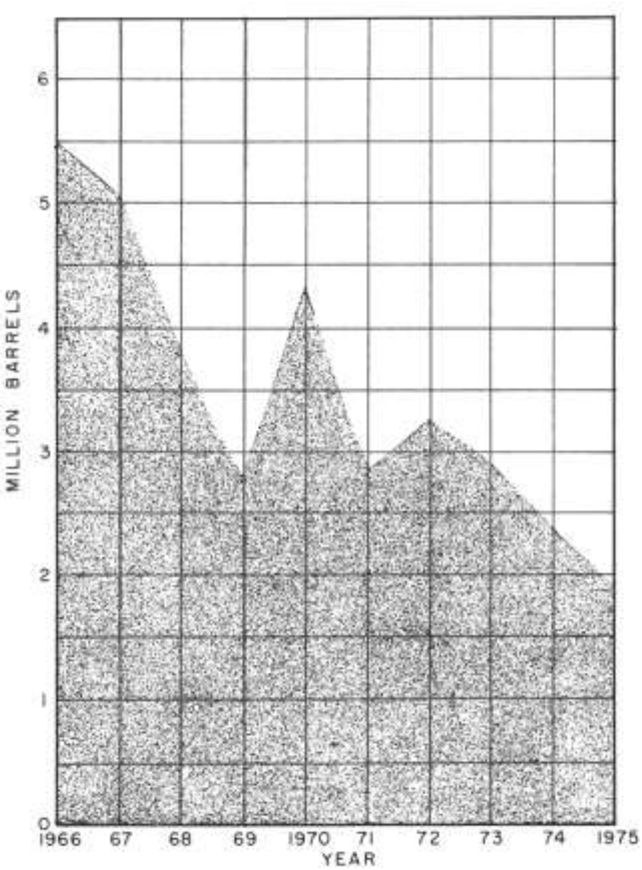
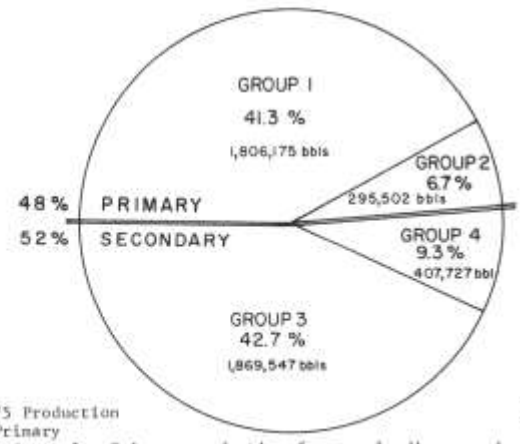


FIGURE 3—SECONDARY OIL PRODUCTION IN NORTHWEST NEW MEXICO, 1966 TO 1975 (*Source: NMOCC*).



1975 Production	Barrels
Primary	
Group 1 - Primary production from pools discovered before Jan. 1,1970	1,806,175
Group 2 - Primary production from pools discovered after Jan. 1,1970	295,502
Secondary	
Group 3 - Secondary production (active units)	1,869,547
Group 4 - Secondary production (inactive units)	407,727
Total	4,378,951

FIGURE 4—DISTRIBUTION OF NORTHWEST NEW MEXICO ANNUAL OIL PRODUCTION FOR 1975 (*Source: NMOCC*).

the 23 active secondary recovery projects, and the production from Group 4 is the annual oil production from secondary projects in which fluids are no longer being injected but which are still producing. As shown in fig. 4, 52 percent of the 1975 oil production from northwest New Mexico was produced by secondary recovery methods. Additional projects in existing pools will have to be in Groups 1 and 2, and our observations indicate that the prospect of successful secondary projects being instituted in very many of these pools is remote.

The outlook for northwest New Mexico's future secondary recovery production is pessimistic. The general annual production decline trend established in 1966 will continue to reach new lows, with only meager relief from additional secondary recovery projects. The few new secondary recovery projects will be limited in size, lacking the capability to produce substantial volumes of crude oil.

Two factors are responsible for the declining secondary production in northwest New Mexico. The first is the state of depletion of the Gallup reservoirs. Many, if not all, of the once prolific pools are near depletion or have been terminated. Each year the volume of oil being produced from these reservoirs decreases.

The second factor is the low success ratio of new discoveries in the basin. During the past 5 years 29 oil pools have been discovered by exploration drilling, 27 of which are small, contributing little to total annual oil production. These pools probably do not contain sufficient reserves to justify the expenditures necessary for secondary recovery operations.

As the result of a study, the State Geologist's Office identified the Tocito Dome "D" Pool as the only pool out of approximately 50 primary producing pools having a potential to support a secondary recovery unit that could ultimately produce over 1 million bbls of oil. The speculative secondary recovery oil reserve that could be extracted from the Tocito Dome Pennsylvanian "D" Pool could be 4 to 5 million bbls of crude oil. Whether this figure is realistic depends on the success of the pilot pressure maintenance program at the Tocito Dome "D" Pool.

Even if this additional speculative new reserve of 4 to 5 million bbls should be realized, it would prolong the productive life of northwest New Mexico by only 2 1/2 years (based on present production rates).

PROJECTIONS

The Legislative Energy Committee and the Energy Resources Board requested that the Office of the State Geologist and the New Mexico Bureau of Mines and Mineral Resources provide oil and gas production projection curves to the year 2000. The information is to be used in estimating consumption and in State revenue planning.

Predicting oil and gas production for future years is an extremely risky exercise; any such study should be viewed as a speculative venture. The speculative nature increases with the number of years projected, and any projection beyond 10 years is dependent on so many qualifiers as to make the usefulness of such projections questionable. What the production will be 10 or 15 years from now depends upon the discovery rate, inasmuch as many wells now producing will be depleted by that date. However, useful projections can be made for older oil or gas reservoirs having a long history of production and established producing trends. Enhanced recovery projections can also be made with some accuracy by studying past results and projecting them to similar reservoirs still under primary production. In older gas pools pressure decline versus cumulative production studies provide useful and often very accurate data for predicting trends.

The problem of predicting production trends for both oil and gas is also complicated by the uncertainties of Federal pricing regulations. As a case in point, the recent increase in the ceiling price of natural gas from approximately 50 cents to $1.50 per thousand cu ft will have a vital impact on both the exploration for new reserves and the development of marginal reserves. The price rise allowed by the Federal Power Commission is now being challenged in court, and new development benefits may not be realized until a final decision is reached.

The approach we have used to project oil and gas production to the year 2000 entailed the construction of sets of curves which show different rates of decline. We have attempted to relate these varying rates to the factors which will surely have a bearing on the decline rate. These factors include the history of past additions to reserves from new discoveries, assessments of future discovery possibilities, an assessment of production which might be expected from enhanced recovery, and decline rates in presently producing reservoirs. Economic factors affecting the oil and gas industry were also considered.

OIL

The oil projection (table 8) depicts oil production that might be expected under varying conditions between now and the year 2000. If no major discoveries are made either in deeper horizons or in new oil provinces, or if development in presently promising areas does not measure up to expectations, the 10-percent decline curve may even be optimistic.

The 5-percent decline curve presumes new oil from discoveries, extensions, and revisions for the years 1976 through 1985 equal to the rate credited to the state during the period 1964 through 1975, amounting to approximately 30 million bbls per year. An additional 200 million bbls may have to be added from new enhanced recovery projects to maintain this rate of decline. This would bring the total of new oil added from both sources to 500 million bbls, an average addition of 50 million bbls per year.

The American Petroleum Institute estimated proven crude oil reserves as of January 1976 at 588 million bbls, bringing the total to 1,088 million bbls. The production through 1985, presuming a 5-percent decline curve, would be approximately 725 million bbls, leaving an unproduced balance of 363 million bbls at the end of 1985.

Increments of new oil added from 1986 through 2000, required to maintain a 5-percent decline in production, will be considerably smaller because of successively smaller annual production rates. The reserve-

TABLE 8—NEW MEXICO'S PROJECTED PRODUCTION OF CRUDE OIL AND CONDENSATE, 1976 TO 2000, BASED UPON VARIED RATES OF DECLINING PRODUCTION (*95,063,000 barrels produced in 1975*)

	Barrels of crude oil and condensate		
Year	3% decline	5% decline	10% decline
1976	92,211,000	90,309,000	85,556,000
1977	89,444,000	85,794,000	77,001,000
1978	86,761,000	81,504,000	69,301,000
1979	84,158,000	77,429,000	62,371,000
1980	81,633,000	73,558,000	56,133,000
1981	79,184,000	69,880,000	50,520,000
1982	76,809,000	66,386,000	45,468,000
1983	74,505,000	63,066,000	40,921,000
1984	72,269,000	59,913,000	36,829,000
1985	70,101,000	56,917,000	33,146,000
1986	67,998,000	54,072,000	29,832,000
1987	65,958,000	51,368,000	26,848,000
1988	63,980,000	48,800,000	24,164,000
1989	62,060,000	46,360,000	21,747,000
1990	60,198,000	44,042,000	19,573,000
1991	58,393,000	41,940,000	17,615,000
1992	56,641,000	39,748,000	15,854,000
1993	54,942,000	37,760,000	14,268,000
1994	53,293,000	35,872,000	12,842,000
1995	51,694,000	34,079,000	11,557,000
1996	50,144,000	32,375,000	10,402,000
1997	48,639,000	30,756,000	9,361,000
1998	47,180,000	29,218,000	8,425,000
1999	45,765,000	27,757,000	7,583,000
2000	44,392,000	26,369,000	6,825,000
Total production			
1976-1985	807,000,000	725,000,000	557,000,000
1986-2000	831,000,000	580,000,000	237,000,000
1976-2000	1,638,000,000	1,305,000,000	794,000,000
Reserves Jan. 1, 1976	588,000,000	588,000,000	588,000,000
Reserves added 1976-2001	1,330,000,000	886,000,000	250,000,000
Balance Jan. 1, 2001	280,000,000	169,000,000	44,000,000

production ratio as of January 1, 1976, was approximately 6.2 to 1 (588 ÷ 95.0). The reserve-production ratio as of January 1, 1986, assuming addition of 500 million bbls during the period and a production total of 725 million bbls, will be 6.4 to 1 (363 ÷ 56.9). The presumption is made, therefore, that we must add sufficient new oil during the period 1986 through 2000 to sustain the production indicated during the period (approximately 580 million bbls) and leave sufficient unproduced oil to insure a reserve-production ratio of approximately 6.4 to 1. This new oil requirement during the 1986 through 2000 period would be approximately 386 million bbls (26 million bbls per year). The balance left unproduced at the end of the year 2000 would be 169 million bbls.

The 3-percent curve is admittedly very optimistic, but it is added to show what might be expected under very favorable economic conditions in the industry coupled with a fortuitous discovery rate. To maintain the 3-percent decline rate, it is estimated that approximately 164 million bbls of new or enhanced recovery oil would have to be added above the amount added between 1964 and 1975. The total recoverable reserve for the period 1976 through 1985 in this instance would be 1,252 million bbls (300 + 200 + 164 + 588). The curve presumes that the additional oil added above the amount needed to maintain the 5-percent decline curve would be added in approximately equal yearly increments and that approximately half of the reserve added would be produced during the 10-year period. Total production from 1976 to 1985 would be approximately 807 million bbls, and the amount of oil remaining in 1985 would be 445 million bbls (1,252 — 807). The reserve-production ratio would be 6.3 to 1 as of January 1, 1986. If the 3-percent decline curve is extended for the period 1986 through 2000, the total production during the 15-year period would be approximately 831 million bbls. To effect this production, and provide a sufficient balance at the end of the period to maintain a reserve-production ratio of 6.3 to 1, the addition of 666 million bbls in new and enhanced recovery oil during that period is necessary. This would leave a balance of approximately 280 million bbls at the end of the year 2000. This new oil requirement amounts to approximately 44 million bbls per year. Meeting this sort of schedule for that period is extremely unlikely.

Using the same methods and making the same assumptions, the 10-percent decline curve would result if new oil added from development and enhanced recovery totaled approximately 164 million bbls for the period 1976 through 1985, with an additional 86 million bbls to be added during the 15-year period 1986 through 2000. Production for the entire 25-year period would be approximately 794 million bbls, and the unproduced balance at the end of the year 2000 would be approximately 44 million bbls.

The State should make future plans based upon the presumption that the oil production decline for the next several years may approach 10 percent per year, because this is a reasonable possibility. Averting such a decline is dependent upon the discovery of substantial new oil reserves, and this cannot be guaranteed.

GAS

Table 9 represents a projection which was made by the State Geologist's Office in the spring of 1976. The table was constructed by adding yearly projected volumes from a 5-percent decline for northwest New Mexico dry gas, from a 5- to 7-percent decline for southeast New Mexico dry gas, and from a 10-percent

TABLE 9—NEW MEXICO'S PROJECTED PRODUCTION (LOWER PROJECTION) OF NATURAL GAS IN BILLIONS CU. FT., 1976 TO 2000

Year	% Decline	SE N.M. dry gas	% Decline	NW N.M. dry gas	% Decline	Csghd gas statewide	Total gas
1975		392.9		504.5		305.7	
1976	- 3	381.1	- 5	479.3	- 5	290.5	1,150.9
1977	- 7	354.4	- 5	455.3		250.2	1,059.9
1978	- 7	329.6	- 5	432.5		215.2	977.3
1979	- 7	306.6	- 5	410.9		184.6	902.1
1980	- 6	288.2	- 5	390.4		158.1	836.7
1981	- 6	270.9	- 5	370.9		134.9	776.7
1982	- 6	254.6	- 5	352.3	- 10	121.4	728.3
1983	- 5	241.9	- 5	334.7	- 10	109.3	685.9
1984	- 5	229.8	- 5	318.0	- 10	98.3	646.1
1985	- 6	216.0	- 5	302.1	- 10	88.5	606.6
1986	- 6	203.0	- 5	287.0	- 10	79.7	569.7
1987	- 6	190.9	- 5	272.6	- 10	71.7	535.2
1988	- 6	179.4	- 5	259.0	- 10	64.5	502.9
1989	- 6	168.6	- 5	246.0	- 10	58.1	472.7
1990	- 6	158.5	- 5	233.7	- 10	52.3	444.5
1991	- 7	147.4	- 5	222.0	- 10	47.0	416.4
1992	- 7	137.1	- 5	210.9	- 10	42.3	390.3
1993	- 7	127.5	- 5	200.4	- 10	38.1	366.0
1994	- 7	118.6	- 5	190.4	- 10	34.3	343.3
1995	- 7	110.3	- 5	180.9	- 10	30.9	322.1
1996	- 7	102.6	- 5	171.8	- 10	27.8	302.2
1997	- 7	95.4	- 5	163.2	- 10	25.0	283.6
1998	- 7	88.7	- 5	155.1	- 10	22.5	266.3
1999	- 7	82.5	- 5	147.3	- 10	20.2	250.0
2000	- 7	76.7	- 5	139.9	- 10	18.2	234.8
Total Production							
1976-1985		2,873.1		3,846.4		1,651.0	8,370.3
1986-2000		1,987.2		3,080.2		632.6	5,700.0
1976-2000		4,860.3		6,926.6		2,283.6	14,070.5

decline in statewide casinghead gas production. The casinghead gas decline used exceeds 10 percent in the years 1977 through 1981 because of an adjustment made necessary by the reclassification of the Blinebry Pool from a gas pool to an oil pool in 1973.

Since that projection was made, the price of new natural gas at the wellhead has tripled, and this will certainly have an important effect on future exploration and development of new gas reserves. It will also have an immediate effect upon infill drilling, as gas produced from infill wells will bring the new price. Gas production for 1976 is running ahead of earlier projections. Total gas production for the state for the first 7 months of 1976 was up 24.4 billion cu ft, or 3.53 percent when compared to the same period in 1975. State dry gas production was up 31.7 billion cu ft, and statewide casinghead gas production was down 7.4 billion cu ft (4.13 percent) for the 7-month period. Table 10 reflects what the estimated production will be from the state as a whole in 1976, based upon updated production information. As the table indicates, we estimate a 1976 production total of 1,221.6 billion cu ft (1.221 trillion cu ft) which would be an increase of 18.5 billion cu ft (1.5 percent). This results from a projected increase of 6 percent for southeast New Mexico dry gas, combined with a 2-percent increase for northwest New Mexico dry gas production and a 5-percent decrease in statewide casinghead gas production. This table also reflects the increased production in the next few years which will likely occur as a result of the recent increase in the wellhead price of natural gas. An increased rate of infill drilling or a rise in the discovery rate might increase production volumes in the next few years above those shown in the table.

If production equals that indicated by table 10, total production for the period 1976 through 1985 would be 9.653 trillion cu ft, and the production in 1985 would be 753 billion cu ft. Production from 1986 through 2000 would be 7.829 trillion cu ft, and the production in the year 2000 would be 367.5 billion cu ft. Total production for 1976 through 2000 would be 17.481 trillion cu ft.

The American Petroleum Institute estimates the present statewide reserve to be 11.8 trillion cu ft. The additional reserve requirement will be 5.7 trillion cu ft (17.5 — 11.8) plus a sufficient reserve to validate the projected production shown in the year 2000. Using American Petroleum Institute reserves the reserve-production ratio as of January 1, 1976, was 9.8 to 1 (11.8 ÷ 1.203). If we assume the reserve-production ratio should be 9.8 to 1 at the end of the year 2000, this would require the reserve to be 3.6 trillion cu ft as of January 1, 2001 (9.8 X 367.5). Therefore, the total reserve addition requirement from 1976 to 2001 would be 9.3 trillion cu ft (5.7 + 3.6), which is 500 billion cu ft less than the estimate of the 9.8 trillion cu ft we have shown in the probable reserve addition forecast (5 trillion cu ft for northwest New Mexico and 4 trillion cu ft for southeast New Mexico + 800 billion cu ft for casinghead).

COMPUTERIZED OIL PRODUCTION DECLINE CURVES

In late 1975 a computer program was used to predict monthly oil production for New Mexico. The program, details of which will be published in 1977, was developed by Allan Gutjahr of the math department at New Mexico Institute of Mining and Technology. Projections were based on oil production for the 30 months preceding October 1975. The actual and predicted monthly production for the period from October 1975 to August 1976 (fig. 5) are in close agreement. Variations have ranged from predicted values of 91,149 bbls of oil below actual production (1-percent error) for November 1975 to 143,450 bbls above actual produc-

TABLE 10—NEW MEXICO'S PROJECTED PRODUCTION (HIGHER PROJECTION) OF NATURAL GAS IN BILLIONS CU. FT., 1976 TO 2000

Year	% Decline[1]	SE N. M dry gas	% Decline[1]	NW N. M. dry gas	% Decline[1]	Csghd gas statewide	Total gas
1975		392.9		504.5		305.7	
1976	+6	416.5	+2	514.6	-5	290.5	1,221.6
1977	-3	404.0	-2	504.3		250.2	1,158.5
1978	-3	391.9	-2	494.2		215.2	1,101.3
1979	-7	364.5	-2	484.3		184.6	1,033.4
1980	-6	342.6	-2	474.6		158.1	975.3
1981	-6	322.0	-3	460.4		134.9	917.3
1982	-6	302.7	-3	446.6	-10	121.4	870.7
1983	-5	287.6	-3	433.2	-10	109.3	830.1
1984	-5	273.2	-3	420.2	-10	98.3	791.7
1965	-6	256.8	-3	407.6	-10	88.5	752.9
1986	-6	241.4	-3	395.4	-10	79.7	716.5
1987	-6	226.9	-3	383.5	-10	71.7	682.1
1988	-6	213.3	-3	372.0	-10	64.5	649.8
1989	-6	200.5	-3	360.8	-10	58.1	619.4
1990	-6	188.5	-3	350.0	-10	52.3	590.8
1991	-7	175.3	-3	339.5	-10	47.0	561.8
1992	-7	163.0	-3	329.3	-10	42.3	534.6
1993	-7	151.6	-3	319.4	-10	38.1	509.1
1994	-7	141.0	-3	309.9	-10	34.3	485.2
1995	-7	131.1	-3	300.6	-10	30.9	462.6
1996	-7	121.9	-3	291.6	-10	27.8	441.3
1997	-7	113.4	-3	282.8	-10	25.0	421.2
1998	-7	105.5	-3	274.3	-10	22.5	402.3
1999	-7	98.1	-3	266.1	-10	20.2	384.4
2000	-7	91.2	-3	258.1	-10	18.2	367.5
Total production							
1976-1985		3,361.8		4,640.0		1,651.0	9,652.8
1986-2000		2,362.7		4,833.3		632.6	7,828.6
1976-2000		5,724.5		9,473.3		2,283.6	17,481.4

[1]Except for the rise projected for 1976

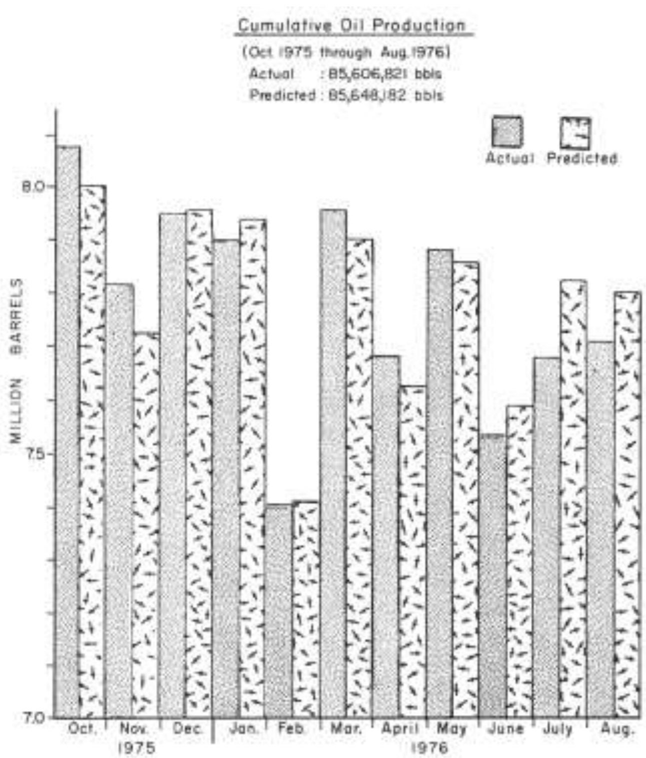


FIGURE 5—COMPUTER PROJECTION OF MONTHLY OIL PRODUCTION.

tion (2-percent error) for July 1976. Cumulative oil production for the 10-month period has been 85,606,821 bbls, and predicted production was 85,648,182 bbls for a difference of 41,361 bbls (.05-percent error).

Although the small error would seem to indicate a high degree of accuracy for projections of this type, there are many factors that can radically change the current decline rate on which the projections are based. Past discoveries, extensions, enhanced recovery programs, and the decline rate of each well and pool are built into the past rate of production. The rate of addition of new oil from drilling and from new enhanced recovery projects must approximate the rate of addition in the past if future projections are to be accurate. Any variance in this rate of addition must be built into future programs.

A rapid decline in the current rate of production seems unlikely, at least for the near future. Most of the state's larger oil pools have passed the sharp decline that normally follows the peak period of production. Once this stage of maturity has been reached, production continues for a number of years at comparatively low volumes but also at much lower decline rates.

In 1975, 524 oil pools in the state reported oil production. Of these, 50 accounted for 80 percent of the total oil produced (exclusive of distillate), and the 10 largest pools were responsible for 52 percent of the oil produced. The production from these 50 pools is obviously quite important as far as future predictions are concerned. An unusually rapid rate of decline would seriously affect future revenue projections for the state. Because of this it was decided that an in-depth study of the 50 largest pools should be done to provide a better foundation for projections of oil production.

The first step in the on-going program is to make a computer projection for each of the 50 pools where possible. Preliminary projections for 7 of the pools have been completed (table 11). The rates are based on the decline from the last year of peak production for each of the individual pools. For the Caprock Queen Pool this was reached in 1964, and the 12 years of production history to 1976 were used to determine the decline rate. The current decline rate for these pools is considerably lower. For Caprock Queen the rate for the past 4 years has been 18 percent per year, and for 1975 the decline amounted to 11 percent. The decline for the Bagley (Silurian-Devonian) Pool has averaged 15 percent per year for the period from 1966 to 1976, but for the past 3 years production has increased at the rate of 4 percent per year. The projected production for these pools for the period from 1976 to 1986 is likely to be low. The level of accuracy of the predictions for 1976 will be used to determine the most valid decline rates for each pool.

Certain pools, such as the Empire Abo, require a different approach. This one pool accounted for 17 percent of the crude oil produced in New Mexico in 1975, and the rate of production is not declining at present. In order to determine future production for this pool, studies are being made of the original oil in place and the ultimate recovery under the present pressure maintenance program. Similar studies are planned for the other pools. Investigations of this type require an analysis of each producing well in the pool and require a considerable amount of time, but procedures are being developed to speed up this process. Once detailed studies of this nature have been completed, making reasonable predictions of the amount of oil which remains to be produced from presently productive pools will be possible.

TABLE 11—COMPUTER PREDICTION OF FUTURE OIL PRODUCTION FROM SEVEN SOUTHEAST NEW MEXICO POOLS (*January 1, 1976, to January 1, 1986*)

County	Rank 1975	Field	Disc. Year	Cumulative production to Jan.1,76 (barrels)	Decline Rate[1]	Projected production Jan.1,76 to Jan.1,86 (barrels)
Chaves/Lea	47	Caprock-Queen	1940	71,305,633	26%	618,001
Chaves	48	Cato-San Andres	1966	13,235,161	33%	455,996
Chaves/Roosevelt	29	Chavaroo-San Andres	1965	17,426,456	24%	1,243,365
Lea	9	Bagley-Pennsylvanian, North	1957	37,819,611	19%	7,280,295
Lea	39	Bagley-Siluro/Devonian	1949	25,473,405	15%	1,233,518
Lea	41	Baum-Upper Pennsylvanian	1955	6,292,923	29%	688,485
Lea	20	Denton-Devonian	1949	90,150,236	11%	4,515,153

1. From peak production

Coal

by **0. J.** Anderson and K. S. Hatton, *Office of the State Geologist, and* F. E. Kottlowski, *New Mexico Bureau of Mines & Mineral Resources*

PRODUCTION

According to the annual report of the State Inspector of Mines, coal production in New Mexico totaled 9,559,920 tons in 1975, compared to 9,668,700 in 1974. Although the tonnage mined and sold was less in 1975 than in 1974, the value of the coal sold increased. The 1975 value of coal sold was $61,030,169 compared with $41,732,019 for the previous year.

The Navajo mine (Utah International, Inc.) and the San Juan mine (Western Coal Company) were responsible for 7,318,499 tons of the 1975 total (table 12); their markets were mine-mouth steam electric plants. In addition, Kaiser Steel Corporation produced over 1 million tons of coking coal from its York Canyon mines in Colfax County, most of which was shipped to its steel mills in Fontana, California. Pittsburg and Midway Coal Mining Company produced 468,000 tons from their McKinley mine which was transported to the Cholla electrical generating plant near Joseph City, Arizona. In 1975 New Mexico coal mines employed 982 persons, an increase of 17 percent over 1974.

Information on New Mexico coal fields, in the San Juan Basin and other parts of the state, were discussed in the previous report of the State Geologist, as well as elsewhere. Tables 13 and 14 provide geological and chemical information on the individual fields.

COAL LEASING AND ROYALTY INCOME

Much of the coal in northwest New Mexico is federally owned. The State accrues revenue from the exploitation of this resource. Accrued revenue from coal lands will take on added importance in the future in view of the projected declines in oil and gas production and the attendant decline in revenue from these resources.

Of all money collected by the Federal government from sales, bonuses, royalties, and lease rentals on Federal coal lands, 10 percent is paid directly to the United States Treasury, 40 percent is paid into a reclamation fund, and the remaining 50 percent is paid to the state in which the minerals were extracted. This division of funds was set up by the amended Federal Mineral Lands Leasing Act of 1920, the Reclamation Act of 1902, and the 1975 Federal Coal Leasing Amendments Act. Prior to the 1975 Federal Coal Leasing Amendments Act, 52.5 percent went to the reclamation fund and only 37.5 percent to the state.

TABLE 12—NEW MEXICO'S COAL STATISTICS, 1974 AND 1975 (*Source: Keystone Coal Industry Manual*), 1976

Company	County	Mine	Tonnage 1974	Tonnage 1975
Kaiser Steel Corp.	Colfax	York Canyon	891,210	1,016,043
The Pittsburg & Midway Coal Mining Co.	McKinley	McKinley	509,417	468,000
Utah International Inc.	San Juan	Navajo	6,955,000	6,073,000
Western Coal Co.	San Juan	San Juan	956,688	1,245,449
Amcoal Inc.	McKinley	Sundance	100,000	-
		Total	9,412,315	8,802,492

Therefore, New Mexico may expect to accrue additional revenue on Federal coal leases as a result of the act.

At the present time only one mine in New Mexico is extracting coal largely or wholly from public lands—the San Juan mine of Western Coal Company that produced 1,245,449 tons in 1975. The contract price of this coal as reported in *Coal Week* (September 1976) is about $5.28 per ton. Assuming that 1976 production is running nearly the same, then under the amended act the State should receive approximately $410,000, half the Federal royalty.

Using New Mexico coal reserve estimates published by Shomaker and others, 1971 (which may be somewhat low), and assuming that these reserves are distributed uniformly throughout the subsurface of a designated coal area (which is not necessarily true), we can apply mineral ownership data derived from a recent in-house study to the area and arrive at a coal reserve figure for each category of ownership—Federal, State, Indian, or private.

A case in point would be the area in the Star Lake-Fruitland field that is designated as strippable. This area is stated to have inferred reserves totaling 365 million tons at depths less than 150 ft. The Federal government owns the coal rights under 58 percent of this land. Of the total coal reserves in this area, 212 million tons are in Federal ownership. The State of New Mexico owns the coal rights to 16 percent of this acreage, so reserves in State ownership are 58.5 million tons.

In the Bisti-Fruitland coal field, inferred strippable reserves at depths less than 150 ft total 958 million tons. The Federal government owns the coal rights to approximately 74 percent of this area, so 709 million tons are in Federal ownership. The percentage figure for State ownership is 8.5 percent (81 million tons). The Federal government has set a 12.5-percent minimum royalty on public lands leased for coal development. In May 1976 the State of New Mexico adopted an 8-percent minimum royalty on State lands leased for coal mining purposes. The State will receive 50 percent of the 12.5-percent Federal royalty, essentially a 6.25-percent royalty on coal extracted from Federal land and an 8-percent royalty on coal extracted from State-owned lands.

Two hypothetical 10-million-ton-per-year coal mines in the Bisti-Fruitland field, for example, might ten years from now be selling coal under contract to a utility company at $20.00 per ton. A typical lease package in the Bisti field might be comprised of 75 percent Federal coal land, 10 percent State coal land, with the remainder being privately held or Indian owned. Twenty million tons per year at $20.00 per ton equals $400,000,000.00. On 75 percent of this amount, the State would be receiving the 6.25-percent royalty, and on 10 percent the State would be receiving the 8-percent royalty. The State of New Mexico would be receiving a total of $21,950,000 in royalty income annually from this hypothetical operation.

TABLE 13—STATISTICS ON NEW MEXICO'S COAL RESOURCES IN THE SAN JUAN BASIN. Compiled by Kay S. Hatton ([1]*Read and others, 1950,* [2]*Kottlowski, Beaumont, and Shomaker, 1975*)

			ANALYSIS													RANK							
Coal Field	Reserves[2] (millions of tons)	Coking	Btu/lb	% Moisture	% Volatile Matter	% Fixed Carbon	% Ash	% Sulfur	Active mines (operator)	Availability to transportation	Unit	Overburden ft	Faulting	Dip	Seam thickness ft	Anthracite	Semianthracite	Bituminous low volatile	Bituminous medium volatile	Bituminous high volatile A	Bituminous high volatile B	Bituminous high volatile C	Subbituminous A ([1]Subbit. A & B)
Navajo	Subbituminous (2,400)		9,200	13.2			20.4	0.32	Navajo mine (Utah International)	Dirt roads connect with US-666	Fruitland Fm.	120'											X[1]
Fruitland	Bituminous (158)		10,200	10.7	35.8	38.1	15.0	0.86	San Juan mine (Western Coal)	Coal used at site	Fruitland Fm.			Low dip monocline, 1.5-3° E.	16 aver. 50 max.						X	X	
Bisti	Subbituminous (1,800)		8,900	10.2	24.9	39.8	18.5	0.6		Gravel & dirt roads connect with NM-44	Fruitland Fm.	Sh. & soft ss.											X
Star Lake	Subbituminous & bituminous (635)		9,400-10,220	10.7-11.5			15-33	0.4-0.7		AT&SF Ry building spur line; gravel & dirt roads connect with NM-44	Fruitland Fm.				Up to 15.9							X	X
Gallup	Bituminous (496)		10,640-11,840[2]	10.0-15.3	45.2	54.8	<10	Aver. 0.6 or less	McKinley mine (Pittsburg & Midway) Sundance mine (Amcoal)	AT&SF Ry building 9 mi spur line	Mesaverde Gp.				Up to 12							X	
Barker Creek	Bituminous (steep beds or thick cover; reserves not calculated)		12,500->14,000				<10	<1.0		US-666	Mesaverde Gp.	Thick ss.		Steep	Up to 2.4						X	X	
Hogback	Bituminous (steep beds or thick cover; reserves not calculated)		12,500->14,000				<10	<1.0	Small underground mines operate periodically for local use	US-666; US-550	Mesaverde Gp.			10-38° E.	Up to 22						X	X	
Toadlena	Bituminous (steep beds or thick cover; reserves not calculated)		12,500->14,000				<10	<1.0		E.-W. paved hwy 2 mi to N. & an extensive network of dirt roads	Mesaverde Gp.	Thick		4-12° SE.	1.5-2.5						X	X	
Newcomb	Subbituminous (85)		7,660-13,680		46.7	53.3	6.6-13.0	<1.0		US-666	Mesaverde Gp.				4-8								X[1]
Chaco Canyon	(31)		9,870-10,220	14.4-17.3	43.3	56.7	7.5-10.2	0.9-2.2	Small drifts & pits operated by the Navajos	NM-56	Mesaverde Gp.				5-6								
Chacra Mesa	(31)		9,870-10,220	14.4-17.3	43.3	56.7	7.5-10.2	0.9-2.2	Small drifts & pits operated by the Navajos	Dirt road connecting with NM-44	Mesaverde Gp.	Thick ss.			Thin								
San Mateo	Subbituminous (21)		11,050	14.9	38.5	41.5	5.2	0.5		NM-53	Mesaverde Gp.	<60-150			3-6; some 12								
Standing Rock	Subbituminous (125)		11,050	14.9	38.5	41.5	5.2	0.5		NM-56 connecting with US-666	Mesaverde Gp.												
Zuni	Subbituminous (6.2)		10,470-10,570	6.0-9.8			16.4-18.6	0.6		NM-32; NM-53	Mesaverde Gp.												
Crownpoint	Subbituminous (15)		10,600				10	1.0	Small drifts mined by the Navajos	NM-56; 5 mi from AT&SF Ry	Mesaverde Gp.	Thick			3.5-6								X[1]
S. Mt. Taylor	Bituminous (1.4)		11,200				6	0.6	Small drifts for local use	AT&SF Ry; US-40	Mesaverde Gp.	Thick volcanics except in small areas			3.5-7							X	
E. Mt. Taylor	Bituminous (1.4)		11,200				6	0.6	Small drifts for local use	Some unimproved dirt roads & primitive roads	Mesaverde Gp.	Thick volcanics except in small areas			3.5-7							X	
La Ventana	Bituminous (15)		8,910-10,790[1]	14.8-19.1	32.0-34.0	40.7-45.1	6.3-9.9	0.6-1.2	Small, intermittently active underground mines	NM-44	Mesaverde Gp.	Thick ss.		Steep; up to 80° W.	3-6							X	X
Monero	Bituminous (reserves not calculated)	Some seams	12,160-13,730	1.7-7.1	34.2-39.0	48.3-48.4	5.3-10.6	0.7-3.5		NM-17; US-184	Mesaverde Gp.		Some	>5° SW.	Up to 7.3					X	X		

TABLE 14—STATISTICS ON NEW MEXICO'S COAL RESOURCES EXCLUSIVE OF THE SAN JUAN BASIN. Compiled by Kay S. Hatton ([1]*Read and others, 1950,* [2]*Kottlowski, Beaumont, and Shomaker, 1975*)

			ANALYSIS													RANK							
Coal Field	Reserves[1] (millions of tons)	Coking	Btu/lb	% Moisture	% Volatile Matter	% Fixed Carbon	% Ash	% Sulfur	Active mines (operator)	Availability to transportation	Unit	Overburden ft	Faulting	Dip	Seam thickness ft	Anthracite	Semianthracite	Bituminous low volatile	Bituminous medium volatile	Bituminous high volatile A	Bituminous high volatile B	Bituminous high volatile C	Subbituminous A
Cerrillos	Anthracite (5.7) Bituminous (47.5)	Weak to moderate	12,100[1]-15,100[2]	1.9-7.6	2.2-35.1	49.0-86.1	6.0-15.0	0.7-1.1		NM-10; AT&SF Ry; rail heads at Cerrillos & Waldo; spur line to Madrid	Mesaverde Gp.		X	Syncline; coal beds dip 15° E.	Up to 6	X	X			X			
Tijeras	Bituminous (1.6)		From Tocco mine 13,900	0.8	36.4	53.9	8.9	0.88		US-66; I-40; NM-10	Mesaverde Gp.		X	2 synclines & anticline, steep dip	Up to 1.67			X				Thin beds X	
Datil Mts.	Subbituminous (reserves not calculated; possibly greater than 1,000)		7,430-11,900[1]	6.5-25.9	30.3-34.5	34.7-51.9	7.1-10.8	0.4-0.5		Ranch roads that connect with US-66 & US-60 to the N. & S.	Mesaverde Gp.	Thick volcanic cap	X	Generally synclinal with complex folding	3-7			X					X
Jornada del Muerto	Bituminous (reserves not calculated)		12,410	2.6	41.6	45.2	10.6	0.6		9 mi on dirt road to US-380, then 14 mi to AT&SF Ry	Mesaverde Gp.	200 at NMBMMR drill hole near Law mine	Minor; may be more	20° to SW.	Up to 3							X	
Carthage	Bituminous (30)	High quality	12,910[1]	2.2	34.0	52.2	11.6	0.7		US-380; 12 mi to AT&SF Ry	Mesaverde Gp.	Mostly 500 to 600	X	20° aver.	4-7 (2 seams)					X	X	X	
Sierra Blanca (Capitan)	Bituminous (1,644)	Weak to moderate	11,960-12,220[1]	2.5-3.1	30.0-34.6	46.0-52.6	14.3-16.9	0.8-1.0		US-380; US-54 & Southern Pacific Ry few miles to W.	Mesaverde Gp.	Coal at 115, 220 & 300 at Carrizozo	X	>5°	Up to 7							X	
Engle	Subbituminous (reserves not calculated)									AT&SF Ry at Engle	Mesaverde Gp.				Up to 2								X
Uña del Gato	Bituminous (17.3)		10,920-11,880[1]	6.1-11.1	29.1-37.7	41.7-51.0	9.5-13.8	0.8-0.9		Ranch roads & NM-10	Mesaverde Gp.		X	Highly faulted homocline	3-5							X	
Tierra Amarilla	Subbituminous (4.4)		10,000				8.0	1.0-1.1	Has been mined for local use	3 mi from US-84	Mesaverde Gp.	Thick ss.			Thin								X
Rio Puerco	Bituminous (reserves not calculated)								Mined for local use	8 mi from AT&SF Ry; US-40 on S; NM-44 on N.	Mesaverde Gp.		X	Steep	Up to 9.6 in N.							X	
Raton	Bituminous (4,700)	X	11,890[1]-14,340[2]	2.5-5.3	35.7 (York Canyon)	54.9 (York Canyon)	8.8 (York Canyon)	0.6 (York Canyon)	York Canyon No. 1 Underground, West York Strip (Kaiser Steel Corp.)	US-85 (I-25); AT&SF Ry	Vermejo & Raton Fms.			Gently westward	6-13 York Canyon					X	X		
Omara	Semianthracite, bituminous (reserves not calculated)	X								Dirt road connecting with NM-41	Mesaverde Gp.		X		3-4.5		X					X	
Pecos River	Bituminous (reserves not calculated)			1.7	22.3	51.4	24.6	2.7		NM-63	Pennsylvanian				1.67				X				

JULY 1976 COAL LEASE SALE

There were ten buyers of coal leases at the sale held by the Commissioner of Public Lands in July 1976. The only companies buying multiple tracts were the Salt River Project Authority, Western Coal Company, and Carbon Coal Company. The Salt River Project bought 18 of the total 47 tracts sold at that time, and Western Coal bought 5.

Much of the coal property bought by the Salt River Project Authority, an Arizona utility company, is situated in areas where the overburden is apt to be in excess of 500 ft thick. Stripping to such depths is logistically and economically unfeasible, and underground mining or in situ gasification may be considered.

Leases purchased by the Carbon Coal Company from the Gallup Gamerco Coal Company are in the Gallup area in R. 18 and 19 W. They are attempting to put together a large lease package in that area in anticipation of a coal market at the Benson, Arizona, generating plant. Western Coal purchased three sections of coal property just east of its San Juan mine, and two more tracts in T. 23 N., R. 13 W., where they already have extensive holdings.

Of 155 tracts offered for sale east of Raton in Colfax County, only one 40-acre tract was sold, and this went for the minimum price of $1.00 per acre with no bonus.

ANTICIPATED DEMAND

In 1975 only 17 percent of the 640 million tons of coal produced in the United States came from western mines. *The 1976 National Energy Outlook,* released by the Federal Energy Administration (FEA), predicts that coal output in 1980 will rise to 799 million tons, of which 31 percent will come from western mines. In 1985 production is projected to rise to 1,040 million tons, and the western mines will produce 36 percent of this amount. The western states will feel the impact of the major expansion in production, increasing from 92 million tons in 1974 to approximately 380 million tons in 1985, a 400 percent increase mainly from surface mining.

Future coal mining operations in New Mexico have been studied by the U.S. Bureau of Mines in 1976. The Pittsburg & Midway Coal Company plans to expand production at the McKinley mine to 5 million tons per year by 1980 to meet the Cholla plant demand and other power markets. The Carbon Coal Company is preparing to open the Gamerco strip mine to meet the coal demand which would be created by the southern Arizona Benson power plant; a firm date has not been set for production at this mine, although planned annual output is listed as 1.5 million tons per year. The Public Service Company of New Mexico will be adding several more units at the San Juan power plant which will result in coal production at the San Juan mine going from 1.2 million tons per year to 5.8 million tons per year by 1980 or 1981. Demand at this plant beyond 1981 will perhaps necessitate coal haulage from the Navajo mine. When Public Service Company completes its 1981 expansion, they will then have all of the base load carried by coal-fired plants, and the gas-fired plants will be used only during periods of peak demand.

In addition to these 4 planned developments or expansions, there are others which could ultimately add as much as 48 million tons per year to the state's coal production. These are the coal gasification plants proposed by Western Gasification Company (WESCO, a joint venture of Pacific Coal Gasification Company of Los Angeles and Transwestern Coal Gasification Company of Houston) on the southern portion of the Utah International lease, and by El Paso Natural Gas Company on their lease, which extends from Burnham eastward to the edge of the Navajo Indian Reservation. However, current reports indicate that these projects have been delayed indefinitely. This uncertainty, plus a 3- to 5-year construction period to get the first units on line, pushes coal gasification into the future so that it does not appear until 1985 on the bar graph (fig. 6).

In yet a more speculative category are plans by Texas Utilities to purchase steam coal from Santa Fe Industries, Inc. holdings near Star Lake and transport the coal to generating plants in southern Texas. The initial memorandum of intent forwarded in mid-1976 set forth a tentative schedule of coal deliveries increasing from 2 million tons per year in 1980 to approximately 20 million tons per year by the 1990's. The memorandum of intent was suspended, but negotiations between these two corporations are continuing.

Plains Electric Generation and Transmission Cooperative, with three 17-megawatt units presently operating near Algodones, New Mexico, has long-range plans to add three 350-megawatt units. To date, neither the plant site nor the coal source has been decided upon. A total generating capacity of 1,050 megawatts for the 3 proposed units will mean an annual coal consumption of approximately 3.5 million tons per year.

Probable demand from these latter 2 proposals has been incorporated into fig. 6. Due to the uncertainties

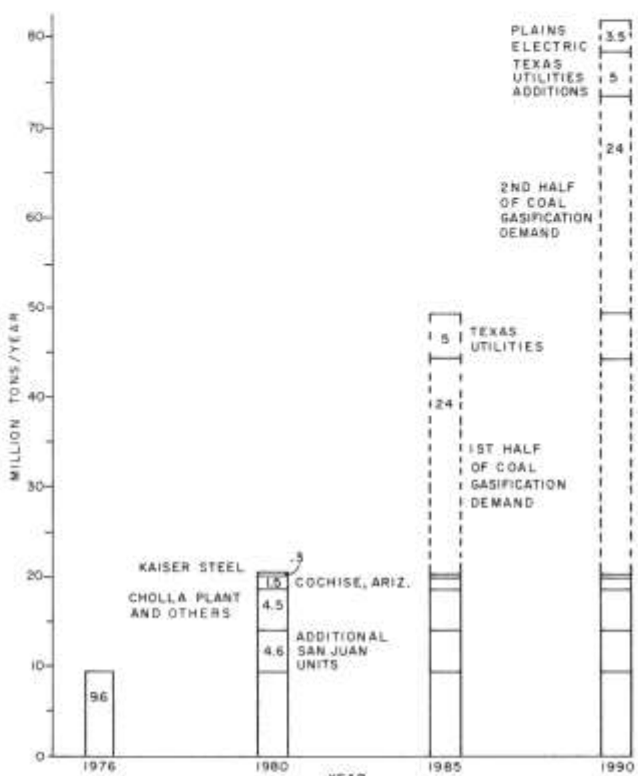


FIGURE 6—NEW MEXICO'S COAL DEMAND PROJECTIONS.

involved, the Texas Utilities demand was delayed until 1985, and the Plains Electric demand until 1990, although the latter may be on line by 1986.

On the strength of the interest shown by the Salt River Project Authority in the deeper San Juan Basin coals, it would appear safe to assume that additional markets will develop in southern Arizona. This project, however, is not in the planning stage, and no demand projections have been made.

RESERVES

The basic overall data on coal reserves in New Mexico has not changed significantly since last year's report. Additional drilling by various companies has increased the amount of strippable reserves in the Raton coal field, in the southern part of the San Juan Basin (in the general area of Star Lake and Standing Rock), and adjacent coal areas near San Luis and west of Gallup. In part, this recent drilling has transferred coal reserves from the "inferred reserves" category to the "known reserves" category. Data on reserves for the individual fields are listed in tables 13 and 14.

Several areas tested in the western part of the Sierra Blanca coal field and in the southern part of the Jornada coal area have revealed complex faulting, steep dips of the coals, and relatively thin seams; north of Sierra Blanca numerous intrusive sills and dikes have also been revealed.

Federal funding to drill test for additional reserves, mainly in the areas in the San Juan Basin where the Fruitland Formation coals lie at strippable depths, has been granted to the U.S. Bureau of Land Management and to the Conservation Division of the U.S. Geological Survey. This activity will increase the knowledge of coal reserves. The present estimate of coal in the San Juan Basin to depths of 250 ft is about 6 billion tons. Additional exploration will add to this reserve but probably not much more than 10 to 20 percent.

Geologic conditions of the areas outside the San Juan Basin and the Raton coal field are such that large new reserves of strippable coal are not likely to be added.

With strip-mining equipment presently being used in New Mexico coupled with the average ratios of overburden to thickness of the coal seams being strip mined, the practicable limit of dragline stripping is about 150 ft. The calculations for the low-sulfur strippable coal in the San Juan Basin made by Shomaker and others (1971) were based on two categories: coal in beds 3 ft thick or thicker beneath less than 150 ft of overburden, and beds 5 ft or thicker covered by more than 150 ft but less than 250 ft of overburden. Strip-mining of the second category of deeper coal would require rehandling the spoil and would be much more expensive than present operations. Thus, the estimates of strippable reserves in the San Juan Basin (Shomaker and others, 1971) are in two groups. The reserves with overburden less than 150 ft strippable by present equipment total more than 3.1 billion tons, whereas the reserves with overburden thickness between 150 to 250 ft are about 2.8 billion tons.

Calculations of deep coal, consisting of coal beds deeper than 250 ft, have been estimated in a recent cooperative study done by the U.S. Bureau of Mines and the New Mexico Energy Resources Board. These quantities of coal should be classified as possible resources rather than as reserves because they are based on interpretations of geophysical logs and of coal chips from deep borings done mainly in exploration for oil and gas. The original estimates of deep Fruitland Formation coal made by the U.S. Geological Survey are in the range of 150 to 200 billion tons and are reasonably accurate. Calculations of deep Mesaverde coals, formerly estimated at 115 billion tons, may be more nearly in the range of 12 to 20 billion tons. Some of these coal beds are below 5,000 ft of overburden.

Use of these deep coals under present underground mining methods is not economic. Some form of in situ gasification or liquefaction would be the most promising method of development.

Uranium

by O. J. Anderson, G. B. Page, and E. C. Arnold, *Office of the State Geologist*

PRODUCTION

New Mexico has been, and continues to be, the major producer of uranium in the United States. By the end of 1975 the Grants uranium region had produced over 52 million tons of ore containing 112,700 tons of U_30_8, or 40 percent of the cumulative total U_30_8 produced in the United States to that date.

In 1974 New Mexico produced 43 percent of the total U_30_8. Wyoming contributed 32 percent, while the other states combined (primarily Colorado, Texas, Utah, and Washington) accounted for 25 percent of the total 12,600 tons (table 15). Although in 1975 a small decrease in total U.S. production occurred, New Mexico's relative contribution increased to 45 percent of the 12,300 tons of U_30_8 produced in the United States. Relative production in Wyoming dropped 2 percent from the preceding year, and the remaining states maintained a constant 25 percent of the total (table 16). Fig. 7 depicts the uranium production by state for 1963 through 1975.

The gross value of New Mexico's 1975 concentrate production based on a weighted-average price of $8.06 per lb was $77,135,834. The tax paid on this amount by the uranium mining industry to the State in the form of severance tax and resource excise tax amounted to $743,948.

STATUS OF PRODUCTION FACILITIES

Uranium production plants in the United States, operating as of January 1, 1976, have a capacity of 28,450 tons of ore per day (ERDA, 1976a). The capacity of new plants expected to be on line in the near future will provide an additional 6,300 tons per day for a projected national milling capacity of 34,750 tons per day. According to milling capacity as shown in table 17, New Mexico could soon be providing over 50 percent of the national production capacity.

Other production facilities planned in the Grants uranium region include conventional mills by Gulf Mineral Resources Co., Phillips Petroleum Co., and Conoco, and in situ leaching and tails leaching by Union Carbide Corp. and Michael P. Grace.

Currently 8 companies have plans to develop or are developing at least 11 additional underground uranium mines in the Grants uranium region. Some of the mines, such as Gulf Minerals' San Mateo mine, will be in excess of 3,000 ft deep, but most will not be producing ore until the 1980's.

TABLE 15—DISTRIBUTION OF 1974 URANIUM PRODUCTION BY STATE (*Source: ERDA, 1975*)

State	Ore weighed and sampled by mills: Tons of ore	Tons U_3O_8	% Total U_3O_8	Concentrate production: Tons U_3O_8
New Mexico	2,997,000	5,400	43	5,000
Wyoming	2,458,000	4,000	32	3,800
Others (Colo. Tex., Ut., Wash.)	1,661,000	3,200	25	2,800
Totals	7,116,000	12,600	100	11,600

TABLE 16—DISTRIBUTION OF 1975 URANIUM PRODUCTION BY STATE (*Source: ERDA, 1976a*)

State	Ore weighed and sampled by mills: Tons of ore	Tons U_3O_8	% Total U_3O_8	Concentrate production: Tons U_3O_8
New Mexico	2,985,000	5,500	45	5,200
Wyoming	2,589,000	3,700	30	3,400
Others (Colo., Tex., Ut., Wash.)	1,791,000	3,100	25	2,900
Totals	7,365,000	12,300	100	11,500

EMPLOYMENT—MINING AND MILLING

In 1975 New Mexico employed 49 percent of the total work force in the uranium mining and milling industry in the United States. According to company records, 3,709 persons were engaged in uranium production in the state, an increase of 50 percent over 1974.

According to some recent estimates by the uranium industry, State agencies, and the University of New Mexico, the total uranium industry work force is expected to increase to 20,000 or 30,000 persons by 1990. More conservative estimates project that about 10,000 persons will be employed by the mid-1980's. Reliable trade sources report that each workplace in the mining industry creates 41/2 to 7 secondary jobs (personal communication, E. P. Chapman, Jr., 1976).

EXPLORATION AND DEVELOPMENT

The State Geologist's Office is recording exploration and development work by the New Mexico uranium industry; drilling location information is updated

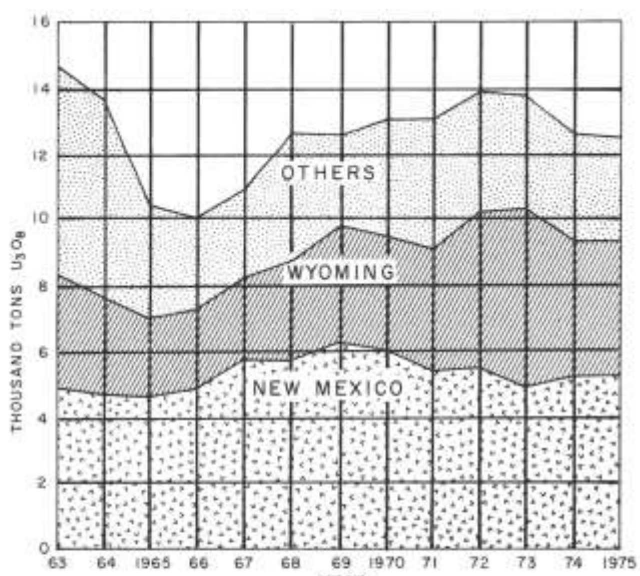


FIGURE 7—URANIUM ORE PRODUCTION BY STATE (CUMULATIVE), 1963 THROUGH 1975 (*Source: ERDA, 1976a*).

TABLE 17—STATUS OF URANIUM PRODUCTION FACILITIES IN THE GRANTS REGION

Mills	Location	Capacity (tons ore/day)
Mills operating in 1975		
Anaconda	Grants	3,000
Kerr-McGee	Grants	7,000
United Nuclear-Homestake Partners	Grants	3,500
Totals in 1975		13,500
New Mills		
United Nuclear (operational 1978)	Church Rock	3,000
Reserve Oil and Minerals/Sohio	Laguna	1,600
Total new mills		4,660
Grand total		18,160

TABLE 18—DISTRIBUTION OF 1975 URANIUM DRILLING BY STATE (*Source: ERDA, 1976a*)

State	Footage drilled	% Total
Wyoming	12,054,000	46.4
New Mexico	5,698,000	21.9
Texas	3,316,000	12.8
Utah	1,538,000	5.9
Colorado	1,362,000	5.2
Others[1]	2,032,000	7.8
Totals	26,000,000	100.0

1. Includes Alaska, Arizona, California, Montana, Nebraska, Nevada, Oklahoma, Oregon, South Dakota, Washington, and eastern United States

monthly. Throughout 1976, 35 to 40 drilling rigs have been assigned to exploration and nearly as many to development. There has been considerable interest in exploration northwest of the Ambrosia Lake district and northeast of the Laguna disdrict, even as far east as the Rio Puerco. Many exploratory holes have been drilled in the Chama embayment south of Canjilon and several in east-central New Mexico. However, the apparent trend is toward ever deeper exploration and development in the Grants uranium region.

The Seven Lakes-Nose Rock discovery reported by Phillips Petroleum Co. in the southern part of T. 19 N., R. 11 W. is located about 24 mi northeast of the nearest producing mine and about 22 mi north of the closest reported uranium mineralization. The new discovery indicates that the Grants uranium region may be 45 or 50 mi wide rather than 20 and points to the possibility of uranium resources far in excess of past estimates.

DRILLING

The total footage drilled for uranium in the United States in 1975 was up 18 percent over 1974. Exploration drilling in search of new ore deposits or extensions to known deposits was 65 percent of the total 1975 drilling. Development drilling, which defines the shape, size, and grade of deposits and provides information for mine planning, accounted for the remaining 35 percent of total drilling. Of the 26,000,000 ft drilled for uranium in the United States, 22 percent took place in New Mexico (table 18).

Drilling trends in the first two-thirds of 1976 have varied from those in past years. New Mexico has accounted for 33 percent of the total national drilling, stimulated by the December 1975 Phillips Petroleum discovery at depths of 3,000 to 3,500 ft. In addition lease expiration dates are causing the acceleration of drilling in New Mexico.

The national average depth of holes drilled in 1975 was 457 ft. In the first two-thirds of 1976, the average depth has been 510 ft. For the same period in 1976, San Juan Basin drill holes have averaged 1,600 ft, while those in Wyoming basins averaged 440 ft. Although Wyoming uranium deposits are found at shallower depths than those in New Mexico, they tend to be much smaller.

URANIUM LEASING ACTIVITY

Land in the Grants uranium region includes the Navajo Reservation, Navajo-allotted lands, Laguna Pueblo, Acoma Pueblo, Cañoncito Band Navajo Reservation, Jemez Pueblo, Zia Pueblo, U.S. Bureau of Land Management (BLM) lands, U.S. Forest Service lands, State and private lands. Approximately 40 to 45 percent of present production is from Indian lands.

At present over 284,000 acres of Indian tribal and Indian-allotted lands are leased for uranium exploration in northwest New Mexico, 270,000 of which are Navajo lands and about 14,000 of which are Laguna Pueblo lands. In addition, the Exxon Company is awaiting approval from the Secretary of the Interior on a proposal to lease 400,000 acres on the Navajo Reservation. An Environmental Impact Statement covering this area is presently being prepared by the U.S. Bureau of Indian Affairs.

At present the number of mining leases filed on Federal uranium-bearing land is not known; the BLM has issued leases and prospecting permits on acquired lands in western New Mexico.

The New Mexico Commissioner of Public Lands is authorized to lease State trust lands for the purpose of mineral extraction. A considerable number of general mining leases have been issued on State land in McKinley, Valencia, and Sandoval Counties. More than 50 separate companies or individuals hold these leases, but at the present time little uranium exploration or development work is in progress on State lands. The State has not offered any lands for general mining lease since October 1975.

The distribution by state of land held for uranium exploration and mining is shown in table 19. Only the acreages held in Wyoming and Utah exceed that held in New Mexico.

TABLE 19—DISTRIBUTION OF LAND HELD FOR URANIUM EXPLORATION AND MINING BY DATE AND STATE (*Source: ERDA, 1976a*)

State	Jan.1,72	Jan.1,73	Jan.1,74	Jan.1,75	Jan.1,76
	Thousand acres				
Arizona	231	486	754	819	942
California	450	491	587	619	619
Colorado	1,315	1,123	1,291	2,592	1,623
Idaho	24	34	34	70	81
Montana	349	324	380	438	418
Nevada	250	250	264	312	321
New Mexico	4,119	3,109	3,158	3,378	3,663
North Dakota	-	-	100	100	100
Oregon	5	30	31	31	31
South Dakota	237	224	81	91	87
Texas	899	641	641	627	622
Utah	2,420	2,602	2,783	3,515	4,185
Washington	133	88	72	76	129
Wyoming	8,575	8,275	8,598	9,608	10,090
Total	19,007	17,677	18,774	21,276	22,911

EMPLOYMENT—EXPLORATION

During 1975 the uranium industry in New Mexico employed 636 persons in exploration (according to company statistics). They were employed in geology, engineering, drilling, logging, aerial services, surveying, and drafting. Secondary employment is not taken into account by these statistics. More than 30 percent of the people involved in uranium exploration in the United States in 1975 were employed in New Mexico.

RESERVES AND POTENTIAL RESOURCES

The following ore reserve estimates were made by ERDA's Grand Junction office from drill-hole and other engineering data obtained from uranium companies. Evaluation of reserves is made in the $10, $15, and $30 per lb U_3O_8 forward-cost categories. The $8 per lb category is no longer used as a result of rising production costs.

In calculating reserves in the various forward-cost categories, estimated operating costs and those capital costs not yet incurred are used. Profit and costs already incurred, such as past expenditures for property acquisition, exploration, and mine development, are not included. The cost categories, therefore, do not indicate the prices at which the estimated reserves would be sold.

Potential resources, as opposed to reserves, include the probable, possible and speculative categories. Probable potential resources are those estimated to occur in known productive uranium districts; possible are those estimated to occur in undiscovered or partly defined deposits in formations or geologic settings productive elsewhere within the same geologic province. Speculative resources are those estimated to occur in undiscovered or partly defined deposits: a) in formations or geologic settings not previously productive within a productive geologic province or b) within a geologic province not previously productive (ERDA, 1976a). The current status of uranium resources in the United States is indicated in table 20.

Fig. 8 illustrates the dominant position of New Mexico U_3O_8 reserves relative to those of other states in the $10, $15, and $30 forward-cost categories. The data were derived from table 21. Although Wyoming has more tons of ore, the grade is lower than the average for New Mexico. New Mexico has a substantially greater reserve of U_3O_8, specifically 56, 48, and 47 percent of United States reserves in the $10, $15, and $30 forward-cost categories respectively.

SUPPLY VS. DEMAND

The production of uranium ore is dependent on the demand for uranium to be fabricated into reactor cores. The future of uranium ore production in New Mexico is directly tied to the expanded use of nuclear energy for the generation of electricity nationwide.

Information available February 1976 indicated that installed nuclear capacity in the United States to the year 2000 is now estimated by ERDA to be 20 percent less than was estimated in 1975. Projected demand for uranium is approximately 25 percent lower. ERDA has forecast U.S. nuclear power growth to the year 2000 and the amount of U_3O_8 needed to sustain that growth. These demand predictions for U_3O_8 have changed constantly and will no doubt continue to change in the future. The predictions are based on planned nuclear power plant construction, plutonium recycling, and enrichment plant tails assay.

In 1974 New Mexico was supplying approximately 43 percent of the national U_3O_8 production. If that percentage of the market is to be maintained, then New Mexico would have to produce the amount of U_3O_8 shown in table 22 through 2000. United States demand shown in the table is based on data from Hanrahan and others, 1976, on nuclear growth.

Although New Mexico reserves are theoretically sufficient to supply the demand until the 1990's, it would be impossible to have all present reserves in production by that date. On the average a time lag of 8 years exists between the discovery of a deposit and the start of production. In addition milling capacity may not be adequate. ERDA projects a shortfall beginning in the early 1980's and continuing indefinitely. The shortfall is projected to begin when contracted nuclear reactor feed requirements exceed uranium delivery commitments. By 1990 the shortfall may be greater than
200_000 short tons

TABLE 20—TONS OF U_3O_8 RESOURCES IN THE U.S. AS OF JANUARY 1, 1976 (*Source: ERDA, 1976b*)

Cutoff Cost ($/lb)	Reserves	Potential		
		Probable	Possible	Speculative
10	270,000	440,000	420,000	145,000
10-15 increment	160,000	215,000	255,000	145,000
15	430,000	655,000	675,000	290,000
15-30 increment	210,000	405,000	595,000	300,000
30	640,000	1,060,000	1,270,000	590,000
By-product 1976-2000[1]	140,000	--	--	--
Total	780,000	1,060,000	1,270,000	590,000

1. Estimated by-product from phosphate and copper production

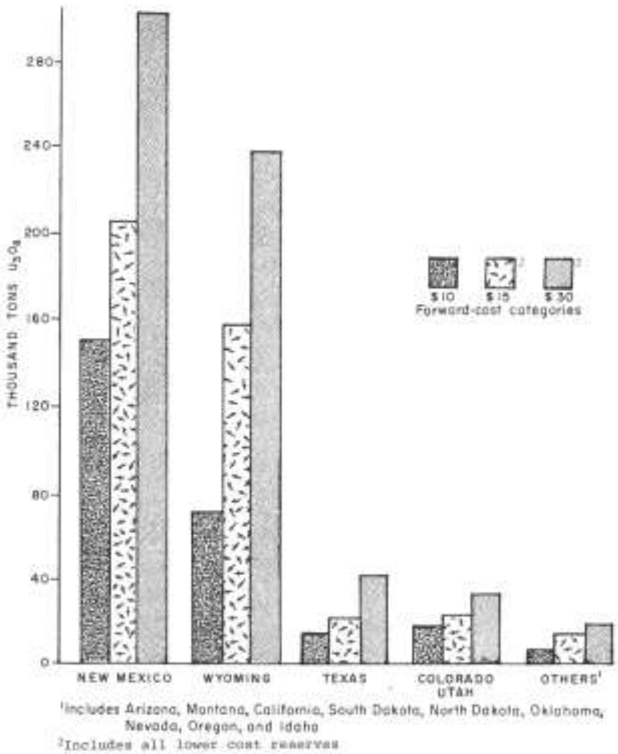


FIGURE 8—DISTRIBUTION OF U_3O_8 RESERVES BY STATE IN THE THREE FORWARD-COST CATEGORIES (*Source: ERDA, 1976a*).

The rising price per pound will undoubtedly attract investment capital to New Mexico. The year-end price in 1975 for spot delivery was reportedly $35.00 per lb of U_3O_8. In 1974 the spot price per lb was $25.35. The October 1976 spot price was $41.00 per lb (Nuclear Exchange Corporation, 1976). A paper by Emanuel Gordon, 1976, cited a conservative estimate of $47.45 per lb by 1980. However, a January 1976 market survey of the contract prices for uranium shows an average commitment price of $14.35 per lb for 1980 delivery. New contracts negotiated in 1976 with New Mexico producers have been in the area of from $25 to $35 per lb.

Within the United States, the average grade of ore in the $10 per lb forward-cost category is 0.17 percent U_3O_8. New Mexico production of $10 per lb ore at a grade of 0.26 percent U_3O_8 makes it economically attractive to investors. The high-grade ore coupled with large quantities of $10 and $15 per lb ore in New Mexico indicates that uranium mining in New Mexico will be an important activity for many years.

TABLE 21—DISTRIBUTION OF URANIUM ORE RESERVES (JANUARY 1, 1976) BY STATE (*Source: ERDA, 1976a*)

State	Tons ore	% U_3O_8	Tons U_3O_8	% Total tons U_3O_8	Number of Deposits
			$10 Reserves		
New Mexico	57,100,000	0.26	151,000	56	73
Wyoming	62,500,000	0.12	73,000	27	64
Texas	19,800,000	0.08	15,000	6	53
Colorado & Utah	6,300,000	0.30	19,000	7	289
Others[1]	10,300,000	0.11	12,000	4	94
Totals	156,000,000	0.17	270,000	100	573
			$15 Reserves[2]		
New Mexico	115,900,000	0.18	206,200	48	106
Wyoming	150,500,000	0.10	158,000	37	157
Texas	30,900,000	0.08	23,900	5	110
Colorado & Utah	13,000,000	0.21	25,900	6	717
Others[1]	18,700,000	0.08	16,000	4	319
Totals	329,000,000	0.13	430,000	100	1,409
			$30 Reserves[2]		
New Mexico	302,000,000	0.10	302,700	47	173
Wyoming	332,600,000	0.07	239,000	37	264
Texas	64,900,000	0.07	43,900	7	130
Colorado & Utah	25,700,000	0.13	34,200	5	849
Others[1]	28,800,000	0.07	20,200	4	403
Totals	774,000,000	0.08	640,000	100	1,819

1. Includes Arizona, Montana, California, North Dakota, Washington, Oregon, South Dakota, Oklahoma, Nevada, and Idaho
2. Includes all lower cost reserves

TABLE 22—PROJECTED U.S. U_3O_8 DEMAND FOR NUCLEAR POWER GROWTH AND DEMAND ON NEW MEXICO RESOURCES

End of year	U.S. U_3O_8 demand[1] (thousand tons)		New Mexico demand to maintain 43% of U.S. production (thousand tons)	
	Annual	Cumulative	Annual	Cumulative
1976	14	14	6.0	6.0
1980	26	95	11.2	40.9
1985	50	295	21.5	126.9
1990	78	625	33.5	268.8
2000	105	1,635	45.2	703.1

1. Hanrahan et al., 1976

Geothermal

by Kay S. Hatton, *Office of the State Geologist*

LOCATION OF MAJOR GEOTHERMAL AREAS

The three principal geothermal areas in New Mexico are located along the Rio Grande rift and in the west-central and southwestern portions of the state. Associated with the Rio Grande rift are the Valles Caldera and Jemez Hot Springs in Sandoval County, Ojo Caliente in Taos County, Socorro Mountain in Socorro County, and Radium Springs and Kilbourne Hole in Doña Ana County.

The portion of the west-central geothermal area with the greatest terrestrial heat flow value lies in the southwest corner of McKinley County. The southwestern geothermal area comprises the Lower Frisco system in Catron County, Gila Hot Springs and Mimbres in Grant County, and the Animas "Hot Spot" (Lightning Dock area) in Hidalgo County. Location and heat flow maps of these areas can be found in Arnold and others, 1976.

LEASING ACTIVITY

An October 15, 1976, U.S. Bureau of Land Management news release reports that the Bureau has issued a total of 64 geothermal leases covering 136,558 acres of national resource land in New Mexico. Seven of these leases, covering 30,428 acres, were issued between January 1 and October 15, 1976; four of these were issued after competitive bidding and three after non-competitive bidding. The BLM conducted a leasing rights sale on October 27, 1976, on eleven parcels of land in the San Ysidro area in Sandoval County, the Lightning Dock area in Hidalgo County, and the Kilbourne Hole area in Doña Ana County. Five of the parcels, covering 5,065 acres, were leased. Federal land in the vicinity of the Valles Caldera will be offered for lease by the BLM if the U.S. Forest Service grants approval after studying an Environmental Impact Statement.

Prior to 1976 the New Mexico State Land Office issued a total of 205 geothermal leases covering 86,124 acres. No geothermal leases have been issued for State land during the first 8 months of 1976.

The specific locations of State geothermal leases may be obtained from the Commissioner of Public Lands in Santa Fe, and of Federal leases from the U.S. Bureau of Land Management in Santa Fe. The major companies holding leases on Federal, State, and private lands are Union Oil Company of California, Phillips Petroleum Corporation, Sunoco Energy Development Company, Chevron Oil Company, Hunt Petroleum Corporation, Anadarko Production Company, Alan and Mary Frances Antweil of Hobbs, N.M., Earth Power Corporation, Thermal Resources, Inc., and The Anschutz Corporation.

RECENT EXPLORATION

Chevron has obtained permission from the New Mexico Oil Conservation Commission (NMOCC) to drill a deep temperature observation well in the central part of the Animas Valley in Hidalgo County. This well will be drilled to a depth of 1,500 ft and will stop short of the producing depth. The company also plans to drill five more wells to a depth of 500 ft, pending results from the first well. The NMOCC has granted Amax Exploration, Inc. permission to drill north of the Chevron Oil Company area in the central part of the Animas Valley, and Sunoco has permission to drill fifteen wells in Sandoval County. Sunoco's wells will be located in the Jemez area, south and west of the Union Oil Company and Los Alamos Scientific Laboratory (LASL) geothermal areas.

Union's geothermal drilling activity in the Valles Caldera during 1976 has been limited to workovers, but the company tentatively plans to drill three new wells in 1977, pending results of tests made in October 1976. New drilling is also dependent on the interest shown by New Mexico power companies in such a project.

LASL plans to drill targets in the Lightning Dock anomaly defined by Dr. Jonathan F. Callender of the University of New Mexico and his coworkers. Funded by the New Mexico Energy Resources Board, this project is entitled *Evaluation of Geothermal Potential of the Basin and Range Province of New Mexico.*

RESEARCH AND DEVELOPMENT

The LASL Hot Dry Rock Geothermal Energy Project is located at the Fenton Hill site, west of the Valles Caldera. The site consists mainly of two drill holes, each about 10,000 ft deep, and a connecting hydraulically made fracture system. Cold water is injected into one drill hole, passed through the fracture system, where it heats, and is withdrawn from the other drill hole.

The connection between the two holes was first established about a year ago. However, it is a poor connection, since there exists a relatively high impedance to the flow of water through the fracture system. In the near future, an attempt will be made to decrease the impedance by a factor of five. Sodium carbonate will be pumped down one hole and up through the other, leaching out silica and carrying it away in the form of sodium silicate.

When the impedance problem has been sufficiently mitigated, project managers will connect a two-module heat exchanger on the surface, with each of the modules rated at 10 megawatts. If the thermal and chemical qualities prove satisfactory, the two drill holes may be deepened to 12,500 ft and a 100 megawatt heat extraction project attempted. This could occur within the next few years.

The Subterrene program is another project at LASL which could be of use to geothermal drillers in the future. Although this project has been halted due to a withdrawal of funding by ERDA, the technology remains and may possibly be continued by industry. The program centers around an experimental drilling method whereby the instrument melts through rock of all types, forming its own glass casing as it goes.

The New Mexico Bureau of Mines and Mineral Resources is currently collecting deep terrestrial heat flow measurements from existing wells throughout the state. In another geothermal project, Bureau personnel are studying associated fluids containing economical amounts of helium, carbon dioxide, methane, and other substances.

Geothermal funding by the State began in 1974. By October 1, 1976, the New Mexico Energy Resources Board had awarded a total of $535,798 for geothermal projects. A total of 15 projects are in progress or have been completed at the New Mexico Institute of Mining and Technology, the University of New Mexico, and New Mexico State University.

FUTURE DEVELOPMENTS

The 22 percent geothermal depletion allowance proposal, which was not approved by Congress in its last session, may be reintroduced during the next session. If passed, this measure will have a very favorable influence on the economics of future geothermal exploration and development.

The Technology Application Center in Albuquerque reports that the Landsat space satellite to be launched in 1977 will contain a heat-sensing channel that may help in mapping new areas with geothermal potential.

ERDA is now planning a study of geothermal potential in the southwestern states. This study will determine project priorities and estimate cost.

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