# REMAINING OIL AND NATURAL GAS RESOURCES OF NEW MEXICO

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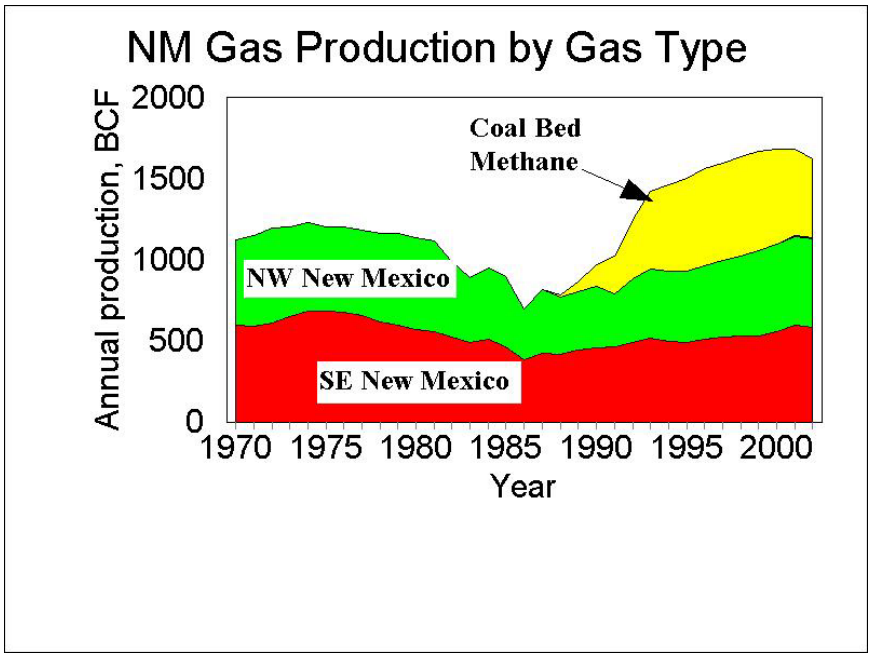


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*New Mexico Bureau of Geology and Mineral Resources*
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# SUMMARY

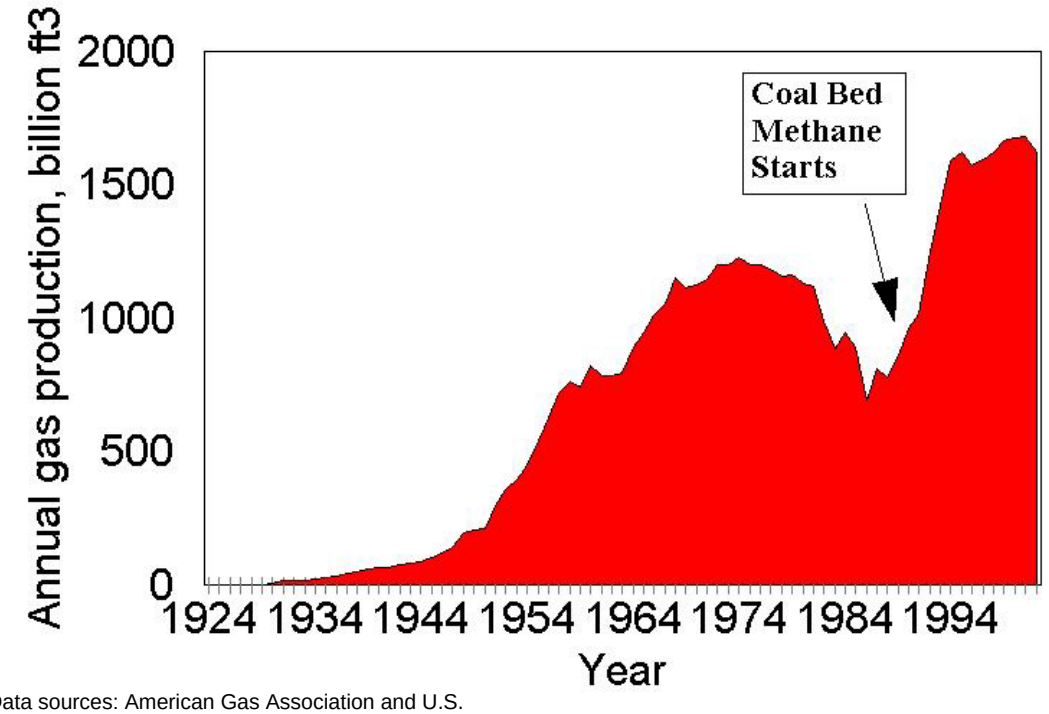
New Mexico has produced 5.2 billion bbls of crude oil and 56 trillion cubic $ft^3$ of natural gas since production of these resources began in the 1920's. During 2002, 67 million bbls oil and 1.6 trillion $ft^3$ gas were produced in New Mexico. ***Available estimates of undiscovered resources indicate a minimum of 1.48 billion bbls oil and between 68 and 89 trillion $ft^3$ gas remain to be produced in the state.*** That is between 32 and 45 years of production for natural gas and 22 years of production for crude oil at present rates of production. In the case of oil, especially, this is a minimum figure because of the limitations involved in estimating an unknown resource that can be neither seen nor measured directly. Most of the oil and gas occurs as undiscovered resources that will require intensive exploration to find and bring into production. Oil and gas prices will affect what will actually be discovered and produced, with lower rates of discovery and production associated with periods of low prices and higher rates of discovery and production associated with periods of high prices.

# NATURAL GAS RESOURCES OF NEW MEXICO

Production of natural gas in New Mexico began in the 1920's and was relatively modest until the 1950's when this clean, convenient and efficient fuel came into common use for domestic and commercial heating and industrial uses. At that time, interstate pipelines were built to carry the gas to market. Additional exploration resulted in the discovery of new gas fields and also oil fields that produce associated natural gas. As these new fields were discovered and developed, production steadily increased into the mid-1970's. At that time, prices for gas were relatively low, demand weakened, and natural gas production in the state started a steep decline.

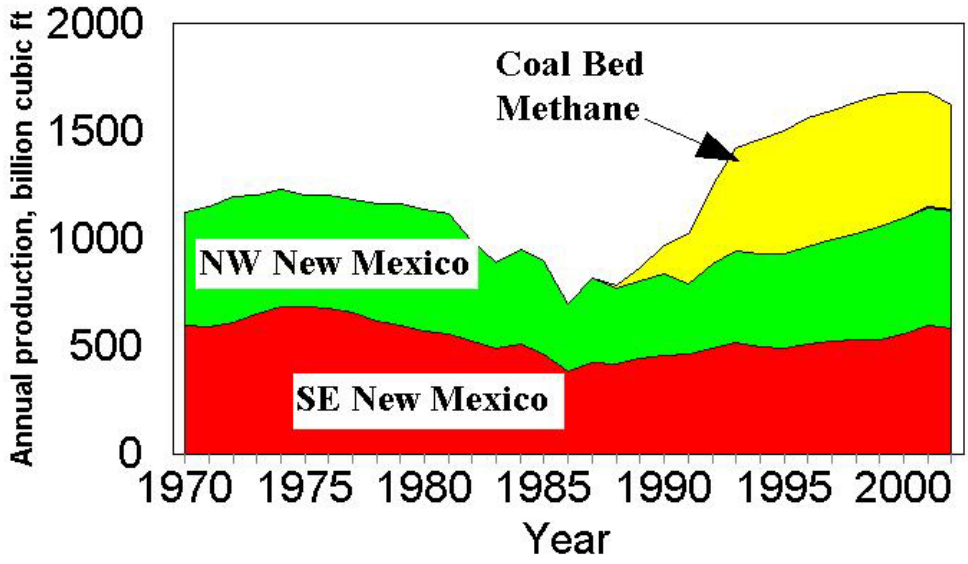
During the late 1980's and 1990's, a new source of natural gas was discovered – coal beds of the Fruitland Formation in the San Juan Basin of northwestern New Mexico. These coal beds had previously not been considered as a significant and economically viable source of natural gas, even though thousands of wells had been drilled through them for decades in order to tap deeper reservoirs of more conventional gas. As the

# NM Gas Production




Data sources: American Gas Association and U.S. Department of Energy

# NM Gas Production by Gas Type




Data sources: American Gas Association and U.S. Department of Energy

Fruitland coals were drilled out and developed during the late 1980's and early 1990's, natural gas production in New Mexico steadily rose and annual gas production soon eclipsed the previous peak of the 1970's. Today, approximately one-third of all natural gas produced in New Mexico is coalbed methane. Most of the remaining gas is split amongst more conventional reservoirs in the San Juan and Permian Basins and is obtained from both gas fields and oil fields. Within the last two years, Fruitland coalbed methane production has started to decline; several gas producers are presently attempting to arrest or stop this decline through recompletions of old wells and increased drilling densities within existing fields. Other new sources of natural gas that have been recently discovered are coalbed methane in the Raton Basin of northeast New Mexico and more conventional gas in the hitherto unproductive Tucumcari Basin of east-central New Mexico and Otero Mesa of south-central New Mexico. These new discoveries demonstrate the potential for gas and oil resources in presently nonproductive frontier areas of New Mexico.

The remaining life span of natural gas production in New Mexico cannot be calculated with absolute certainty although it can be solidly inferred to exist. Most is present in gas fields that have yet to be discovered. A scientifically reasonable quantitative estimate of remaining resources can be obtained by looking at published values of ***proved reserves*** (the natural gas that has already been discovered and is known to be present with a high degree of certainty in known, discovered oil and gas fields) and ***undiscovered resources*** (the natural gas that has not yet been discovered but can be reasonably inferred to exist in undrilled reservoirs and undrilled parts of existing gas fields based upon sound and established scientific principles). Proved reserves are calculated and published annually by the Energy Information Administration of the U.S. Department of Energy and are estimated with a high level of certainty. An in-depth estimate of undiscovered natural gas resources was issued in 1994 by the U.S. Geological Survey for all U.S. basins; an update of selected plays that increased gas resources in the San Juan Basin by 50% was issued in 2002. A similar update has not been undertaken for the Permian Basin, but work is pending. In addition, the Potential Gas Committee of the Potential Gas Agency publishes a gas resource assessment of all U.S. basins every two years. The estimates of undiscovered gas resources published by the Potential Gas Committee are larger for most basins than estimates provided by the U.S. Geological

Survey. In general, the U.S. Geological Survey estimates emphasize resources in known productive trends while the Potential Gas Committee provides estimates that place more emphasis on prospective nonproductive trends. In its 2002 reassessment of the San Juan Basin, the U.S. Geological Survey also started to place emphasis on several currently nonproductive trends that are likely to contain significant volumes of untapped gas, including unconventional gas such as coalbed methane and shale gas.

Natural gas reserve and resource estimates for New Mexico from the various sources are given below. These are most likely or mean values issued by the source organizations, not maximum or minimum possible values.

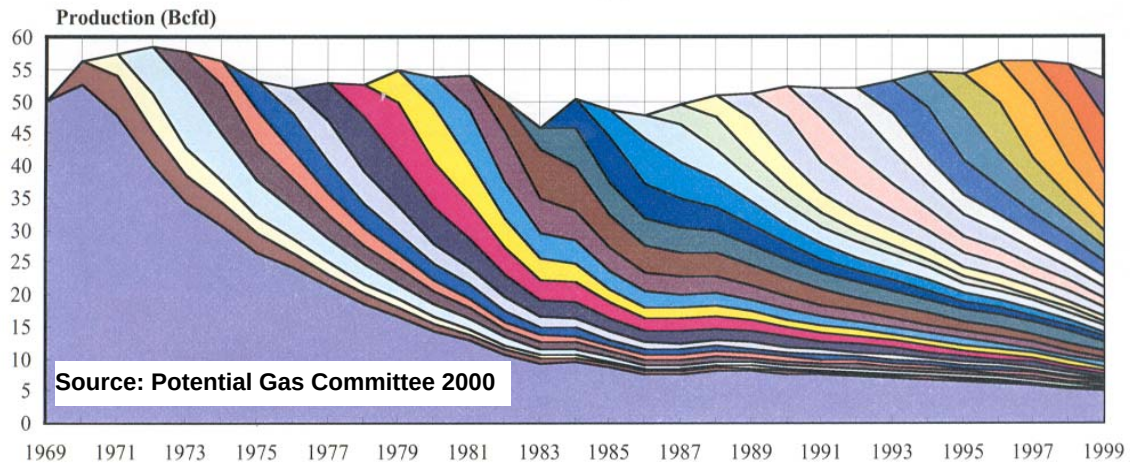
| | ***Source*** | ***Gas Trillion ft$^3$*** |
|---|---|---|
| ***Proved reserves*** | Energy Information Administration U.S. Dept of Energy | 17.3 |
| ***Undiscovered resources*** | U.S. Geological Survey | 51.2 |
| ***Undiscovered resources*** | Potential Gas Committee | 72.1 |
| ***Total resource base*** | | 68.5-89.4 |

The values of undiscovered resources published by the U.S. Geological Survey and the Potential Gas Committee are not exclusive to New Mexico. Instead, they cover multiple basins that cross state lines and do not indicate resource assessments for each state. New Mexico estimates were obtained from the basinal data by apportioning the estimates of undiscovered resources according to the approximate state distribution of proved reserves (DOE numbers) in these multi-state basins.

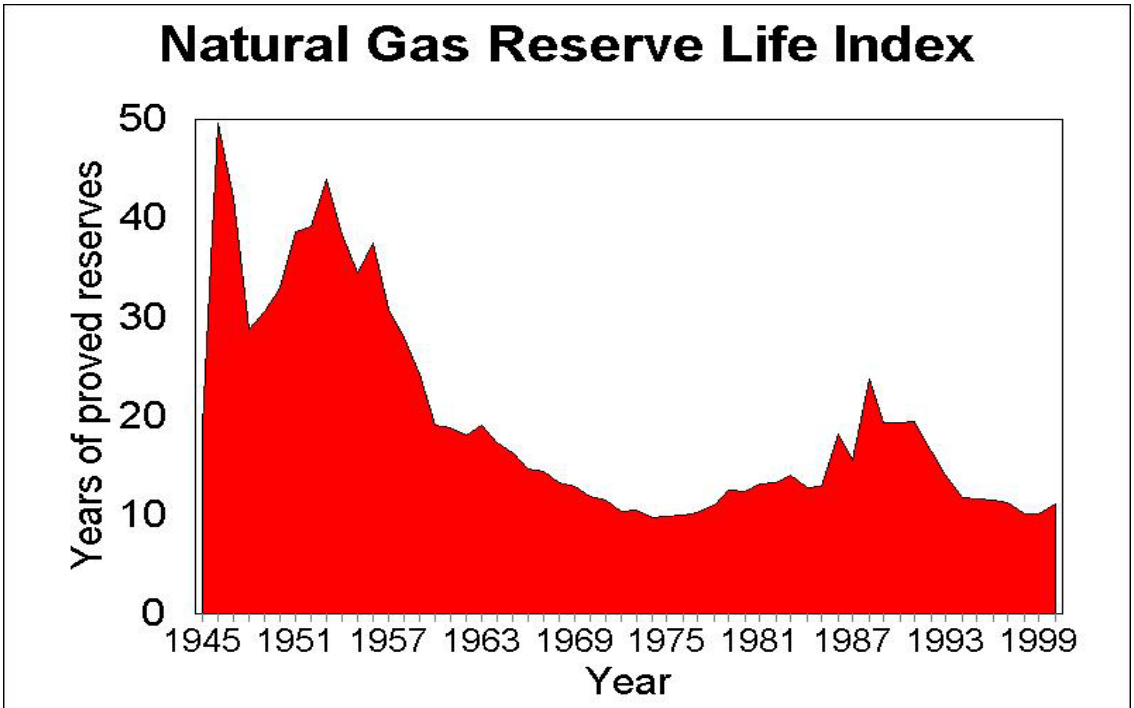
At present rates of production (1.6 trillion ft$^3$ per year), proved reserves will last 10.8 years. Undiscovered gas resources, if eventually explored for and developed, could be produced at present production rates for between 32 years and 45 years, depending on whether one uses the U.S. Geological Survey estimates or the Potential Gas Committee estimates. Of course, if exploratory successes decrease, rates of production will decrease and the productive life of gas in New Mexico will be extended considerably since lesser volumes of the undiscovered resource will be added to proved reserves in any given year. The productive life span of New Mexico gas will also increase if new and previously

unrecognized sources of natural gas come into play, similar to the Fruitland coalbed methane.

Gas is not produced at constant rates from wells over the lifetimes of those wells. As a well comes into production and starts to deplete the gas reserves it taps, production will start to decrease. Although the present ***Reserve Life Index*** for gas (the ratio of proved reserves to present annual production) is 11.5 years, the proved reserves in currently existing wells will be produced over a longer period of time if no additional wells are drilled and completed and no new gas is explored for and discovered. In 2000, the Potential Gas Committee produced the following graph that indicates, for the entire U.S., that approximately 50% of current gas production is obtained from wells drilled and completed during the past five years. It is this new gas that allows production rates to be maintained. If not for the new gas, production rates would be cut in half approximately every five years.




**Daily natural gas production in the United States (in billion $ft^3$ per day) vintaged by the year wells were drilled and completed. Each color band indicates the production history of natural gas first brought into production from wells drilled during the year that the color band first appears. The large purple area starting at the left is the production history of gas obtained from all wells drilled before 1970. The total production from all wells drilled before 1995 decreased approximately 50% between 1995 and 1999 from 55 billion $ft^3$ per day in 1995 to less than 30 billion $ft^3$ per day in 1999.**



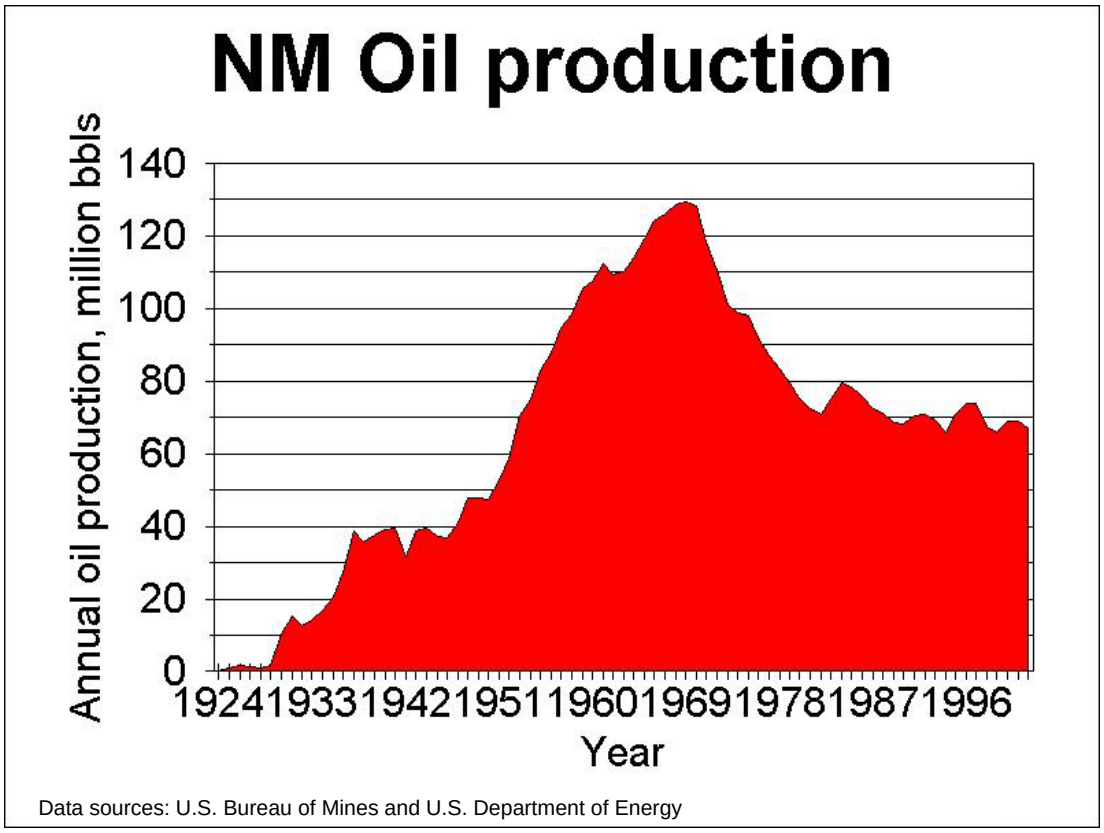
The numbers represented by this graph were calculated from data published by the American Gas Association and the U.S. Department of Energy

# CRUDE OIL RESOURCES OF NEW MEXICO

Production of crude oil in New Mexico began in the 1920's and steadily increased through 1969 when a maximum annual production of 129 million bbls was attained as new oil fields were discovered through exploration and drilling and these fields were developed. Production then began a steady decline until the late 1970's when the decline was arrested. At first, the arrest of production decline was directly related to the oil embargoes and associated high prices of the late 1970's and early 1980's. During this period, record levels of drilling took place and many new fields were discovered and rapidly developed.

During the middle 1980's and much of the 1990's oil prices were very low as the embargoes ended and much new oil came into production on the international scene. At times, wellhead crude prices received by New Mexico producers dipped below $9/bbl. Exploration and development stagnated along with drilling. Yet, the steep production

decline that characterized the 1970's did not return and the production decline became almost level although punctuated by short-term increases.




There are four main reasons for the almost constant level of production in the 1980's and 1990's. **First**, new plays and trends were discovered in southeast New Mexico and significant new oil came into production as a result of these discoveries. Perhaps chief among these was the Brushy Canyon play whose play-wide production increased to almost 7 million bbls per year by the early 1990's. **Second**, much new oil came into production as a result of recognizing bypassed pay in older wells. **Third**, the Dagger Draw field of Eddy County, initially discovered in the early 1960's, was "rediscovered" in the late 1980's and drilling and production in this prolific reservoir boomed with annual production peaking at 5.9 million bbls per year in 1992, or 8.3% of total New Mexico production (the other 2000 oil and gas fields in the state provided the remaining 91.7% of production in 1992). Dagger Draw remained mostly undeveloped for more than 20 years because the reservoir geology of the field was poorly understood.

And **fourth**, new technologies came into play during the 1980's and 1990's that improved new field drilling success rates; chief among these new technologies was the development and commercialization of 3-D seismic techniques.

The remaining life span of oil production in New Mexico can be calculated in a manner similar to that used for natural gas (described above). Estimates of proved reserves and undiscovered resources appear in the following table. As for natural gas, U.S. Geological Survey estimates of undiscovered resources are for basins that cross state lines. New Mexico estimates were calculated by apportioning basin resource estimates according to proved reserves in those basins.

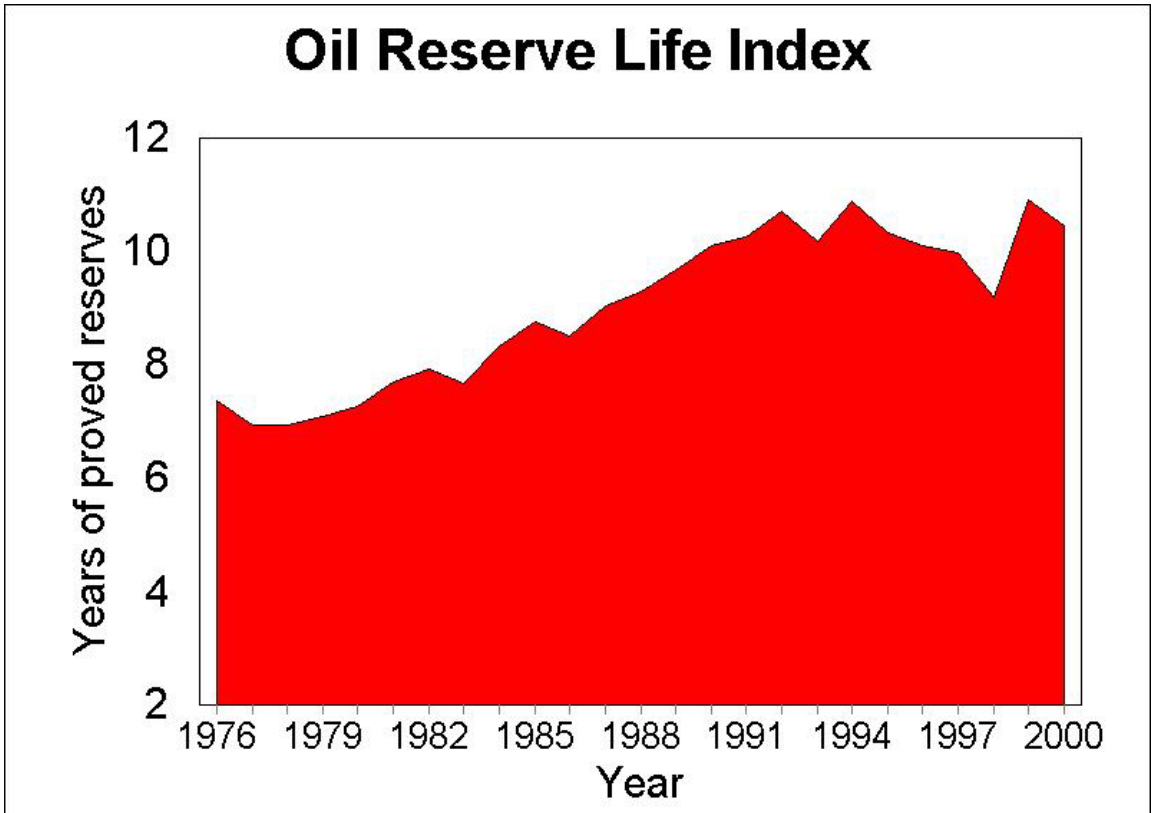
| | ***Source*** | ***Oil, million bbls*** |
|---|---|---|
| ***Proved reserves*** | Energy Information Administration<br>U.S. Department of Energy | 705 |
| ***Undiscovered resources*** | U.S. Geological Survey | 776 |
| ***Total resource base*** | | 1481 |

The total resource base (proved reserves + undiscovered resources) is 1.48 billion bbls using the DOE supplied data of proved reserves and the U.S. Geological Survey supplied estimates of undiscovered resources. At current levels of production, these data indicate a resource life of approximately 22 years.

The crude oil resource estimates warrant further comment. DOE-published estimates of proved reserves for 1994 were 718 million bbls. During this same year, the U.S. Geological Survey issued data that indicate undiscovered resources of 776 million bbls. A total of 623 million bbls of crude oil have been produced in New Mexico since 1994.

If the U.S. Geological Survey estimates of undiscovered resources were complete, New Mexico should only have 871 million bbls of producible oil left in the ground. In other words, 42% of the 1994 resource base estimate has been produced. Yet the ***Reserve Life Index*** for crude oil in New Mexico (the ratio of proved reserves to annual production) has actually increased slightly since 1994 as shown in the accompanying graph. This trend of the Reserve Life Index indicates two things. First, the production of

proved reserves has been replaced by undiscovered resources every year and, as exploratory discoveries are made, unproven resources have become proved reserves at a rate that replaces production. Second (and perhaps more importantly), the very stable trend of the oil Reserve Life Index provides a sound indication that the U.S. Geological Survey seriously underestimated undiscovered resources in their 1994 study. If the 1994 estimates were correct and New Mexico had produced 42% of its remaining 1994 resource base while maintaining essentially stable production, one would expect the Reserve Life Index to have shrunk. Instead, it has increased slightly.



The numbers represented by this graph were calculated from data published by the U.S. Bureau of Mines and U.S. Department of Energy

This analysis is not meant to criticize the 1994 U.S. Geological Survey estimates, which were based on sound technology. Rather, this analysis demonstrates the difficulty of calculating an undiscovered resource base of a commodity that can be neither seen nor measured directly. Although detailed information of the U.S. Geological Survey estimates is sketchy at best, it appears that those estimates concentrated on known trends

and plays and did not provide for significant resources in undiscovered plays (for example the Brushy Canyon play of southeastern New Mexico) or rejuvenated older fields that had long been considered to bear only minor resources (for example the Dagger Draw field). It is also possible that the U.S. Geological Survey data did not fully factor resources made producible or discoverable through the application of new technologies such as horizontal drilling or 3-D seismic surveys. Unlike the situation for natural gas, undiscovered national and regional crude oil resource estimates are made solely by the U.S. Geological Survey. For gas, the Potential Gas Committee also calculates undiscovered resources based on different methodologies and using personnel who have extensive regional or local experience. The U.S. Geological Survey estimates should be considered as an extremely reliable minimum resource base that is less than what actually exists by an unknown but probably large value.

## ECONOMICS - THE ROLE OF OIL AND GAS PRICES IN RESOURCE ESTIMATES

Prices received at the wellhead for crude oil and natural gas have a large effect on whether or not technically recoverable resources will actually be discovered or produced. When prices for oil and gas are low, exploration companies conduct fewer seismic surveys and drill fewer wells. Generally shallower reservoirs are targeted because costs associated with drilling and completing wells and lifting crude oil and associated brine waters are substantially less than in deeper reservoirs. Drilling is generally concentrated on risk-adverse development and infill of known discovered reservoirs when oil and gas prices are low. In addition, more permeable reservoirs that will yield higher rates of production per well are generally targeted.

When oil and gas prices are high and are expected to remain high for substantial lengths of time, opposite trends emerge for exploration and development activities. Exploration and development companies become somewhat less risk adverse and some will conduct exploratory drilling programs in areas further away from known production. More seismic surveys and surveys based on other indirect exploration techniques are conducted. More exploratory wells will be drilled. Deeper reservoirs may become renewed targets for both exploration and development and low-permeability, low-yield

reservoirs (such as tight gas or shale gas) become increasingly sought after. A greater amount of the resource base will be explored for, discovered, and produced.

The 1994 U.S. Geological Survey undiscovered resource estimates included a component of oil and gas prices. These estimates are shown for New Mexico in the following table.

| | ***Oil resources (undiscovered), million bbls*** | ***Gas resources (undiscovered), trillion $ft^3$*** |
|---|---|---|
| ***Technically recoverable oil, gas*** | 776 | 32 (from 1994 estimate) |
| ***Oil recoverable at $18/bbl; gas at $2/thousand $ft^3$*** | 520 | 17 |
| ***Oil recoverable at $30/bbl; gas at $3.34/thousand $ft^3$*** | 632 | 22 |

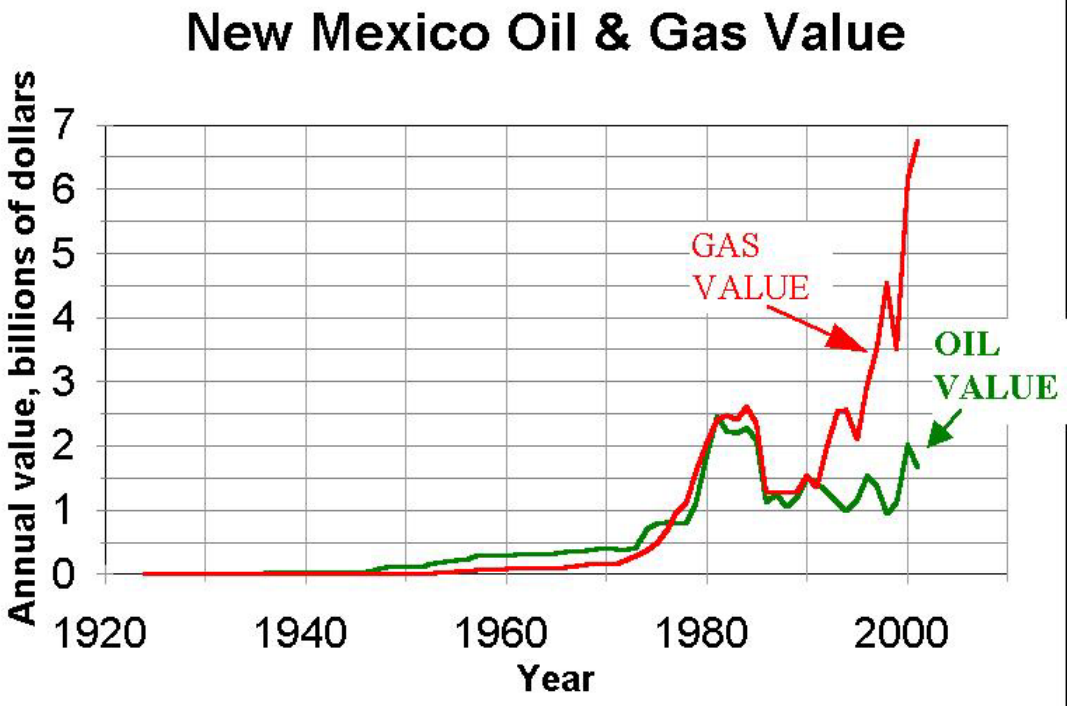
These estimates demonstrate the serious effects of price on the producibility of crude oil and natural gas. The effect is greater for gas than for oil, presumably because higher gas prices will allow producers to pursue marginal low-permeability gas as well as deep (>15,000 ft) gas. Improved technology that will decrease drilling and production costs and improved exploration technology and concepts can help mitigate the adverse effects of low prices.

## VALUE OF PRODUCED OIL AND GAS

The cumulative value of natural gas produced in New Mexico since production began in the 1920's is $67 billion. The cumulative value of produced oil is $47 billion. The following chart indicates that the annual value of produced gas has increased over the past decade from approximately $1.5 billion to more than $6 billion. The reason for this substantial increase in value is twofold. First is the addition of coalbed methane production in the late 1980's and 1990's. Second is the national increase in natural gas

prices over the past few years that has resulted from a tightening of gas supplies. The average gas price in New Mexico was $1.59 per thousand $ft^3$ during 1990. During 2001 it was $ 4.01 per thousand $ft^3$.

The value of produced oil in New Mexico increased from approximately $1.5 billion in 1990 to $2 billion in 2000. The reasons for this increase were approximately stable production accompanied by an increase in average price from $22 per bbl during




Data sources: U.S. Bureau of Mines, American Gas Association, New Mexico Energy Minerals and Natural Resources Department, and New Mexico Taxation and Revenue Department

1990 to $29 per bbl during 2000. During periods of low oil prices, value of production decreases because of both reduced prices and reduced volumes of production.

## SUMMARY

Significant volumes of crude oil and natural gas remain to be produced in New Mexico. Available resource estimates indicate there is a minimum of 22 years of crude

oil and between 32 and 45 years of natural gas that can be produced at current production rates. These are almost certainly minimal values, especially in the case of crude oil. Most of the existing resource base is not in proved reserves in known oil and gas fields. Rather, it occurs as undiscovered resources that will only be found and produced through application of sophisticated exploration methodologies and concepts and, ultimately, drilling. Production of oil and gas will decline unless new reserves of oil and gas are discovered, developed, and produced. If production rates decline because of decreased exploration and development activities (which could result from lengthy periods of reduced prices), then the already known resource base will be stretched out and last longer, although at lesser production rates and correspondingly reduced values.