

Information Circular 8708

PB252473



Helium Resources of the United States, 1973

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REPRODUCED BY:
U.S. Department of Commerce
National Technical Information Service
Springfield, Virginia 22161

NTIS

This publication has been cataloged as follows :

Moore, Billy J

Helium resources of the United States, 1973. [Washington]
U.S. Bureau of Mines [1976]

17 p. illus., tables. (U.S. Bureau of Mines. Information circular 8708)

Includes bibliography.

1. Helium. I. U.S. Bureau of Mines. II. Title. (Series)

TN23.U71 no. 8708 622.06173

U.S. Dept. of the Int. Library

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HELIUM RESOURCES OF THE UNITED STATES, 1973

by

B. J. Moore¹

ABSTRACT

This Bureau of Mines publication reviews U.S. helium resources as of January 1, 1973. These resources, estimated to be 693.7 billion cubic feet, are broken down into four classifications, as follows: helium in storage, 34.9 billion cubic feet; helium in measured helium-rich natural gas reserves, 119.5 billion cubic feet; helium in measured helium-lean natural gas reserves, 62.8 billion cubic feet; and helium in indicated or undiscovered natural gas resources, 476.5 billion cubic feet. The helium in undiscovered natural gas is considered a national resource; however, this gas may not be discovered depending on many factors beyond the scope of this paper, and most of the helium in natural gas will be dissipated as the gas is consumed for fuel and other purposes.

INTRODUCTION

Estimates of the helium resources of the United States have been made for several years by the Bureau of Mines, Division of Helium, in connection with a search for helium occurrences that has been conducted for more than 50 years. The evaluation work on the helium resources is done to insure a continuing supply of helium to fill essential Federal needs and to provide information to the public on a limited and wasting natural resource. This responsibility of insuring a supply of helium to meet essential Federal needs was assigned to the Secretary of the Interior originally in 1925, and the latest legislation is the Helium Act Amendments of 1960. Further, the Mineral Leasing Act of 1920 reserves all helium found under Federal oil and gas leases to the United States.

The helium resources of the Nation are reported in four categories: (1) Helium in storage; (2) helium in measured helium-rich natural gas reserves; (3) helium in measured helium-lean natural gas reserves; and (4) helium in indicated and undiscovered natural gas resources. Category 1, helium in storage, is the helium stored by the Department of the Interior as part of its conservation efforts. Category 2, helium in measured helium-rich natural gas reserves, is defined as that helium in measured natural gas

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reserves having a helium content of 0.3 percent or more. Category 3, helium in measured helium-lean natural gas reserves, is defined as that helium in measured natural gas reserves having a helium content of less than 0.3 percent. Category 4, helium in indicated and undiscovered natural gas resources, includes helium in as yet undiscovered natural gas resources as estimated by the Potential Gas Committee (PGC), which is sponsored by the Colorado School of Mines Foundation, Inc. The value of 0.3 percent helium has no particular significance except that generally as the helium content goes down, the cost of recovery goes up. Helium recovery cost is a function of many other variables, such as average annual daily rate of gas processed, hydrocarbon recovery, and life of the reserves.

ACKNOWLEDGMENTS

The basic information on which the estimate of helium resources has been made has come from individual gasfields where helium has been located, and from estimates of future discoveries. Without the assistance of the oil and gas industry, State and national agencies, and many individuals engaged in oil and gas exploration, the data collection and evaluation of the Nation's helium reserves would be impossible. Clearly one of the major methods of helium resources evaluation has been to use data from industrial efforts to locate natural gas.

HELIUM RESOURCES

The helium resources of the United States, as defined for the purposes of this report, are those which occur either as a constituent of natural gas or have been previously separated from natural gas and have been stored for future use. Figure 1 shows the breakdown of these helium resources. Helium is a minor constituent of all natural gas, and the helium resources included in these estimates are found in natural gas in identified gasfields or in fields which are surmised to exist based on expert opinion. Economic extraction of the helium from these identified and undiscovered sources may be either currently or potentially feasible. Included with these resources are those helium deposits categorized as reserves. These helium reserves are defined as helium in identified gas reserves having at least 0.3 percent helium by volume and at least 100 million cubic feet of recoverable helium.

In a Department of the Interior News Release on April 15, 1974, definitions of terminology regarding categories of resources were given. These terms were jointly adopted by both the Bureau of Mines and the Geological Survey and are used throughout this report. These recently adopted terms can be compared to commonly used terms in the natural gas industry. The adopted terms and the comparable gas industry terms as used in this report are shown in figure 1 and defined in the appendix.

To estimate volumes of helium contained in natural gas, it is necessary to have some method of obtaining the helium content of natural gas resources. Helium contents used in this report came from the Bureau's records of helium analyses in natural gas. The analysis of natural gas and the evaluation of helium resources were begun in 1917. Over 14,000 analyses of natural gas

	IDENTIFIED			UNDISCOVERED	
	DEMONSTRATED			HYPOTHETICAL (Possible)	SPECULATIVE (Speculative)
	STORED	MEASURED (Proved)	INDICATED (Probable)		
ECONOMIC	34.9 Bcf	Helium-rich gas 119.5 Bcf			
	R E S E R V E S Total 154.4 Bcf				
SUBECONOMIC			97.6 Bcf	149.1 Bcf	229.8 Bcf
	62.8 Bcf	R E S O U R C E S Total 693.7 Bcf			

FIGURE 1. - Helium resources of the United States. Terms in parentheses are those used by the PGC and commonly used in industry. Bcf = billion cubic feet.

samples from wells and pipelines in the United States have been made. Through 1973, 10,201 of these analyses had been published in 17 Bureau of Mines publications listed in the Bibliography at the end of this report.

Helium in Storage

In 1961, the Government contracted to purchase helium from extraction plants which were built by private companies adjacent to large natural gas transmission pipelines. The gas, principally from the West Panhandle and Hugoton gasfields, was being produced for fuel, and as the gas was burned, the helium was released to the atmosphere and wasted. The helium was purchased from four private companies. Using private funds, these four companies constructed five helium extraction plants to serve the Government programs. The helium was delivered into a Government-owned pipeline which connected all plants with the Cliffside helium storage field near Amarillo, Tex.

Deliveries of helium to the Bureau of Mines for storage commenced in December 1962, and as of January 1, 1973, 31.2 billion cubic feet of helium was in underground storage. (Notice of termination of helium purchases was given March 28, 1971, to the four companies from which the Bureau was buying

helium.) In addition, 1.0 billion cubic feet of helium was stored for private companies under separate storage contracts, and 2.7 billion cubic feet of helium production from Bureau of Mines plants not currently needed to meet Federal demand was also stored by the Bureau. Thus, the total volume of helium in storage as of January 1, 1973, was 34.9 billion cubic feet.

The storage site, Cliffside field, is a partially depleted natural gasfield in which the gas and storage rights are owned by the Government. The field was the source of helium-bearing natural gas which was processed for helium extraction at the Government's Amarillo Helium Plant from 1929 until the plant ceased helium extraction operations in April 1970. These operations partially depleted the natural gas from the Cliffside field. There remains in the field about 212 billion cubic feet of natural gas with a helium content of about 1.86 percent. Helium contained in the remaining native gas is included with the helium in measured natural gas reserves.

Helium in Measured Reserves of Natural Gas

Helium in measured reserves of natural gas is divided into two classifications, helium-rich and helium-lean natural gas. These classifications are differentiated by helium content. Helium-rich natural gas is that gas which contains 0.3 percent or more helium, while helium-lean natural gas is that gas which contains less than 0.3 percent helium.

Helium in Helium-Rich Natural Gas

As of January 1, 1973, it was estimated that there were 119.5 billion cubic feet of helium contained in the measured natural gas reserves of the United States that had helium contents of 0.3 percent or more. These reserves were located in 93 fields in 10 States. Estimates of the helium reserves in helium-rich gas in each of these States are shown in table 1.

TABLE 1. - Helium reserves of the United States, by State

(Volumes in million cubic feet at 14.73 psia and 60° F)

State	MMcf of helium
Arizona.....	1,789
Colorado.....	1,660
Kansas.....	55,336
Montana.....	581
New Mexico.....	733
Oklahoma.....	13,345
Texas.....	39,666
Utah.....	3,031
West Virginia.....	112
Wyoming.....	3,262
Total United States.....	119,515

The Bureau of Mines has made estimates of helium reserves in the Nation since 1950. Each year, as more data were collected and additional experience was gained, these estimates have been more comprehensive and more specific.

In the first efforts of estimating helium reserves, estimates were confined to the helium contained in the major helium-rich natural gasfields in the Oklahoma and Texas Panhandles and in southwest Kansas. Fields included in these estimates were Hugoton, which extended from Kansas through the Oklahoma Panhandle and into the Texas Panhandle, West Panhandle in Texas, Greenwood in Kansas, Keyes in Oklahoma, and Cliffside in Texas. These fields still contain the bulk, over 85 percent or 103.1 billion cubic feet, of the helium reserves in the Nation's helium-rich gas. The natural gas that makes up this 85 percent of the rich-helium reserves is being produced for fuel, and the helium is lost with the flue gas.

In 1961, a program was initiated to estimate the helium reserves of all fields from which samples of helium-rich gas had been analyzed in connection with the helium evaluation program. Data on these smaller fields have been collected from all known available sources over these intervening years, and this information has been evaluated to assess the total helium reserves of the country. The helium reserves estimates for each year beginning in 1950 appear in table 2. Table 2 also compares the trend of helium reserves of the United States with the natural gas reserves as estimated by the American Gas Association (AGA).

TABLE 2. - Helium and natural gas reserves estimates from 1950 through 1973

(Volumes in million cubic feet at 14.73 psia and 60° F)

Beginning of year ¹	Helium in helium-rich natural gas	Helium in storage	AGA estimates of natural gas reserves
1950.....	248,642.	82	179,401,693
1951.....	242,675	81	184,584,745
1952.....	242,675	86	192,758,910
1953.....	235,713	87	198,631,566
1954.....	229,745	86	210,298,763
1955.....	222,783	86	210,560,931
1956.....	216,816	70	222,482,544
1957.....	210,849	46	236,483,215
1958.....	203,887	24	245,230,137
1959.....	197,919	17	252,761,792
1960.....	192,946	106	261,170,431
1961.....	194,373	268	262,326,326
1962.....	194,373	438	266,273,642
1963.....	191,311	509	272,278,858
1964.....	187,855	2,042	276,151,233
1965.....	177,886	5,317	281,251,454
1966.....	169,695	8,870	286,468,923
1967.....	163,589	12,407	289,332,805
1968.....	155,076	16,138	292,907,703
1969.....	148,408	19,863	287,349,852
1970.....	140,386	23,693	275,108,835
1971.....	135,850	27,573	290,746,408
1972.....	127,873	31,491	278,805,618
1973.....	119,515	34,903	266,084,846

¹AGA reserve estimates are given as of December 31 of previous year.

All of the large reserves of helium mentioned previously, except the native gas in Cliffside field, and most of the smaller reserves are being produced for fuel. This resulted in about 8.4 billion cubic feet per year of helium being lost without beneficial use. The purchases of helium extracted under contract saved an average of about 3.5 billion cubic feet of this once wasting helium from 1963 through contract termination. In 1972, about 4.1 billion cubic feet of helium was extracted; however, the balance, or 4.3 billion cubic feet, was produced with the natural gas and lost to the atmosphere without beneficial use.

In addition to the fields now being depleted of their helium reserves because of production of natural gas for fuel, there are several fields containing helium-rich gas that are not now being produced. These are classed as nonwasting helium reserves. There are 39 fields in this category. The reasons for not producing these natural gas reserves are varied. Some are located in remote areas where pipeline connections are not available presently; in other cases, some of the gas is used for pressure maintenance operations to produce associated oil. In the majority of instances, the helium is in natural gas with low heating value and thus not valuable for fuel. The fields included in the first two groups will probably be put on production eventually, and the helium reserves will then be removed from the nonwasting category.

It is estimated that almost 9 billion cubic feet of helium is contained in the measured natural gas reserves of the nonwasting, helium-rich gasfields. Of this 9 billion cubic feet, about 5.6 billion cubic feet is contained in gasfields located on Federal lands. The Government retains title to helium under Federal oil and gas leases; therefore, title to this helium is held by the Government, even though the oil and gas rights may be leased. These nonwasting reserves, then, may serve as a backup to the helium stored by the Government and are an integral part of the Government's helium conservation efforts.

Helium in Helium-Lean Natural Gas

The AGA has compiled estimates of the natural gas reserves of the United States each year since 1945. The estimate for December 31, 1972,² was used in conjunction with helium contents derived from the gas analysis data from the Bureau's helium analysis files to estimate the volume of helium in the helium-lean measured natural gas reserves of the Nation. The AGA yearly reserve estimates and helium reserve estimates are shown in table 2 and figure 2.

Measured natural gas reserves of the United States were estimated by AGA to be 266,085 billion cubic feet as of December 31, 1972. This estimate was made by combining estimates of gas reserves of several geographic divisions within the country. Table 3 shows the gas reserve estimates for each geographical area as published by the AGA.

²American Gas Association Committee on Natural Gas Reserves. Report of natural gas reserves of the United States. No. 22-73, Mar. 19, 1973.

TABLE 3. - AGA natural gas proved¹ reserve estimates with applicable helium content and helium in helium-lean gas

(Volumes in million cubic feet at 14.73 psia and 60° F)

Area	Natural gas reserves	Applied helium content, fraction	Contained helium
Alabama.....	245,714	0.00041	101
Alaska.....	31,455,443	.00015	4,718
Arkansas.....	2,455,877	.00087	2,137
California.....	5,328,862	.00007	373
Colorado.....	1,655,200	.00055	² 730
Florida.....	180,629	.00030	54
Illinois.....	545,361	.00123	671
Indiana.....	87,324	.00117	102
Kansas.....	11,938,716	.00145	² 424
Kentucky.....	938,082	.00125	1,173
Louisiana:			
North.....	3,320,328	.00035	1,162
South.....	71,651,006	.00006	4,299
Michigan.....	1,296,815	.00120	1,556
Mississippi.....	1,104,336	.00051	563
Montana.....	1,064,036	.00076	809
Nebraska.....	50,260	.00098	49
New Mexico:			
Northwest.....	8,160,874	.00027	² 2,167
Southeast.....	4,174,773	.00039	1,628
New York.....	139,184	.00093	129
North Dakota.....	441,625	.00049	216
Ohio.....	1,146,677	.00147	1,686
Oklahoma.....	14,492,030	.00087	² 10,795
Pennsylvania.....	1,406,948	.00082	1,154
Texas:			
District 1.....	1,620,405	.00019	308
District 2.....	9,496,136	.00006	570
District 3.....	20,696,874	.00006	1,242
District 4.....	24,334,110	.00006	1,460
District 5.....	1,171,395	.00032	375
District 6.....	5,710,441	.00038	2,170
District 7B.....	663,560	.00153	1,015
District 7C.....	2,581,980	.00099	2,556
District 8.....	15,481,337	.00039	6,038
District 8A.....	2,366,951	.00084	1,988
District 9.....	1,559,594	.00119	1,856
District 10.....	9,359,260	.00106	² 2,879
Utah.....	1,022,110	.00051	² 428
Virginia.....	35,921	.00098	35
West Virginia.....	2,345,957	.00080	1,877
Wyoming.....	4,088,728	.00032	1,308
Miscellaneous.....	269,987	-	-
Total.....	266,084,846	-	62,801

¹See appendix for definition.

²Helium-rich fuel gas reserves subtracted from total natural gas reserves before average helium content applied.

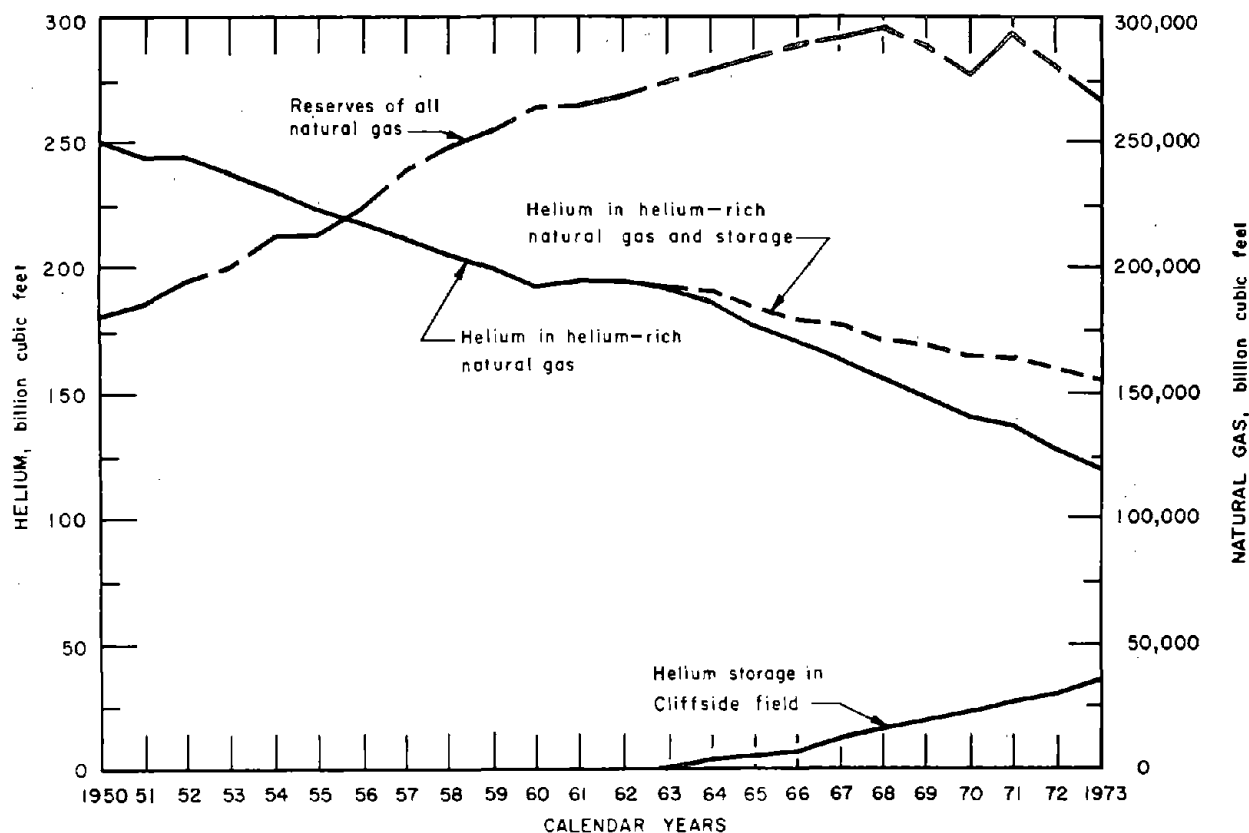


FIGURE 2. - Helium contained in helium-rich natural gas, helium in storage, and reserves of natural gas of the United States.

Gas analysis data from the helium analysis files were used to estimate an average helium content for the helium-lean natural gas reserves of each AGA reporting area. These average helium contents are shown in table 3. These values were then applied to the estimated natural gas reserves to estimate the helium contained in the helium-lean natural gas. In areas where the helium-rich natural gas reserves are located, these values were subtracted from the AGA estimates before the lean helium content average was applied. Total helium volume contained in measured helium-lean natural gas reserves of the United States is 62.8 billion cubic feet. A breakdown by geographical regions is given in table 3.

Helium in Potential Reserves of Natural Gas

The United States has large resources of natural gas that are as yet undiscovered, according to the PGC. Resources were estimated to total 1,146 trillion cubic feet as of December 31, 1972.³ The PGC is sponsored by the Potential Gas Agency, Mineral Resources Institute, Colorado School of

³Potential Gas Committee. Potential Supply of Natural Gas in the United States (as of December 31, 1972). Potential Gas Agency, Miner. Res. Inst., Colo. School Mines Foundation, Inc., November 1973, 47 pp.

Mines Foundation, Inc., and is made up of representatives from the oil and gas producing industry, gas transmission industry, gas distribution industry, Government, and academic community. The Committee made its initial report on future natural gas supply in 1967, although a predecessor committee, Future Gas Supply Committee, produced a report in 1964.

The resources reported by the PGC are broken down into three categories: probable, possible, and speculative. The PGC defines these terms as follows:

- "Probable - The most assured of new supplies results from the growth of existing fields.
- "Possible - Less assured is the supply from new field discoveries in formations previously productive; such new fields would be distinctly separated from existing fields.
- "Speculative - The most nebulous of new supplies is attributable to new field discoveries in formations or provinces not previously productive."

In comparing the PGC definitions with the terminology adopted by the Bureau of Mines and Geological Survey, it appears that the PGC "probable" class is closely related to the Federal "indicated" category. This would then bring the "probable" resources into the "identified" range on the chart on page 3. This is a seeming contradiction to the PGC's treatment of that class of reserves; however, it appears to be the best resolution. A geological Survey report discusses the PGC estimates stating on page 19 that the "probable category includes, however, some known resources, in the sense of having been discovered but not completely developed, and some unknown resources, so that this category brackets the boundary between the known and the unknown."⁴ For the present report, the PGC "probable" category will be compared to "identified" reserves, and PGC's "possible" and "speculative" will fall in the "undiscovered" category in Bureau of Mines terminology.

To estimate the helium contained in the potential natural gas resources, as estimated by the PGC, average helium contents for the various PGC reporting areas (shown in figure 3) were applied to the estimates of gas resources. These average helium contents were again derived from the results of the Bureau's evaluation of helium occurrences and gas analysis. Helium contained in these potential gas reserves is estimated to be 476 billion cubic feet. Average helium contents used for the various PGC regions ranged from 0.006 percent to 0.178 percent. Table 4 shows the PGC estimate of potential natural gas resources by category of estimate and geographic area. The average helium content applied to the gas resources and the estimated helium contained in the natural gas are shown in table 5. It was assumed that the helium content of the gas discovered in the future would be the same as past discoveries in all PGC areas except Area J North. Area J North includes the Texas Panhandle, Oklahoma, and Kansas; consequently, the area contains over 90 percent of the proved or measured helium-rich gas reserves. Since it is not deemed likely

⁴Theobald, P. K., S. P. Schweinforth, and D. C. Duncan. Energy Resources of the United States. U.S. Geol. Survey Circ. 650, 1972, 27 pp.

that helium-rich gasfields of the size of Hugoton or West Panhandle will be discovered in the future, it seemed prudent to discount these large "reservoirs" when considering the helium content of future discoveries. Because of this, the weighted average helium content of the helium-lean natural gas streams leaving Area J North was used for the potential or undiscovered gas reserves.

TABLE 4. - Potential gas reserves of the United States as of December 31, 1972, as estimated by the Potential Gas Committee¹

Area	Probable reserves	Possible reserves	Speculative reserves	Total U.S.
A.....	26	9	67	102
B.....	2	4	54	60
C.....	(²)	5	4	9
D.....	8	24	58	90
E.....	56	84	(²)	140
G.....	58	47	20	125
H.....	13	26	20	59
I.....	6	6	6	18
J North.....	21	39	24	84
J South.....	17	33	11	61
L.....	5	13	14	32
K.....	54	94	218	366
Total.....	266	384	496	1,146

¹Potential Gas Committee. Potential Supply of Natural Gas in the United States (as of December 31, 1972). Potential Gas Agency, Miner. Res. Inst., Colo. School Mines Foundation, Inc., November 1973, 47 pp.

²No reserves.

TABLE 5. - Helium content and contained helium in the potential gas reserves of the United States

(Volumes in billion cubic feet at 14.73 psia and 60° F)

Area	Helium content, fraction	Helium in probable reserves	Helium in possible reserves	Helium in speculative reserves	Helium in total potential reserves
A.....	0.00108	27.93	9.66	71.97	109.56
B.....	.00042	.84	1.67	22.56	25.07
C.....	.00178	(¹)	8.85	7.08	15.93
D.....	.00065	5.17	15.52	37.50	58.19
E.....	.00006	3.34	5.01	(¹)	8.35
G.....	.00007	4.04	3.27	1.40	8.71
H.....	.00110	14.22	28.44	21.88	64.54
I.....	.00032	1.91	1.91	1.91	5.73
J North.....	.00109	22.77	42.28	26.02	91.07
J South.....	.00053	8.96	17.40	5.80	32.16
L.....	.00007	.35	.91	.97	2.23
K.....	.00015	8.06	14.17	32.67	54.90
Total.....	-	97.59	149.09	229.76	476.44

¹No reserves.

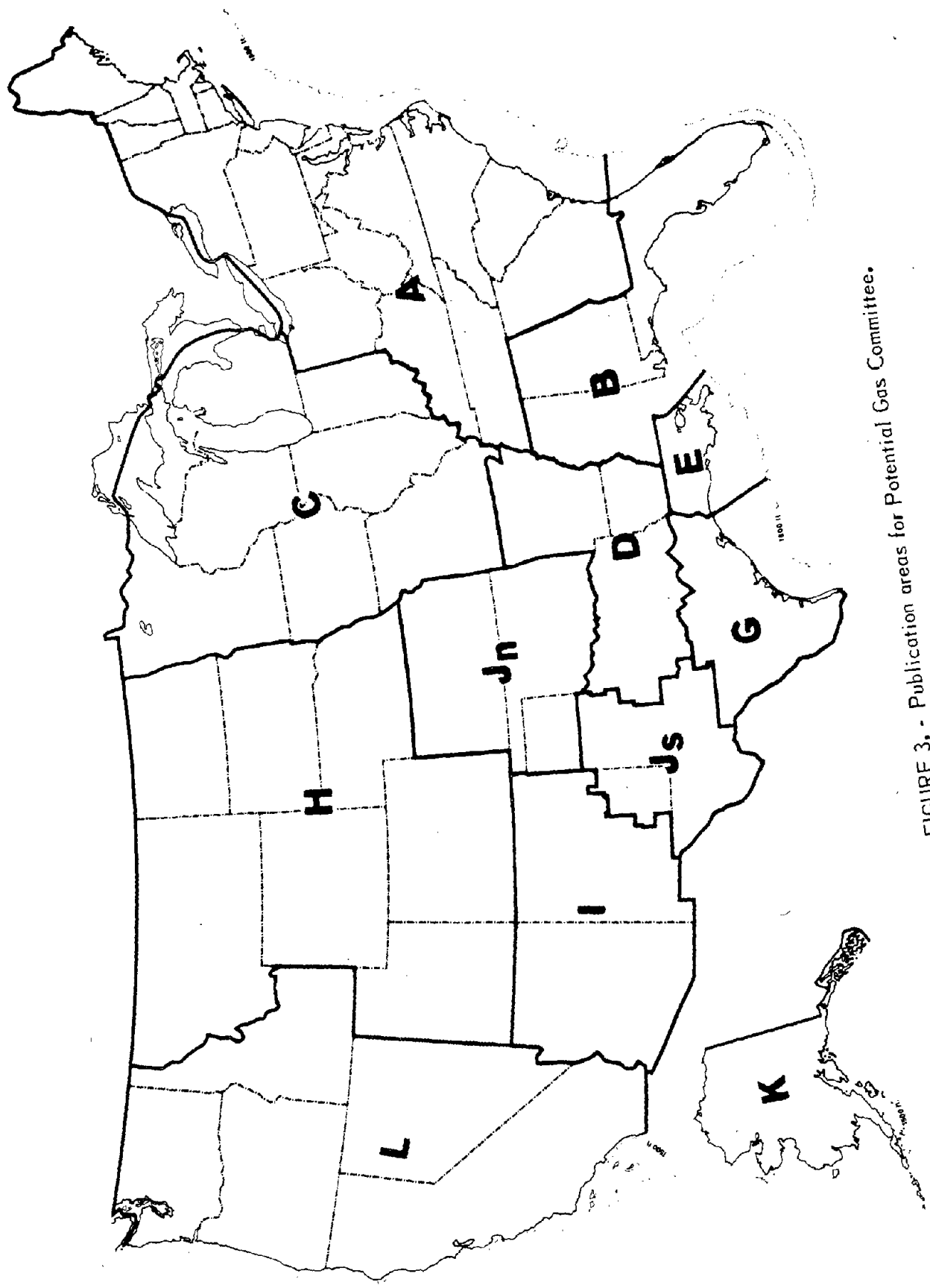


FIGURE 3. - Publication areas for Potential Gas Committee.

DISSIPATION OF HELIUM RESOURCES

The Future Requirements Committee (FRC), sponsored by the Future Requirements Agency, has reported the results of a national biennial survey of gas requirements since 1964; the latest report in this series is entitled "Future Gas Consumption of the United States."⁵ The purpose of these reports is to establish a system that will provide a generally accepted, continuing long-range analysis of natural gas requirements. The committee is similar in organization and structure to the PGC. Regional work committees survey companies within their area to determine their forecasts of future gas demand. The FRC natural gas consumption forecasts are shown in table 6.

TABLE 6. - FRC estimates of future gas consumption in the United States

(Volumes in trillion cubic feet at 14.73 psia and 60° F)

Year	Gas consumption ¹
1973.....	24.8
1974.....	25.0
1975.....	25.2
1976.....	25.5
1977.....	26.1
1978.....	26.4
1979.....	26.8
1980.....	27.1

¹Volumes are based on natural gas having a heating value of 1,000 Btu per cubic foot.

To forecast available helium in natural gas produced for market, the average helium content for each area was applied to annual consumption estimates from table 6. Since FRC forecasts of demand estimates extended only through 1980, these demand estimates were extrapolated through the assumed depletion of the natural gas reserves that were estimated by the PGC. The extrapolated data were used to forecast available helium after 1980. These forecasts were made by PGC designated areas, and the results were compiled for all of the areas in the United States. This compilation is shown in figure 4 and table 6.

⁵Future Requirements Committee. Future Gas Consumption of the United States. Future Requirements Agency, Denver Res. Inst., University of Denver, v. 5, November 1973, 80 pp.

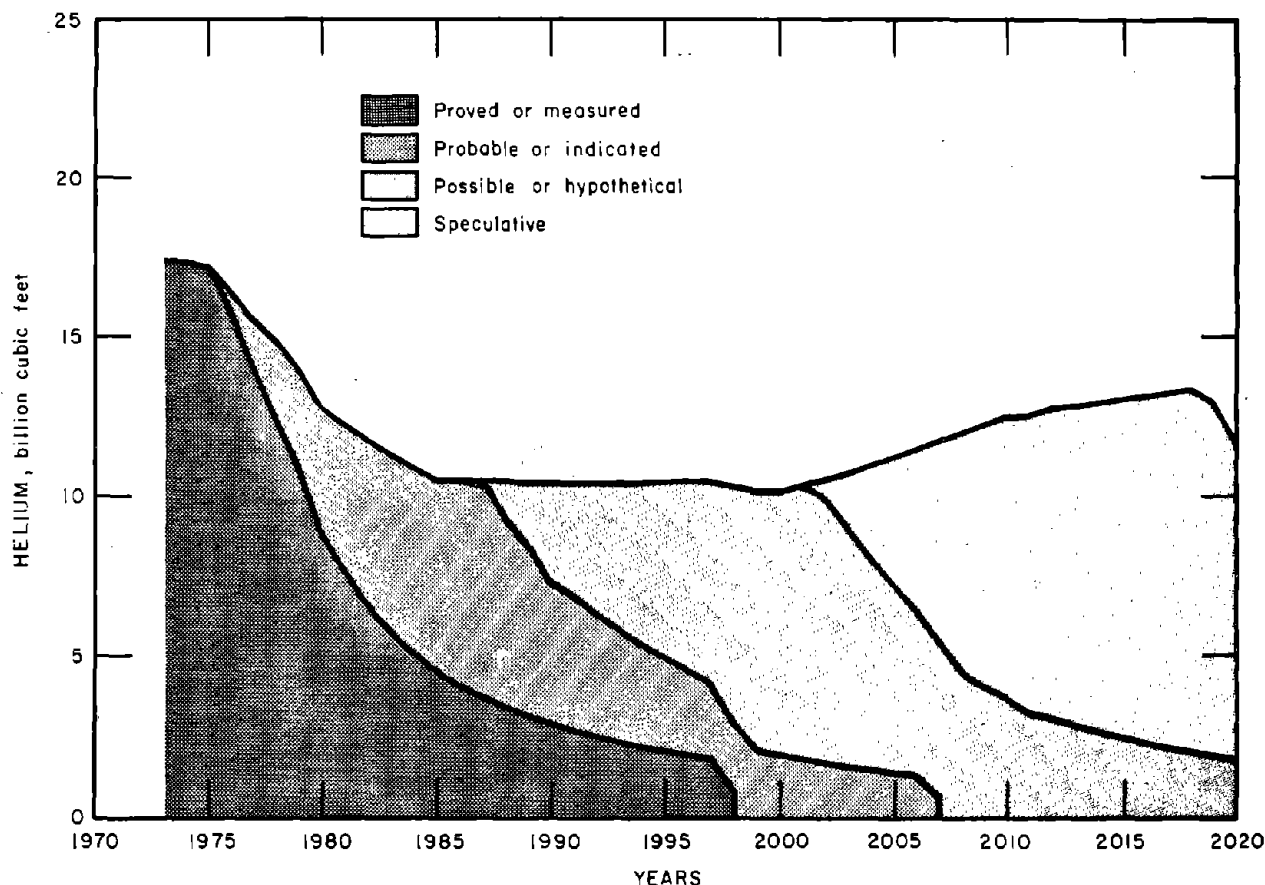


FIGURE 4. - Estimated helium in natural gas production from all resources in the United States.

Table 7 estimates the total helium contained in future U.S. natural gas production assuming that the natural gas resources estimated to exist by the PGC will all be discovered and that they will be discovered at the rate necessary to fulfill the demand, exclusive of imports and synthetic gas. Such forecasts must be qualified by several factors since discovery rates depend on many variables and cannot be predicted with a very high degree of certainty. Also, part of the total demand for natural gas will be filled by imports and by synthetic natural gas, and the volume imported depends on many changing conditions and is subject to great uncertainty. Finally, much of the natural gas demand over the period covered may go unfulfilled if the economic and other incentives do not materialize to encourage industry exploratory work to search for and find new gas reserves.

TABLE 7. - Total helium estimated to be contained in future natural gas production in the United States

(Volumes in billion cubic feet at 14.73 psia and 60° F)

Year	Helium	Year	Helium
1973.....	17.41	1997.....	10.58
1974.....	17.38	1998.....	10.34
1975.....	17.18	1999.....	10.19
1976.....	16.48	2000.....	10.27
1977.....	15.53	2001.....	10.38
1978.....	14.87	2002.....	10.58
1979.....	14.01	2003.....	10.78
1980.....	12.80	2004.....	10.95
1981.....	12.24	2005.....	11.18
1982.....	11.75	2006.....	11.43
1983.....	11.27	2007.....	11.66
1984.....	10.89	2008.....	11.98
1985.....	10.52	2009.....	12.22
1986.....	10.48	2010.....	12.39
1987.....	10.43	2011.....	12.52
1988.....	10.46	2012.....	12.67
1989.....	10.41	2013.....	12.81
1990.....	10.45	2014.....	12.94
1991.....	10.41	2015.....	13.08
1992.....	10.43	2016.....	13.25
1993.....	10.44	2017.....	13.34
1994.....	10.47	2018.....	13.47
1995.....	10.50	2019.....	12.98
1996.....	10.58	2020.....	11.72

CONCLUDING STATEMENT

In conclusion, it appears that relatively large volumes of helium will be available from natural gas through 2020. This helium, however, will likely be in leaner concentrations than the gas being processed for helium today. Helium extraction plants will have to process larger quantities of gas, and will probably be located on gas transmission systems which bring together, at one point, large volumes of natural gas.

The Bureau of Mines had over 31 billion cubic feet of helium in storage at the beginning of 1973. In addition to the stored helium, there are about 4 billion cubic feet of helium in the native gas in the Cliffside storage field owned by the Bureau. This helium, plus the helium now being extracted from the Keyes field in Oklahoma by the Bureau under a life-of-the-field contract, will serve to fulfill the Bureau's mission of supplying helium to meet all essential Government needs for many years beyond 2000.

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APPENDIX A.--GLOSSARY OF RESOURCE TERMS¹

Resource.--A concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible. (A)

Reserve.--That portion of the identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination. The term ore is also used for reserves of some minerals. (A)

Identified resources.--A collective term for the sum of materials in both measured and indicated resources. (A)

Measured.--Material for which estimates of the quality and quantity have been computed, within a margin of error of less than 20 percent, from analyses and measurements from closely spaced and geologically well-known sample sites. (A)

Proved reserves.--May be both drilled and undrilled. Undrilled reserves are located so close to the drilled reserves that every reasonable probability exists that they will be producible when drilled. Proved reserves are recoverable under existing economic and operating conditions. (B).

Indicated.--Material for which estimates of the quality and quantity have been computed partly from sample analyses and measurements and partly from reasonable geologic projections. (A)

Probable reserves.--The most assured of new supplies results from the growth of existing fields. (B)

Undiscovered resources.--Unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geologic knowledge and theory. (A)

Potential supply.--This is the prospective quantity of gas yet to be found or to be added to existing fields exclusive of proved reserves. (B)

Hypothetical resources.--Undiscovered materials that may reasonably be expected to exist in a known mining district under known geologic conditions. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as a reserve or identified-subeconomic resource. (A)

Possible reserves.--Less assured is the supply from new field discoveries in formations previously productive; such new fields would be distinctly separated from existing fields. (B)

Speculative resources.--Undiscovered materials that may occur either in known types of deposits in a favorable geologic setting where no discoveries

¹See end of appendix for key to sources A, B, and C.

have been made, or in as yet unknown types of deposits that remain to be recognized. Exploration that confirms their existence and reveals quantity and quality that will permit their reclassification as reserves or identified-subeconomic resources. (A)

Speculative reserves.--The most nebulous of new supplies is attributable to new pool or new field discoveries in formations or provinces not previously productive. (B)

Economic resources.--Those resources, both identified and undiscovered, that are estimated to be economically recoverable. (C)

Subeconomic resources.--Identified and undiscovered resources that are not presently recoverable because of technological and economic factors but which may be recoverable in the future. (C)

Key to Sources

A--Taken from the April 15, 1974, news release of the Department of the Interior entitled "New Mineral Resource Terminology Adopted."

B--Potential Gas Committee. Potential Supply of Natural Gas in the United States (as of December 31, 1972). Potential Gas Agency, Miner. Res. Inst., Colo. School Mines Foundation, Inc., November 1973, 47 pp.

C--Recoverable Oil and Gas Resources in the United States, by B. M. Miller, H. L. Thomsen, G. L. Dolton, A. B. Coury, T. A. Hendricks, F. E. Lennartz, R. B. Powers, E. G. Sable, and K. L. Varnes. (U.S. Geol. Survey Circ. 725, 1975, 78 pp.; free on application to the U.S. Geological Survey, National Center, Reston, Va. 22092.)

