

Information Circular 8803

Helium Resources of the United States, 1977

By B. J. Moore



UNITED STATES DEPARTMENT OF THE INTERIOR
Cecil D. Andrus, Secretary

BUREAU OF MINES
Lindsay D. Norman, Acting Director

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

This publication has been cataloged as follows:

Moore, Billy J

Helium resources of the United States, 1977 / by B. J. Moore. [Washington] : U.S. Dept. of the Interior, Bureau of Mines, 1979.

25 p. : diags. ; 27 cm. (Information circular - Bureau of Mines ; 8803)

Bibliography: p. 22-23.

I. Helium. I. United States. Bureau of Mines. II. Title. III. Series: United States. Bureau of Mines. Information circular - Bureau of Mines ; 8803.

TN23.U71 no. 8803 622.06173

U.S. Dept. of the Int., Office of Library and Information Services

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Washington, D.C. 20402

Stock No. 024-004-01751-4/Catalog No. I28.27 :8803

REPORT DOCUMENTATION PAGE	1. REPORT NO. BuMines IC 8803	2.	3. Recipient's Accession No. PB 80-101744	
4. Title and Subtitle Helium Resources of the United States, 1977			5. Report Date 1979	
7. Author(s) B. J. Moore			6.	
9. Performing Organization Name and Address U.S. Bureau of Mines, Helium Operations Box H 4372, Herring Plaza Amarillo, Texas 79101			8. Performing Organization Rept. No.	
12. Sponsoring Organization Name and Address Office of Associate Director--Mineral and Materials Research and Development Division of Helium Washington, DC 20241			10. Project/Task/Work Unit No.	
15. Supplementary Notes			11. Contract(C) or Grant(G) No. (C) (G)	
16. Abstract (Limit: 200 words) This Bureau of Mines publication estimates that U.S. helium resources as of January 1977 were 710 billion cubic feet. These resources are broken down into four classifications, as follows: Helium in measured natural gas resources and in storage, 201 billion cubic feet; helium in indicated natural gas resources, 150 billion cubic feet; helium in hypothetical natural gas resources, 175 billion cubic feet; and helium in speculative natural gas resources, 184 billion cubic feet. Most of the helium in natural gas is presently dissipated when natural gas is consumed as fuel and for other purposes. Helium resources of the United States may also be divided into three other categories: (1) Depleting and undiscovered natural gas resources, 589 billion cubic feet; (2) nondepleting natural gas, 83 billion cubic feet; and (3) storage, 38 billion cubic feet, of which 37 billion cubic feet is federally owned and 1 billion cubic feet is privately owned. The United States does not have any significant leasehold rights in the depleting fuel gas resources. However, through the Department of the Interior, it does have leasehold rights to about 70 percent of the helium found in nondepleting natural gas, and it owns over 90 percent of the helium in storage.			13. Type of Report & Period Covered Information Circular	
17. Document Analysis a. Descriptors b. Identifiers/Open-Ended Terms c. COSATI Field/Group			14.	
18. Availability Statement Available from NTIS		19. Security Class (This Report)	21. No. of Pages 31	
		20. Security Class (This Page)	22. Price A03-A01	



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HELIUM RESOURCES OF THE UNITED STATES, 1977

by

B. J. Moore¹

ABSTRACT

This Bureau of Mines publication estimates that U.S. helium resources as of January 1977 were 710 billion cubic feet. These resources are broken down into four classifications, as follows: Helium in measured natural gas resources and in storage, 201 billion cubic feet; helium in indicated natural gas resources, 150 billion cubic feet; helium in hypothetical natural gas resources, 175 billion cubic feet; and helium in speculative natural gas resources, 184 billion cubic feet.² Most of the helium in natural gas is presently dissipated as natural gas is consumed as fuel and for other purposes.

Helium resources of the United States may also be divided into three other categories: (1) Depleting and undiscovered natural gas resources, 589 billion cubic feet; (2) nondepleting natural gas, 83 billion cubic feet; and (3) storage, 38 billion cubic feet, of which 37 billion cubic feet is federally owned and 1 billion cubic feet is privately owned. The United States does not have any significant leasehold rights in the depleting fuel gas resources. However, through the Department of the Interior, it does have leasehold rights to about 70 percent of the helium found in nondepleting natural gas, and it owns over 90 percent of the helium in storage.

INTRODUCTION

This Bureau of Mines publication is the second that reports on the helium resources of the United States. The first reported helium resources as of January 1, 1973,³ while this current publication reports resources as of January 1, 1977. Estimates of the helium resources of the Nation have been made for the past 25 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 helium resources is done (1) to insure a continuing supply of helium to fill essential Federal needs, (2) to provide information to the Secretary of the Interior so as to properly manage

¹Chief, Section of Helium Resources Evaluation, Branch of Helium Resources, Helium Operations, Bureau of Mines, Amarillo, Tex.

²See appendix for definition of terms.

³Moore, B. J. Helium Resources of the United States, 1973. BuMines IC 8708, 1976, 17 pp.

the helium resources reserved to the United States on Federal land, and (3) to provide the public with information on a limited natural resource that is being wasted. The Mineral Leasing Act of 1920 reserves all helium found under the terms of Federal oil and gas leases to the United States, and the responsibility of insuring a supply of helium to meet essential Federal needs was assigned to the Secretary of the Interior by the Helium Act of March 3, 1925. The latest legislation on helium is the Helium Act Amendments of 1960.

This report contains estimates of helium in the indicated category of resources in nondepleting gasfields, whereas the previous report included only helium in storage, helium in fuel gas, and helium in the measured reserves of nondepleting fields with at least 0.3 percent helium. These indicated nondepleting helium resources total 56.0 billion cubic feet. A large percentage of the helium resources found in nondepleting natural gas is found on Federal lands, and leases on these lands reserve helium ownership to the United States. Thus, even though production in the period from January 1, 1973, to January 1, 1977, has depleted some of the helium resources, the total reported in this publication of 710 billion cubic feet is greater than the 694 billion cubic feet reported in the previous publication.

The helium resources are reported in four categories: (1) Helium in measured natural gas reserves and in storage, (2) helium in indicated natural gas resources, (3) helium in hypothetical natural gas resources, and (4) helium in speculative natural gas resources. Helium in storage is the helium stored by the Department of the Interior in the Cliffside storage field near Amarillo, Tex. Included with the helium in measured natural gas reserves is that helium in natural gas having a minimum helium content of 0.3 percent. Helium in indicated, hypothetical, and speculative natural gas resources includes helium expected to be found as a result of extensions to known existing fields and helium in as yet undiscovered natural gas resources as estimated by the Potential Gas Committee (PGC).

The helium percentage of 0.3 mentioned above has no particular significance today. In earlier years, this so-called helium-rich gas was the only gas of concern to the helium resources evaluation program. Now, because of the wider scope of the present helium resource survey and because gases containing less helium can be economically processed, the terms "0.3 percent helium" and "helium-rich gas" are no longer appropriate. Helium recovery cost is a function of many other variables, such as average daily rate of gas processed, hydrocarbon recovery, life of the reserves, total helium reserves, and the helium content.

HELIUM RESOURCES

The helium resources of the United States, as defined for the purposes of this report, are those that occur as a constituent of natural gas and those that have been previously separated from natural gas and stored for future use. The natural gas in which the helium is found may be normal fuel gas or naturally occurring gas of low heating value. Figure 1 shows the estimated helium resources of the United States in these various classifications. Based on past experience, helium appears to be a minor constituent of all natural gas.

IDENTIFIED		UNDISCOVERED	
MEASURED INCLUDING STORED HELIUM (PROVED)	INDICATED (PROBABLE)	HYPOTHETICAL (POSSIBLE)	SPECULATIVE (SPECULATIVE)
201	150	175	184
TOTAL		RESOURCES	
		710	

← INCREASING DEGREE OF GEOLOGICAL ASSURANCE →

FIGURE 1. - Helium resources of the United States as of January 1, 1977, by category of resource. (Volumes in billions of cubic feet at 14.73 psia and 60° F; industry terminology in parentheses.)

In the Bureau of Mines files of gas analyses, some older analyses of gas samples show no helium present, but it is believed that with the more precise analytical equipment available today, some helium would have been detected. All samples of recent years have contained at least traces of helium. The helium resources shown in figure 1 are contained in both identified and undiscovered natural gas resources. The undiscovered gas resources were estimated to exist in a study made by the PGC, but whether they will be discovered or whether it will be economical to extract helium from them will depend on many factors. 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.

The resource terms or classifications used throughout this report and shown on figure 1 are defined in the appendix. These terms are somewhat different than terms used by the PGC and other segments of the gas industry. However, the two systems of terminology can be compared, and the corresponding industry terms are shown in parentheses in the figure.

To estimate the volume of helium contained in the natural gas resources of the United States, it is necessary to have some method of obtaining the helium content of these resources. Helium contents used in this report were derived from the Bureau's records of helium analyses of natural gases. The analysis of natural gas and the evaluation of helium resources were begun in 1917. Over 15,000 analyses of natural gas samples from wells and pipelines in the United States have been made. Through 1976, 11,317 of these analyses had been published in 20 Bureau of Mines publications, which are listed in the bibliography 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 in the Oklahoma and Texas Panhandles and in southwest Kansas, 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 extract crude helium for sale to the Government. The helium was delivered into a Government-owned pipeline which connected all plants with the Cliffside helium storage field near Amarillo, Tex. Further information concerning the Government's helium purchases can be found in the first report in this series.⁴

Helium in storage as of January 1, 1977, totaled 38.3 billion cubic feet. Of this, 36.9 billion cubic feet was accepted by the Government from the conservation plants under contract or court order or was produced by Government-owned helium extraction plants and was excess to Federal market demands. The other 1.4 billion cubic feet is stored by the Government for private companies under separate contracts. 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 207 billion cubic feet of natural gas with a helium content of about 1.86 percent. Minor amounts of natural gas are now being produced from the field to facilitate storage and plant operations. 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 three groups by helium content. These helium content groupings are as follows: 0 to 0.1 percent, 0.1 to 0.3 percent, and 0.3 percent or more.

⁴Work cited in footnote 3.

Helium in Natural Gas Containing 0.3 Percent or More Helium

As of January 1, 1977, it was estimated that there was 96.7 billion cubic feet of helium contained in the measured natural gas reserves having at least 0.3 percent helium in the United States. These reserves were located in 78 fields in 10 States (table 1).

TABLE 1. - Helium reserves of the United States
in natural gas reserves containing
0.3 percent or more helium,
by State

(Million cubic feet at 14.73 psia and 60° F)

<u>State</u>	<u>Helium</u>
Arizona.....	824
Colorado.....	1,023
Kansas.....	45,407
Montana.....	471
New Mexico.....	630
Oklahoma.....	11,502
Texas.....	26,327
Utah.....	4,131
West Virginia.....	117
Wyoming.....	6,313
Total.....	96,745

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. These estimates were confined to the helium contained in the major fields with gas having at least 0.3 percent helium in the Oklahoma and Texas Panhandles and in southwest Kansas. Fields included in these estimates were Hugoton, which extends 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 currently contain about 80 percent, or 76.4 billion cubic feet, of the helium found in gas having at least 0.3 percent helium. The natural gas from all these fields except Cliffside is being produced for fuel, and the helium that is not extracted is lost with the flue gas as the natural gas is burned.

In 1961 the Bureau initiated a program to estimate the helium reserves of all fields from which samples containing more than 0.3 percent helium had been analyzed in connection with the gas-sampling program. Data on these smaller fields have been collected from all known available sources over the 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, which 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 in estimated natural gas reserves containing 0.3 percent or more helium

(Million cubic feet at 14.73 psia and 60° F)

Year	Helium contained in natural gas having at least 0.3 percent helium	Helium in storage	AGA estimates of natural gas reserves ¹
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
1974.....	113,470	37,426	249,950,207
1975.....	108,358	37,501	237,132,497
1976.....	101,152	37,760	228,200,176
1977.....	96,745	38,261	216,026,074

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 the loss of over 8 billion cubic feet of helium per year prior to the implementation of the crude helium purchases in late 1962. The purchases of helium extracted under the contracts saved an average of about 3.5 billion cubic feet per year of this once wasted helium from 1963 through November 12, 1973, when acceptance of helium from the conservation plants ceased. It is estimated that in 1976 about 1.3 billion cubic feet of helium was extracted and used or stored in Cliffside field. This helium was processed by both Government and private plants. About 6.1 billion cubic feet of helium in gas containing at least 0.3 percent helium was lost to the atmosphere as the gas was used for fuel.

In addition to the fields now being depleted of their helium reserves because of production of natural gas for fuel, at least 34 fields with gas having at least 0.3 percent helium are not now being produced. These are classified as nondepleting helium reserves. The 34 known fields in this category contain an estimated 49.6 billion cubic feet of helium. 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, however, the helium is in natural gas that has low heating value and thus is 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 nondepleting category.

It is estimated that about 15.7 billion cubic feet of measured helium is contained in these nondepleting fields. Of this 15.7 billion cubic feet, about 12.9 billion cubic feet is estimated to be contained in gasfields on Federal lands. The Government retains title to all helium under Federal lands; therefore, title to this helium is held by the Government, even though the oil and gas rights may be leased. These nondepleting reserves on Federal lands 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 Natural Gas Containing 0.1 to 0.3 Percent Helium

Prior to 1974, no efforts had been made to estimate the helium contained in natural gas of less than 0.3 percent helium content on an individual field basis. The technology and economics of multiple operations now available make it potentially feasible to process lower-helium-content gas for helium, so a program is now underway to evaluate the helium resources in fields containing gas with at least 0.1 percent helium. This program is undertaken on an area-by-area basis, and eventually the entire United States will be evaluated. As of January 1, 1977, evaluation of the helium in fields with gases having helium contents of 0.1 to 0.3 percent had been completed in Colorado, Montana, Utah, and Wyoming. Work is in progress to evaluate these resources in Oklahoma, Kansas, Nebraska, North Dakota, and South Dakota.

The resources contained in gases with helium contents of 0.1 to 0.3 percent in those States for which evaluations have been completed follow:

<u>State</u>	<u>Million cubic feet</u>
Colorado.....	109
Montana.....	345
Utah.....	34
Wyoming.....	19,157
<u>Total.....</u>	<u>19,645</u>

¹At 14.73 psia and 60° F.

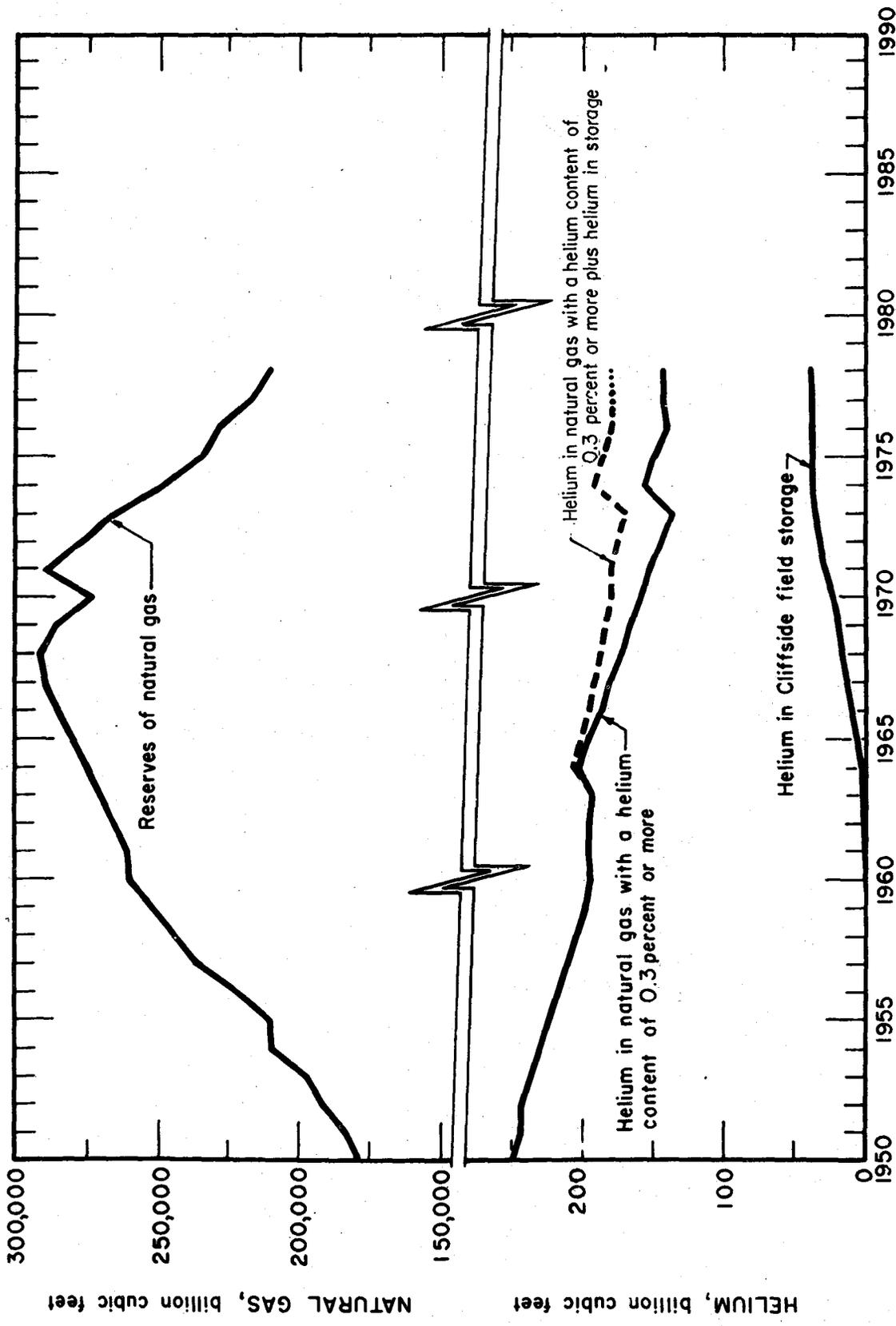


FIGURE 2. - Helium in natural gas containing 0.3 percent or more helium, helium in storage, and reserves of natural gas of the United States.

Helium resources in gases with helium contents of 0.1 to 0.3 percent located in other States are estimated by using the helium contents of those same fields from which we have gas samples in conjunction with those gases having 0.09 percent helium or less to find an average helium content of a State or a subdivision of a State. By using an average helium content and applying that content to the estimated gas reserves of an area, less those natural gas reserves contained in the fields having at least 0.3 percent helium, an estimate of the helium contained in gases having 0.29 percent helium or less can be made.

The AGA has compiled estimates of the natural gas reserves of the United States each year since 1945. The estimate for December 31, 1976,⁵ 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 measured reserve of gas having less than 0.3 percent helium. The AGA yearly reserve estimates and helium reserve estimates are given in table 2, and trends are depicted on figure 2.

Measured natural gas reserves of the United States were estimated by AGA to be 216,026 billion cubic feet as of December 31, 1976. This estimate was made by combining estimates of gas reserves of several geographic divisions within the country. Table 3 shows the gas reserve estimate for each geographical area as published by the AGA.

Gas analysis data from the helium analysis files were used to estimate an average helium content for the gases having less than 0.3 percent helium in 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 gas with a lower helium content. In areas where helium reserves in natural gas having at least 0.3 percent helium are located, the natural gas containing that helium was subtracted before the helium content was applied; in Colorado, Montana, Utah, and Wyoming, where helium resources in gases having helium contents of 0.1 to 0.3 percent have been evaluated on an individual field basis, the gas reserve estimates and helium contents were similarly adjusted. Total helium volume contained in measured reserves of natural gas with less than 0.3 percent helium is estimated to be 66.1 billion cubic feet. A breakdown by geographical regions is given in table 3.

⁵American Gas Association, Committee on Natural Gas Reserves. Report of Natural Gas Reserves of the United States. Apr 17, 1977, 8 pp.

TABLE 3. - American Gas Association natural gas proved¹ reserve estimates as of December 31, 1976, with applicable helium content fraction and helium in gas having less than 0.3 percent helium

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

Area	Natural gas reserves	Helium content fraction	Helium contained in natural gas having less than 0.3 percent helium
Alabama.....	707,153	0.00048	141
Alaska.....	31,929,552	.00015	4,790
Arkansas.....	1,728,271	.00088	1,486
California.....	5,342,031	.00005	268
Colorado.....	1,887,785	.00180	² 3,739
Florida.....	257,502	.00030	78
Illinois.....	376,876	.00122	459
Indiana.....	45,401	.00221	57
Kansas.....	11,950,564	.00466	² 3,399
Kentucky.....	771,544	.00135	992
Louisiana:			
North.....	2,508,892	.00040	853
South.....	54,992,864	.00004	2,200
Michigan.....	1,598,146	.00170	1,726
Mississippi.....	1,061,314	.00049	520
Montana.....	1,106,270	.00161	² 4,642
Nebraska.....	59,158	.00260	52
New Mexico:			
Northwest.....	7,995,389	.00026	² 2,075
Southeast.....	3,921,228	.00030	1,177
New York.....	236,029	.00073	213
North Dakota.....	405,944	.00060	195
Ohio.....	1,350,581	.00134	2,012
Oklahoma.....	12,435,333	.00165	² 8,874
Pennsylvania.....	1,651,898	.00073	1,305
Texas:			
District 1.....	1,164,851	.00034	303
District 2.....	6,295,697	.00004	252
District 3.....	14,191,629	.00004	568
District 4.....	13,315,253	.00004	533
District 5.....	819,266	.00029	246
District 6.....	4,334,567	.00027	1,084
District 7B.....	748,947	.00180	1,071
District 7C.....	2,053,997	.00153	2,075
District 8.....	10,879,589	.00030	4,227
District 8A.....	1,324,061	.00076	900
District 9.....	1,216,469	.00213	1,302
District 10.....	8,307,084	.00411	² 4,065
Utah.....	829,862	.00119	² 5,416
Virginia.....	56,393	.00073	56
West Virginia.....	2,273,273	.00073	² 1,796
Wyoming.....	3,704,383	.00049	² 6,994
Miscellaneous ⁷	191,028	NA	NA
Total.....	216,026,074	NAp	66,141

NA Not available. NAp Not applicable.

¹ See appendix for definition.

² Natural gas reserves containing gases with helium contents of at least 0.3 percent subtracted from total natural gas reserves before average helium content applied.

³ Helium resources of 109 MMcf in gases with helium contents of 0.1 to 0.3 percent evaluated separately but included in total.

⁴ Helium resources of 345 MMcf in gases with helium contents of 0.1 to 0.3 percent evaluated separately but included in total.

⁵ Helium resources of 34 MMcf in gases with helium contents of 0.1 to 0.3 percent evaluated separately but included in total.

⁶ Helium resources of 12,470 MMcf in gases with helium contents of 0.1 to 0.3 percent evaluated separately but included in total.

⁷ Includes reserves of Arizona, Iowa, Maryland, Minnesota, Missouri, South Dakota, Tennessee, and Washington.

Helium in Potential Resources of Natural Gas

The United States is estimated to have large resources of natural gas that are as yet undiscovered, according to the PGC.⁶ These undiscovered natural gas resources were estimated to total 948 trillion cubic feet as of December 31, 1976.⁷

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 the 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 figure 1. This is a seeming contradiction to the PGC's treatment of that class of reserves; however, it appears to be the best placement. A Geological Survey report discusses the PGC estimates,⁸ stating (p. 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 the category brackets the boundary between the known and the unknown." For this report and the previous Bureau study, the PGC "probable" category will be compared to the "indicated" group under "identified" resources, and PGC's "possible" and "speculative" will compare with "hypothetical" and "speculative" 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

⁶The PGC is sponsored by the Potential Gas Agency, Mineral Resources Institute, Colorado School of Mines, and is made up of representatives from the oil- and gas-producing industry, gas transmission industry, Government and academic community. The Committee made its initial report on future natural gas supply in 1967, although a predecessor committee, the Future Gas Supply Committee, produced a report in 1964.

⁷Potential Gas Committee. Potential Supply of Natural Gas in the United States (as of December 31, 1976). Potential Gas Agency, Colorado School of Mines, 1977, 45 pp.

⁸Theobald, P. K., S. P. Schweinforth, and D. C. Duncan. Energy Resources of the United States. U.S. Geol. Survey Cir. 650, 1972, 27 pp.

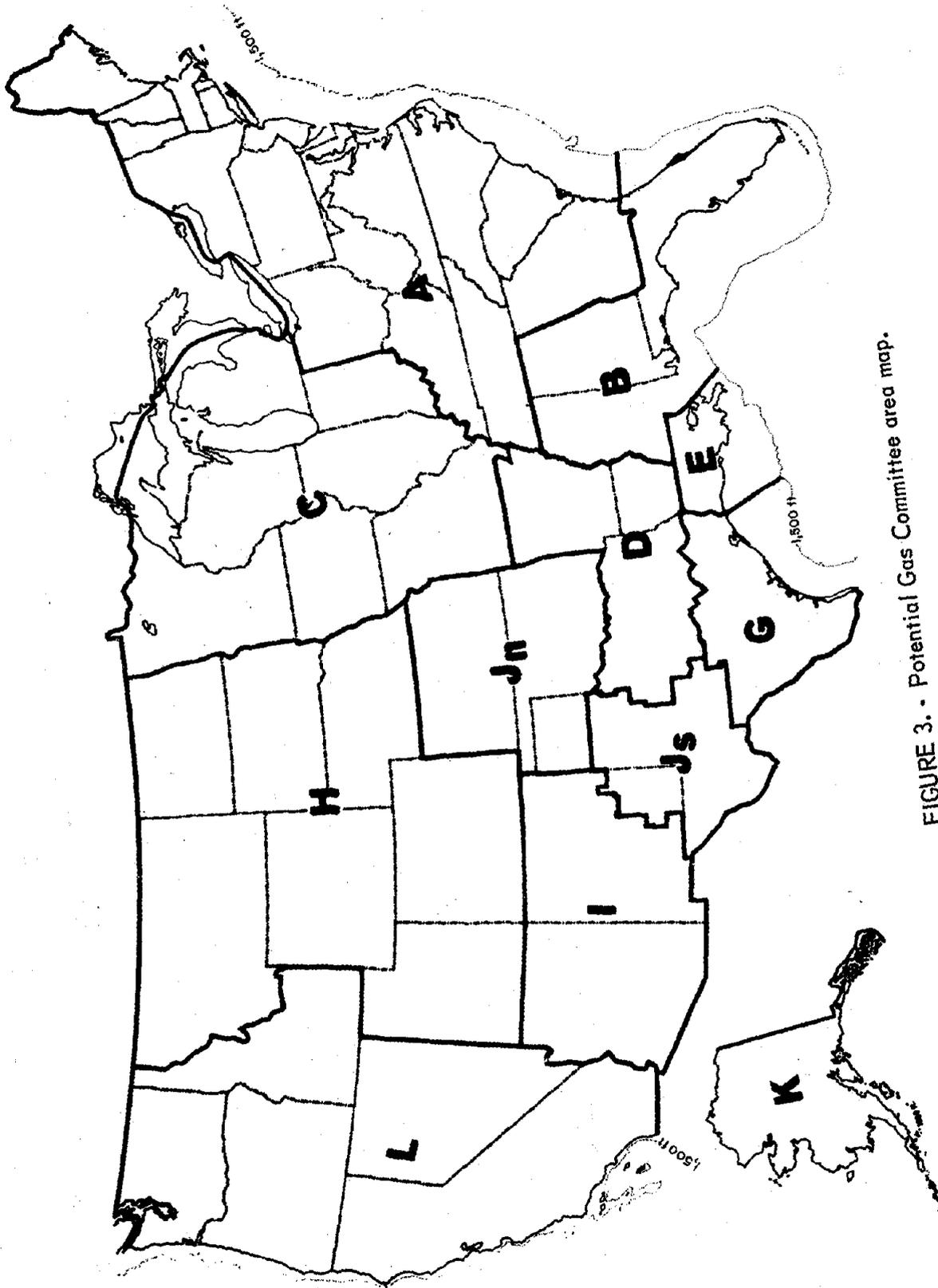


FIGURE 3. - Potential Gas Committee area map.

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 resources is estimated to be 453 billion cubic feet. In addition to this helium in the potential fuel gas resources, the Bureau of Mines estimates that there are 56 billion cubic feet of helium in indicated resources of known fields containing nondepleting gas. These resources are classified as nondepleting. This, then, brings the total helium resources in the indicated, hypothetical, and speculative categories to 509 billion cubic feet.

Average helium contents used for the various PGC regions ranged from 0.004 to 0.162 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 these 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 J north, which includes the Texas Panhandle, Oklahoma, and Kansas. This area contains about 84 billion cubic feet of the helium in proved or measured gas reserves having at least 0.3 percent helium. Since it is not deemed likely that gasfields with more than 0.3 percent helium 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 natural gas streams having 0.29 percent or less that were leaving area J north was used for the potential of undiscovered gas resources.

TABLE 4. - Potential Gas Committee estimate of potential supply of natural gas in the United States as of December 31, 1976, by geographical area

(Trillion cubic feet at 14.73 psia and 60° F)

Area	Probable	Possible	Speculative	Total
A.....	25	9	68	102
B.....	5	6	40	51
C.....	<1	4	2	6
D.....	8	21	25	54
E.....	49	69	<1	118
G.....	39	50	4	93
H.....	15	31	18	64
I.....	2	3	2	7
J north.....	27	72	8-58	¹ 132
J south.....	18	37	1	56
K.....	23	45	157	225
L.....	4	16	20	40
Total.....	215	363	¹ 370	948

¹ Speculative figures are averaged for area J north.

TABLE 5. - Estimated helium in potential supplies of natural gas as of December 31, 1976, by Potential Gas Committee area

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

Area	Helium content fraction	Indicated helium in probable gas	Hypothetical helium in possible gas	Speculative helium in speculative gas	Total helium
A.....	0.00094	23.46	8.41	63.95	95.82
B.....	00046	2.29	2.75	18.39	23.43
C.....	00162	.39	6.44	3.22	10.05
D.....	00069	5.49	14.48	17.23	37.20
E.....	00004	1.96	2.76	.04	4.76
G.....	00005	1.95	2.51	.20	4.66
H.....	00104	¹ 64.02	32.27	18.72	115.01
I.....	00026	² 8.16	.78	.52	9.46
J north.....	00111	29.92	79.92	36.65	146.49
J south.....	00047	8.46	17.39	.47	26.32
K.....	00015	3.45	6.74	23.56	33.75
L.....	00005	.20	.81	1.00	2.01
Total.....	Nap	149.75	175.26	183.95	508.96

Nap Not applicable.

¹ Includes 48.12 Bcf helium in nondepleting resources.

² Includes 7.63 Bcf helium in nondepleting resources.

NATURAL GAS DISCOVERY RATES

In connection with its work of estimating the natural gas reserves of the United States, the AGA publishes each year the volumes of gas added to the natural gas reserves. The additions to the reserves, since 1946 are shown in table 6. These additions were greater each year than the volume of gas produced until 1968, when this trend was reversed. This resulted in a decrease of the estimated reserves of natural gas in the United States in 1968 and each year thereafter, except in 1970, when the reserves on Alaska's North Slope were added.

The rate of discovery of natural gas is dependent upon many factors. Among these factors are the availability of drilling prospects, price of gas and oil, regulatory climate, economic climate, supply-demand situations, and economic incentives. If Alaskan reserves added in 1970 are excluded, discovery rates have dropped from an average of some 18 to 20 trillion cubic feet in 1955-67 to less than 10 trillion cubic feet in 1968-76.

TABLE 6. - Additions to the proved natural gas reserve of the United States as estimated by the American Gas Association

(Million cubic feet at 14.73 psia and 60° F)

Year	Additions	Year	Additions	Year	Additions
1946.....	17,632,864	1957.....	20,008,055	1968.....	13,697,008
1947.....	10,921,187	1958.....	18,896,718	1969.....	8,375,004
1948.....	13,823,090	1959.....	20,621,252	1970.....	¹ 37,196,359
1949.....	12,605,464	1960.....	13,893,979	1971.....	9,825,421
1950.....	11,984,290	1961.....	17,166,422	1972.....	9,634,563
1951.....	15,965,808	1962.....	19,483,959	1973.....	8,825,049
1952.....	14,267,602	1963.....	18,164,667	1974.....	8,679,184
1953.....	20,341,936	1964.....	20,252,138	1975.....	10,483,688
1954.....	9,547,070	1965.....	21,319,279	1976.....	7,555,468
1955.....	21,897,619	1966.....	20,220,432		
1956.....	24,716,114	1967.....	21,804,333		

¹Alaskan reserves added.

In figure 4, a plot of the cumulative additions from table 6 is shown. A least-squares fit of several segments of the plot was made, and the lines were extrapolated based on the segments for 1946-76, 1950-76, and 1970-76.

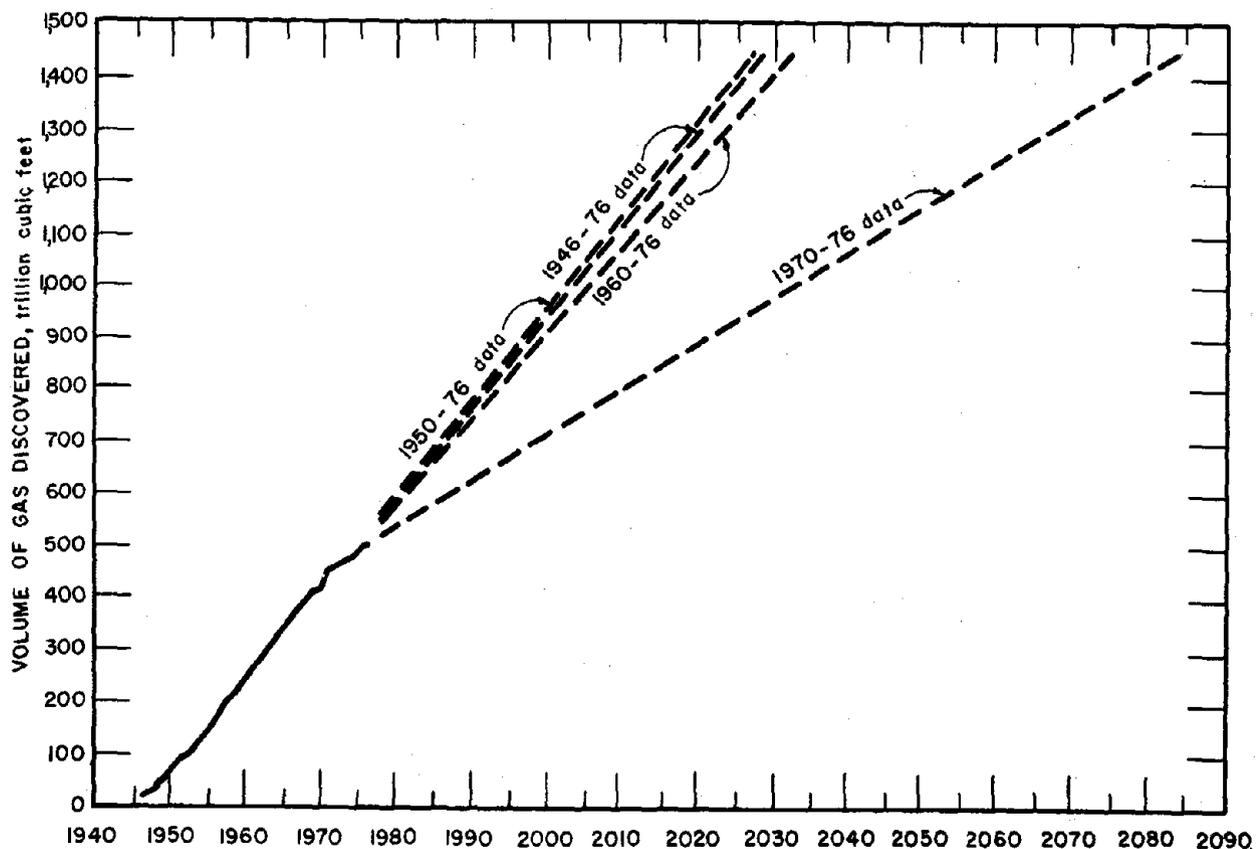


FIGURE 4. - Cumulative additions to American Gas Association's estimated reserves and extrapolation of segments of these additions.

Whereas, all four extrapolations are straight-line projections, in reality the discovery rate is likely to decline, as the limit of total resources is approached. For the period with which this report is concerned, the discovery rates appear reasonable, however.

The projections based on the first three segments are grouped very closely, with annual discoveries ranging from 16.4 to 17.7 trillion cubic feet. At these rates, the 948 trillion cubic feet of undiscovered natural gas resources estimated by the PGC will all be discovered by about 2030. The fourth projection, based on the additions to reserves for 1970-76, gives markedly different results. The additions depicted by this curve were about 8.8 trillion cubic feet per year, only about half the discovery rates for the other three periods. This rate of discovery would extend the time required to find all the natural gas resources to 2080.

With even the lowest of the four rates of discovery about 8.8 trillion cubic feet per year, it appears that the United States can produce the volumes of gas that are projected by methods explained under the next section on dissipation of helium resources. The natural gas reserves would be called upon to make up the difference in the discovery and production rates. This would continue the trend of reduction of the Nation's natural gas inventory that was started in 1968.

DISSIPATION OF HELIUM RESOURCES

The Gas Requirements Committee (GRC), formerly known as the future Requirements Committee (FRC), has reported the results of a national biennial survey of gas requirements since 1964; the latest report in this series is dated December 1975.⁹ 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,¹⁰ and regional work committees survey companies within their areas to determine their forecasts of future gas demand. The GRC natural gas consumption forecasts are shown in table 7.

⁹Gas Requirements Committee. Future Gas Consumption of the United States. Gas Requirements Agency, Denver Research Institute, University of Denver, v. 6, December 1975, 112 pp.

¹⁰See footnote 6.

TABLE 7. - Gas Requirements Committee estimates of future gas consumption in the United States

(Billion cubic feet at 14.73 psia and 60° F)

Year	Domestic natural gas ¹	Supplemental gas supplies	Total consumption
1976.....	20,879	475	21,354
1977.....	20,291	680	20,971
1978.....	19,701	1,198	20,899
1979.....	19,309	1,377	20,686
1980.....	18,950	1,638	20,588
1985.....	17,445	3,158	20,603

¹Volumes are based on natural gas having a heating value of 1,000 Btu per cubic foot. National average heating value of natural gas was 1,024 Btu per cubic foot in 1974.

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 7. Since GRC forecasts of demand estimates extended only through 1985, these demand estimates were extended to 2020 to obtain a usable forecast of future helium availability. The extension of the forecast for 1986 through 2020 was based on past production, shown in figure 5, the GRC

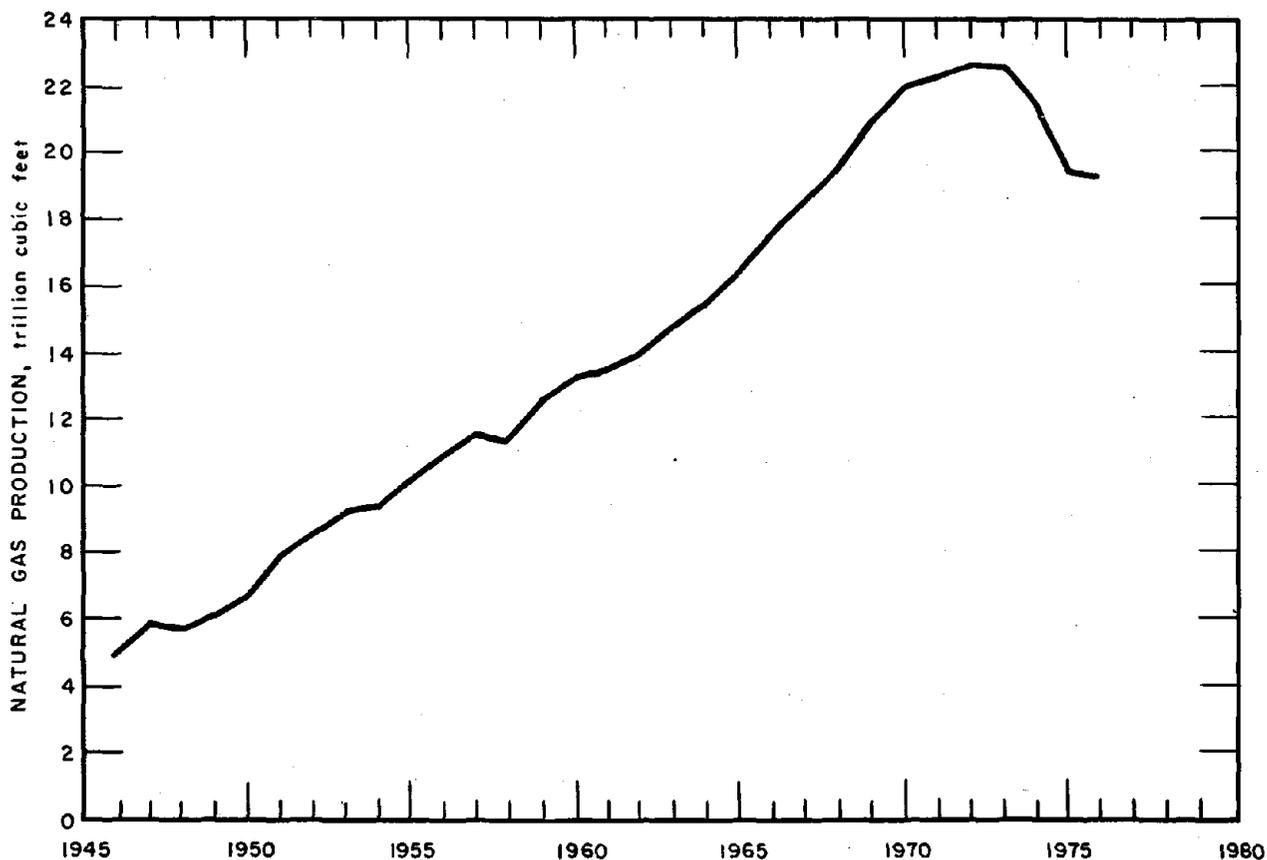


FIGURE 5. - American Gas Association annual gas production estimates.

prediction through 1985, the volume of proved reserves, and the undiscovered gas resources estimated by the PGC. Assumptions used in constructing the curve were (1) gas production through 1985 would be as forecasted by the GRC, (2) the total remaining natural gas resource base is 1,164 trillion cubic feet, (3) annual producing rates would be 7.5 to 10 trillion cubic feet by 2030, and (4) consumption from 1977 to 2030 would be approximately 720 trillion cubic feet. Using these criteria, a geometric series was constructed to simulate production (fig. 6). At the rate of depletion forecasted by using this curve with production studies of each of the PGC areas, the resources in the speculative category will not be needed by 2020 to supply the production. The forecasts of production of natural gas for all PGC areas were compiled for the total United States. These forecasted natural gas volumes and the helium expected to be produced with the gas are shown in table 8. The volumes of helium estimated to be contained in the natural gas production are shown in figure 7.

TABLE 8. Total natural gas and contained helium estimated to be produced in the United States

(Billion cubic feet at 14.73 psia and 60° F)

Year	Natural gas production	Contained helium	Year	Natural gas production	Contained helium
1977.....	19,502	15.17	2000.....	13,478	6.52
1978.....	19,302	15.01	2001.....	13,181	6.38
1979.....	19,002	14.78	2002.....	12,953	6.27
1980.....	18,667	13.95	2003.....	12,620	6.08
1981.....	18,306	13.16	2004.....	12,543	5.83
1982.....	18,042	11.53	2005.....	12,308	5.74
1983.....	17,719	10.76	2006.....	12,108	5.65
1984.....	17,496	10.13	2007.....	11,836	5.53
1985.....	17,138	9.50	2008.....	11,588	5.42
1986.....	17,019	9.03	2009.....	11,364	5.33
1987.....	16,815	8.61	2010.....	11,160	5.23
1988.....	16,509	8.36	2011.....	10,974	5.16
1989.....	16,287	8.15	2012.....	10,816	5.09
1990.....	15,936	7.90	2013.....	10,648	5.02
1991.....	15,647	7.69	2014.....	10,523	5.02
1992.....	15,410	7.51	2015.....	10,298	4.97
1993.....	15,119	7.33	2016.....	10,098	4.87
1994.....	14,968	7.20	2017.....	9,897	4.78
1995.....	14,632	7.05	2018.....	9,798	4.73
1996.....	14,354	6.90	2019.....	9,598	4.64
1997.....	14,132	6.82	2020.....	9,397	4.53
1998.....	14,091	6.73			
1999.....	13,661	6.61			

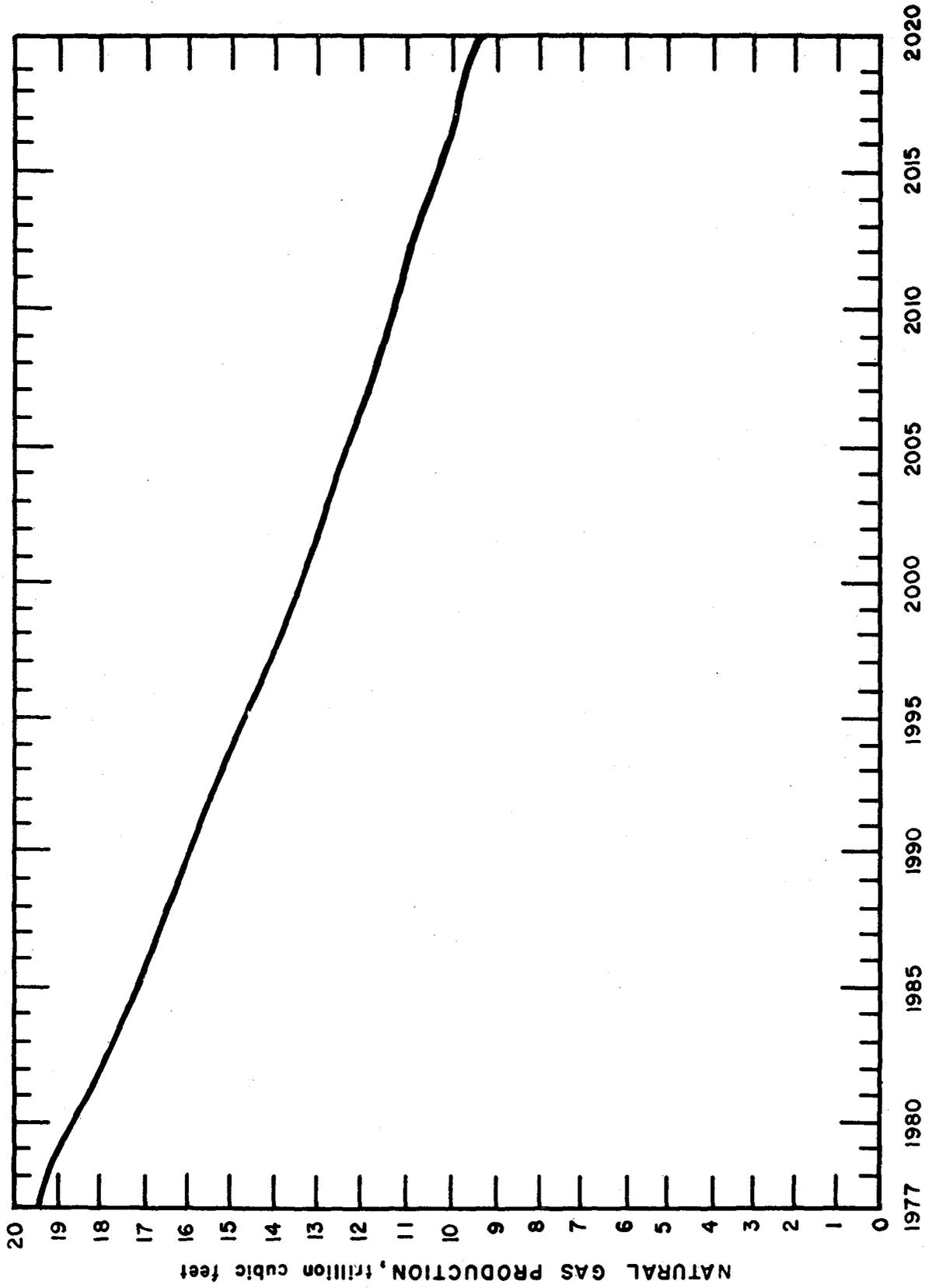


FIGURE 6. - Projected natural gas production in the United States.

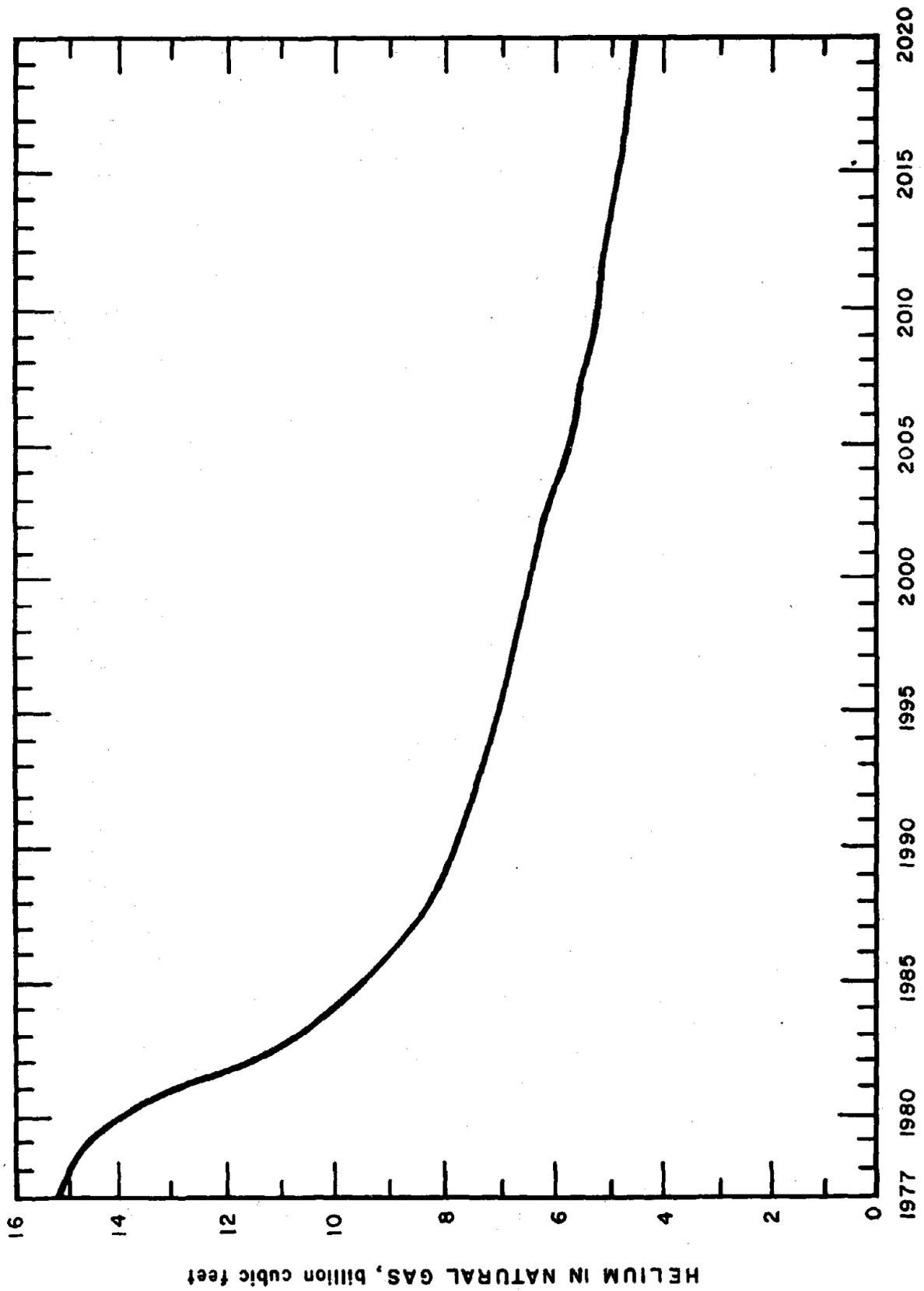


FIGURE 7. - Projected helium in natural gas production in the United States.

Some of the demand for natural gas as forecasted by the GRC is expected to be filled by imports, synthetic natural gas (SNG), or imported liquified natural gas (LNG). Allowance has been made in the forecasts for that eventuality. Again it must be emphasized that discovery rates and production rates depend on many variables. Unless proper conditions exist, much of the demand may go unfulfilled, and much of the potential gas resource may remain undiscovered.

CONCLUDING STATEMENT

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 occur in 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 large volumes of natural gas together at one point.

At the beginning of 1977, there was about 38.3 billion cubic feet of helium in storage in Cliffside field. Of this total, the Bureau of Mines owns 35.4 billion cubic feet. About 1.5 billion cubic feet was accepted under court order, and its ownership is being contested in the courts.

An additional 1.4 billion cubic feet belongs to private companies and is being stored under separate storage contracts. In addition to the stored helium, there is about 3.8 billion cubic feet of helium in the native gas in the Cliffside storage field which is also owned by the Bureau. This stored helium, the helium now being extracted from the Keyes field in Oklahoma by the Bureau under a life-of-the-field contract, and the helium on Federal lands in currently nondepleting fields 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.--GLOSSARY¹

Helium Resource.--All helium contained in natural gases and helium that has been extracted from natural gases and is being stored for future use.

Helium Reserve.--The portion of the identified helium resource that is in storage and the helium contained in the measured and indicated resources of gases containing at least 0.3 percent helium. These are the resources now being processed for helium or those most likely to be processed if helium demand is increased.

Helium in Storage.--The helium stored by the Federal Government in Cliffside field.

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

Measured*.--Helium in gas reserves for which estimates have been made with a margin of error of less than 20 percent.

Measured resources are comparable to those reserves termed "proved" by the gas industry.

Indicated*.--Helium in gas resources associated with measured reserves for which estimates have been made by using reasonable engineering and geologic projections.

Indicated resources are comparable to those resources termed "probable" by the gas industry.

Undiscovered Resources.--Unspecified deposits of helium surmised to exist on the basis of broad geologic knowledge and theory.

Hypothetical Resources*.--Undiscovered helium that may reasonably be expected to exist in a known gas-producing area under known geologic conditions. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as an identified resource.

Hypothetical resources are comparable to those resources termed "possible" by the gas industry.

Speculative Resources*.--Undiscovered helium deposits that may occur either in known types of deposits in a favorable geologic setting where no discoveries 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 will permit their reclassification.

Speculative resources are comparable to those resources also termed as speculative by the gas industry.

¹Asterisk (*) beside a term indicates that there is a comparable gas industry term; these terms are explained at the end of the entry.

Depleting Natural Gas Resource.--A natural gas deposit that is being depleted by production for use as fuel or other purposes.

Nondepleting Natural Gas Resource.--A natural gas deposit that is not being produced because of the low heating value of the gas, lack of market, or some other reason.

