HELIUM

By Joseph B. Peterson

Grade-A helium (99.995% or better) sales volume in the United States by private industry and the U.S. Bureau of Mines (USBM) was 75.4 million cubic meters [2,719 million cubic feet (MMcf)] in 1994.[1] Grade-A helium exports by private producers were 25.0 million cubic meters (901 MMcf) for total sales of 100.4 million cubic meters (3,619 MMcf) of U.S. helium. The USBM price for Grade-A helium, f.o.b. plant, was $1.983 per cubic meter [$55 per thousand cubic feet (Mcf)], and bulk liquid helium was $2.524 per cubic meter ($70 per Mcf) on January 1, 1994, with additional costs for container services and rent. Private industry increased their helium prices last year, but they are lower than the USBM.

Legislation and Government Programs

The Federal Helium Program is designed to provide all Federal agencies with its current and estimated future helium needs to carry out other Government programs authorized and funded by Congress. The USBM major helium customers are the Department of Defense (DOD), the National Aeronautics and Space Administration (NASA), and the Department of Energy (DOE).

In accordance with the Vice President's National Performance Review (NPR), the Federal Helium Program is being re-engineered to run more efficiently. NPR suggestions to discontinue nonrevenue-producing functions and increase efficiencies of helium operations have been implemented into the operation of the Helium Program. In addition, implementation of other streamlining and revenue enhancing suggestions for Helium Field Operations is planned.

Several bills (i.e., Helium Privatization Act of 1995 and Helium Disposal Act of 1995) have been introduced in subcommittees of the 104th Congress. Most of the proposed legislation includes variations of the following points:

- Cease production and sales of Grade- A helium, leaving Federal customers to buy their helium from private industry;
- Dispose of all helium production, refining, and sales related assets;
- Sell crude from the helium reserve in an orderly manner;
- Continue operation of the helium storage system, which includes the storage fields and the pipeline system, for storage and distribution of both government-owned and privately owned crude helium;
- Continue federal land lease helium extraction contracts; and
- Cancel the helium debt.

Supporters of these activities are of the opinion that the original purpose of the Helium Act has been accomplished and that private industry is capable of supplying any anticipated helium demands from private and Federal customers.

Production

In 1994, 18 privately owned domestic helium plants were operated by 14 companies. Thirteen of the privately owned plants and the USBM plant extracted helium from natural gas. All extraction plants except one use cryogenic extraction processes. The volume of helium recovered from natural gas increased 12.7%, while sales increased about 5.1% in 1994. A shortage of private helium production was prevented by purifying crude helium that had been stored in the USBM's Cliffside Field. All natural gas processed for helium recovery came from gasfields in Colorado, Kansas, Oklahoma, Texas, Utah, and Wyoming. Eight private plants and the USBM plant purified helium this year. This includes a new plant startup in Moab, UT. Pressure-swing adsorption is used for helium purification at seven of the eight private helium plants and at the USBM plant. The USBM also uses cryogenic purification for backup. The USBM and seven private plants that produce Grade-A helium also liquefy helium. The plant operators and locations are Air Products and Chemicals Inc., Hansford County, TX, and Liberal, KS; Exxon Co., U.S.A., Shute Creek, WY; BOC Gases Inc., Otis, KS; Unocal, Moab, UT; and Praxair, Inc., Bushton and Ulysses, KS. Nitrotec's helium plants near Burlington and near Cheyenne Wells, CO, produce Grade-A helium but do not liquefy it. (*See tables 1, 2, and 3, and figures 1 and 2*.)

Domestic production data for helium are developed by the USBM from records of its own operations as well as the High Purity Helium Survey, a single, voluntary canvass of private U.S. operations. Of the seven operations to which a survey request was sent, 100% responded, and those data plus data from USBM operations represent 100% of the total helium sales and recovery shown in table 2.

Domestic measured and indicated helium resources as of January 1, 1994, (the latest figures available) are estimated to be 12.7 billion cubic meters [457 billion cubic feet (Bcf)]. The resources include measured reserves and indicated resources estimated at 6.7 billion cubic meters (241 Bcf) and 0.9 billion cubic meters (32 Bcf), respectively, in natural gas with a minimum helium content of 0.3%. A slight increase in the measured reserves of helium is reported due to ongoing evaluations of the Nation's depleting helium resources. The measured reserves included nearly 1 billion cubic meters (34 Bcf) stored by the USBM in the helium conservation storage system. Measured helium resources in natural gas with a helium content of less than 0.3% are estimated to be 1.2 billion cubic meters (44 Bcf). Indicated helium resources in natural gas with a helium content of less than 0.3% are estimated to be 3.8 billion cubic meters (137 Bcf). Approximately 4.4 billion cubic meters (157 Bcf) or 91% of the domestic helium resources under Federal ownership are in the Riley Ridge area and the Church Buttes Field in Wyoming and in the Cliffside Field in Texas.

Most of the domestic helium resources are in the midcontinent and Rocky Mountain regions of the United States. The measured helium reserves are in approximately 102 gasfields in 11 States. About 86% of these reserves is contained in the Hugoton Field in Kansas, Oklahoma, and Texas; the Keyes Field in Oklahoma; the Panhandle and Cliffside Fields in Texas; and the Riley Ridge area in Wyoming. The USBM analyzed a total of 148 natural gas samples from 16 States during 1994 in conjunction with its program to survey and identify possible new sources of helium.

Consumption and Uses

The major domestic end uses of helium were cryogenics, welding, and pressurizing and purging. Minor uses included synthetic breathing mixtures, chromatography, leak detection, lifting gas, heat transfer, and controlled atmospheres. (*See figure 3*.) The Pacific and Gulf Coast States were the principal areas of helium consumption.

The USBM sales to Federal agencies and their contractors totaled 6.61 million cubic meters (238 MMcf) in 1994, a decrease of 16.6% when compared with the prior year's sales. This decrease was due largely to slowdowns in DOD programs and budget restraints imposed on all Federal agencies by Congress.

The Federal agencies purchase its major helium requirements from the USBM. Direct helium purchases by DOD, NASA, DOE, and the National Weather Service constituted most of the USBM Grade-A helium sales. Most remaining helium sales to Federal agencies were made through USBM contract distributors, who purchased equivalent volumes of USBM helium under contracts described in the Code of Federal Regulations (30 CFR 602). Some of the contract distributors also have General Services Administration helium supply contracts. These contracts make relatively small volumes of helium readily available to Federal installations at lower freight charges by using the contractors' existing distribution systems.

Estimated 1994 domestic consumption by end use was based on a 1991 domestic end-use survey conducted to determine the trends in helium usage. The information from that survey showed that welding, pressure/purging, lifting gas, leak detection, and inert atmosphere applications were the leading usages of gaseous helium. Magnetic resonance imaging applications dominated liquid helium usage. (*See figure 3.*)

Stocks

The volume of helium stored in the USBM helium conservation storage system, including the conservation pipeline network and Cliffside Field, totaled 965 million cubic meters (34.8 Bcf) at yearend. The storage system contains crude helium purchased under contract by the USBM from 1962 to 1973 and privately owned helium stored under contract. Excess private helium is extracted from natural gas supplying fuel markets in the winter and stored by the USBM under contract. This privately owned crude helium is returned to the owners as needed for purification to supply private demand. During 1994, 38.8 million cubic meters (1,399 MMcf) of private helium was delivered to the USBM helium conservation storage system and 20 million cubic meters (724 MMcf) was withdrawn for a net increase of 18.8 million cubic meters (675 MMcf) of private helium in storage. (*See table 4.*)

Transportation

All Grade-A gaseous helium sold by the USBM was shipped in cylinders, modules (large gas cylinders), special railway tankcars, or highway tube semitrailers. Small gas cylinders were filled at the Amarillo plant, and railway tankcars are filled at the Exell plant. The USBM discontinued sale of Grade-A gaseous helium sales via cylinder on July 1, 1994. Other shipping containers for gaseous helium can be filled at either plant. The USBM liquid helium was shipped in dewars and semitrailers from the Exell plant. Private producers and/or distributors shipped helium predominantly as a liquid in semitrailers. These semitrailers delivered the liquid helium to distribution centers where some of it was gasified and compressed into trailers and small cylinders for delivery to the end user. The remaining liquid helium was sold as bulk liquid or repackaged in dewars of various sizes for delivery.

Prices

The USBM price for Grade-A helium, f.o.b. plant, was $1.983 per cubic meter ($55 per Mcf) and bulk liquid helium was $2.524 per cubic meter ($70 per Mcf) on January 1, 1994, with additional costs for container services and rent. Private industry increased helium prices last year, but lagged behind the USBM price.

Foreign Trade

Exports of Grade-A helium, all by private industry, decreased by 10.7% in 1994 to 25 million cubic meters (901 MMcf). (*See table 3.*) Since 1992, U.S. helium exports have decreased 22.8%. About 37% of the exported helium was shipped to Europe. Belgium, France, Germany, and the United Kingdom, collectively, received about 93% of the European exports. About 40% of the U.S. helium exports went to Asia, with Japan receiving about 90%. Other exports were as follows: about 9% to North America; about 3% to Australia-New Zealand; 3.3% to the Middle East; 5.7% to South America; 1.5% to Central America; about 1% to Africa; and the remainder to the Caribbean. The shipments of large volumes of helium to Western Europe were attributed to helium uses in cryogenic research and superconducting applications. Significant volumes also were used in breathing mixtures for diving, welding, and as a lifting gas. Although no helium was imported by the United States in 1994, import tariffs on helium remained at the 3.7% rate for most favored nations established on January 1, 1987. The non-most-favored-nation tariff also remained unchanged at 25%. No changes in import tariffs are scheduled at this time.

World Review

World production of helium, excluding the United States, was estimated to be 13 billion cubic meters (469 MMcf), most of which was extracted in Poland and Russia. The remainder was produced in small plants in China and India. (*See table 5.*)

Current Research and Technology

Technology that uses liquid helium to produce superconducting temperatures continues to be developed and utilized. Liquid helium continues to be used at Fermi National Accelerator Laboratory for Tevatron/Tevatron 1, which was the world's first superconducting particle accelerator. The liquid helium-cooled superconducting magnets used in this accelerator provide an intense and extremely steady magnetic field using only a fraction of the energy required by conventional electromagnets. The Tevatron is presently the second most energetic particle accelerator in the world (1.6 trillion electron volts).

Argonne National Laboratory is developing a marine magneto hydrodynamic propulsion system for military and commercial use. This system has no moving parts, but uses magnetic fields and electricity to pump water through a tube. Researchers at Argonne used the world's largest liquid-helium-cooled superconducting dipole magnet to study this propulsion system. Development of this technology could lead to a new generation of water transportation vessels that would travel more quickly, quietly, and efficiently than present ships.

Liquid helium use in magnetic resonance imaging (MRI) continues to increase as the medical profession accepts and develops new uses for this equipment. The MRI equipment is providing accurate diagnoses of medical problems where exploratory surgery was previously required. Another medical application being developed uses MRI to determine through blood analysis if a patient has any form of cancer. Most researchers seem to think it will be at least 4 to 8 years before uses of the new high-temperature (about -184° C or -300° F) superconducting materials affect liquid helium demand.

Lifting gas applications are increasing. The U.S. Navy and U.S. Air Force are investigating the use of airships to provide early warning systems to detect low-flying cruise missiles. The Drug Enforcement Administration has installed six tethered radar blimps along the southern border of the United States to detect drug smugglers. In addition, NASA is now using helium-filled balloons to sample the atmosphere in Antarctica to determine what is

depleting the ozone layer that protects the Earth from harmful ultraviolet radiation. In the commercial market, several companies in addition to Goodyear are now using "blimps" for advertising.

The development of Strategic Defense Initiative (SDI) weapons such as the antisatellite (ASAT) rocket, chemical laser, and rail gun has slowed with the decline of the "cold war." The ASAT rocket uses liquid helium-cooled infrared sensors for target location and guidance. Gaseous helium is used in the lasing gas mixture of the chemical laser, and liquid helium is used to cool the tracking telescope used to locate the target and aim the laser beam. High-pressure gaseous helium provides the initial push that inserts the projectile into the bore of the rail gun at a velocity of about 1,770 kilometers per hour (1,100 miles per hour). Electromagnetic energy applied along the bore accelerates the projectile to a final velocity of about 14,500 kilometers per hour (9,000 miles per hour). Superconducting magnetic energy storage (SMES) also is being investigated to provide power for DOD laser systems and electric power peak shaving in commercial applications. SMES allows the accumulation and storage of electrical energy over the long term (hours) when excess capacity is available and discharges it in minutes or as needed to provide for peak demands. Some small commercial units are already in service.

Other evolving technologies that require the unique properties of helium are (1) metastable helium for energy storage, which involves raising helium electrons to an excited energy state and then stabilizing the atom there; (2) fiber-optic production, where an ultrapure inert atmosphere is required; (3) helium-filled plastic pillows, where helium's low density is required to simulate a precursor wave from a nuclear blast; (4) helium ion tumor treatment, where large inert particles are required; (5) liquid helium-cooled superconducting microswitches, called Josephson junctions, which are much faster than conventional semiconductors and use less power; (6) "Aneutronic" nuclear fusion, where nuclear energy is produced by fusion of deuterium and helium-3, results in few or no neutrons; (7) helium-hydrogen breathing mixtures that enable deep-sea divers to reach depths below 580 meters (1,700 feet); and (8) an 11% oxygen-in-helium mixture is being used at NASA's Ames Research Center in its combustion-driven Shock Tunnel Facility. This facility is similar to a wind tunnel but provides the much higher pressures and velocities needed to test space plane models at Mach 16.

Outlook

Until recently, all superconductors required liquid helium (-269° C or -452° F) to reach superconducting temperatures. Current research on superconductors has resulted in the discovery of superconducting materials that operate above liquid nitrogen temperatures (-196° C or -320° F). These new superconductors have physical limitations, such as brittleness and poor current-carrying capacities, which have precluded their use in most superconducting applications. As these physical problems are solved, the new materials will replace liquid helium-cooled superconductors.

Since 1990, the market for U.S.-produced helium has grown at an average annual rate of 4.3%. Private industry's market has been growing at 6.2% per year, while the Federal market has dropped 41% since 1990. In 1994, private industry supplied about 91% of the domestic demand while the USBM supplied the remaining 9%. Private industry supplies all of the U.S. helium exports. The foreign market decreased in 1994, accounting for only 25% of U.S. helium sales. Helium exports have decreased 22.8% since 1992.

The outlook for helium is slowing in the Federal sector with cutbacks and elimination of programs that use large volumes of helium. High-temperature superconductors are beginning to be used in commercial applications. Continued decline in U.S. helium exports is expected due to startup of an Algerian production facility.

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[1]All metric helium volumes herein reported are at 101.325 kilopascals absolute (14.696 psia) and 15° C (59° F). Helium volumes, reported in parentheses following metric units, are measured in cubic feet at 14.7 psia and 70° F. One thousand cubic feet (1 Mcf) at 14.7 psia and 70° F = 27.737 cubic meters at 101.325 kilopascals absolute and 15° C. One cubic meter at 101.325 kilopascals and 15° C = 36.053 ft^3 at 14.7 psia and 70° F.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Helium. Ch. in Commodity Annual Report, annual.
Helium. Ch. in Minerals Commodity Summary, annual.
Information Circular 9129, Analyses of Natural Gases, 1917-85, by B. J. Moore and S. Sigler.
Information Circular 9301, Analyses of Natural Gases, 1986-90, by J. E. Hamak and S. Sigler.
Information Circular 9318, Analyses of Natural Gases, 1991, by J. E. Hamak and B. D. Gage.
Information Circular 9356, Analyses of Natural Gases, 1992, by J. E. Hamak and S. Sigler.
Information Circular 9342, Helium Resources of the United States, 1991, by J. E. Hamak and B. D. Gage.

TABLE 1
OWNERSHIP AND LOCATION OF HELIUM EXTRACTION PLANTS
IN THE UNITED STATES IN 1994

Category and owner or operator	Location	Product purity
Government-owned:		
U.S. Bureau of Mines	Masterson, TX	Grade-A helium 1/
Private industry:		
Air Products Helium, Inc.	Hansford County, TX	Do.
Do.	Liberal, KS	Do.
Enron Helium Co.	Bushton, KS	Crude helium
Exxon Co., U.S.A.	Shute Creek WY	Grade-A helium 1/
BOC Gases	Otis, KS	Do.
KN Energy, Inc.	Scott City, KS	Crude helium 2/
National Helium Corp.	Liberal, KS	Crude helium
Maxus Energy Corp.	Sunray, TX	Do.
Mesa, Inc.	Fain, TX	Do.
Do.	Satanta, KS	Do.
Nitrotec	Burlington, CO	Grade-A helium
Do.	Cheyenne Wells, CO	Do.
Trident NGL, Inc.	Ulysses, KS	Crude helium
Phillips Petroleum Co.	Dumas, TX	Do.
Do.	Hansford County, TX	Do.
Praxair, Inc.	Bushton, KS	Grade-A helium 1/
Do.	Elkhart, KS	Deactivated
Do.	Ulysses, KS	Grade-A helium 1/
Unocal	Moab, UT	Grade-A helium 1/

1/ Including liquefaction.
2/ Output is piped to Ulysses, KS, for purification.

TABLE 2
HELIUM RECOVERY IN THE UNITED STATES 1/ 2/

(Thousand cubic meters)

	1990	1991	1992	1993	1994
Crude helium:					
U.S. Bureau of Mines total storage	(12,800)	(9,550)	(9,360)	(8,850)	(7,200)
Private industry:					
Stored by U.S. Bureau of Mines	14,100	26,600	25,300	29,600	38,800
Withdrawn	(21,300)	(18,100)	(17,900)	(16,400)	(19,500)
Total private industry storage	(7,200)	8,500	7,400	13,200	19,300
Total crude helium	(20,000)	(1,050)	(1,960)	4,350	12,100
Stored private crude helium withdrawn from storage and purified by the U.S. Bureau of Mines for redelivery to industry	(178)	(613)	(510)	(638)	(610)
Grade-A helium:					
U.S. Bureau of Mines sold	11,200	9,400	8,630	7,930	6,610
Private industry sold	73,700	78,700	85,800	87,600	93,800
Total sold	84,900	88,100	94,400	95,500	100,000
Total stored	20,200	(1,660)	(2,470)	3,710	11,500
Grand total recovery	105,000	86,400	91,900	99,200	112,000

1/ Negative numbers are enclosed in parenthesis ( ) to denote net withdrawal from the USBM underground storage facility, a partially depleted natural gas reservoir in Cliffside Field near Amarillo, TX.
2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significate digits; may not add to totals shown.

TABLE 3
TOTAL SALES OF GRADE-A HELIUM PRODUCED
IN THE UNITED STATES

(Million cubic meters)

Year	Volume		
	Domestic sales	Exports 1/	Total sales
1990	60.1	24.7	84.8
1991	61.0	27.1	88.1
1992	63.7	30.7	94.4
1993	67.6	28.0	95.6
1994	75.4	25.0	100.4

1/ Source: Bureau of the Census.

TABLE 4
SUMMARY OF U.S. BUREAU OF MINES HELIUM CONSERVATION STORAGE SYSTEM OPERATIONS 1/ 2/

(Thousand cubic meters)

	1992	1993	1994
Helium in conservation storage system at beginning of period:			
Stored under U.S. Bureau of Mines conservation program	903,000	894,000	885,000
Stored for private producers under contract	49,200	56,100	68,700
Total	952,000	950,000	954,000
Input to system:			
Net deliveries from U.S. Bureau of Mines plants 3/	(9,360)	(8,850)	(7,200)
Stored for private producers under contract	25,300	29,600	38,800
Total	15,900	20,800	31,600
Redelivery of helium stored for private producers under contract 3/	18,400	17,000	20,000
Net addition to system 3/	(2,420)	3,780	11,500
Helium in conservation storage system at end of period:			
Stored under U.S. Bureau of Mines conservation program	894,000	885,000	878,000
Stored for private producers under contract	56,100	68,700	128,000
Total	950,000	954,000	1,010,000

1/ Crude helium is injected into or withdrawn from the USBM underground storage facility, a partially depleted natural gas reservoir in Cliffside Field near Amarillo, TX.
2/ Previously published and 1994 data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
3/ Numbers in parentheses indicate net withdrawal from storage.

TABLE 5
WORLD GRADE-A HELIUM PRODUCTION
CAPACITY, DECEMBER 31, 1994

(Million cubic meters)

	Capacity
United States 1/	114
Rest of world e/	13
Total e/	127

e/ Estimated.
1/ Includes capacity of plants on standby as well as operating plants.

Figure 1

HELIUM RECOVERY IN THE UNITED STATES

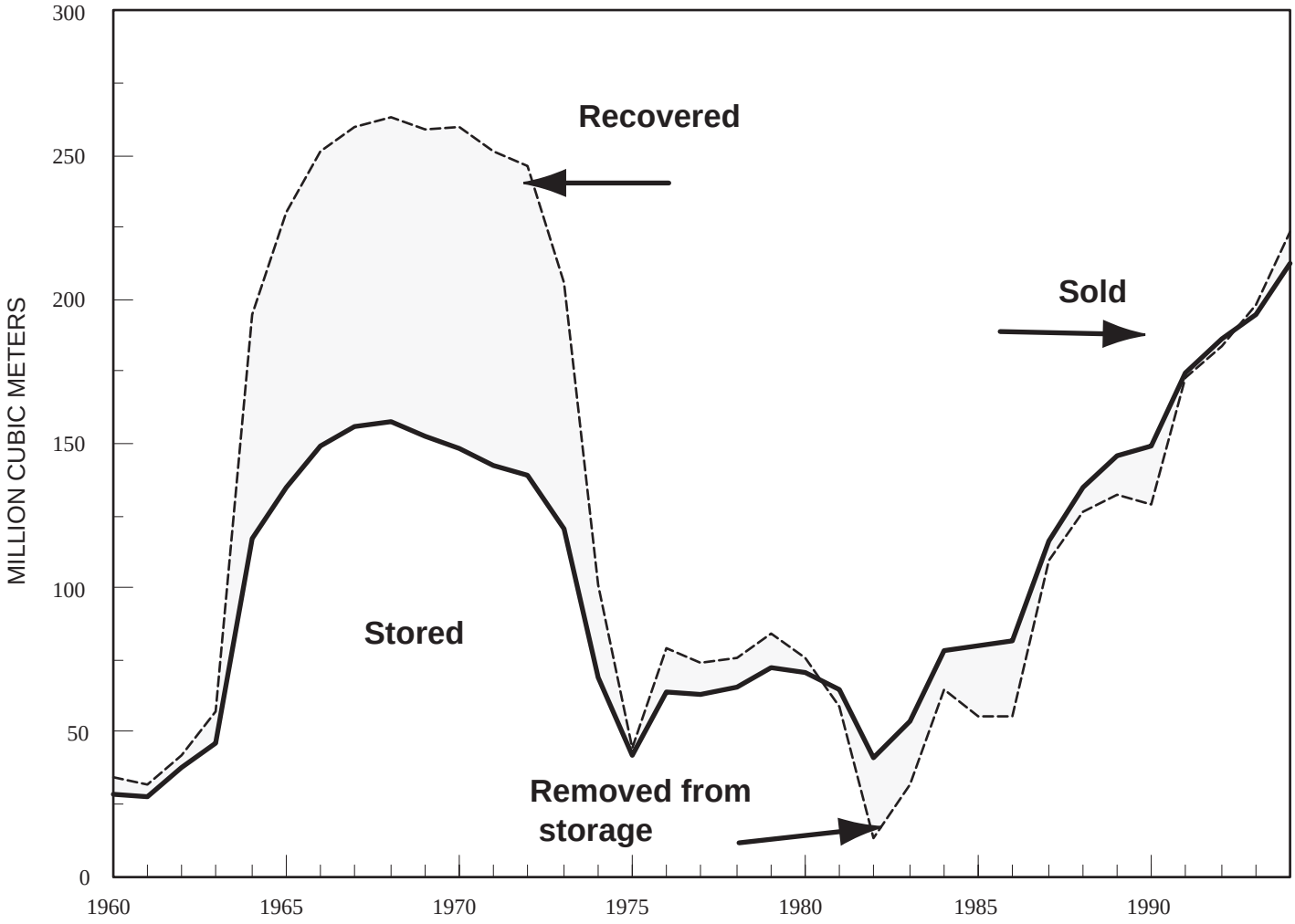


FIGURE 2

MAJOR U.S. HELIUM-BEARING NATURAL GAS FIELDS

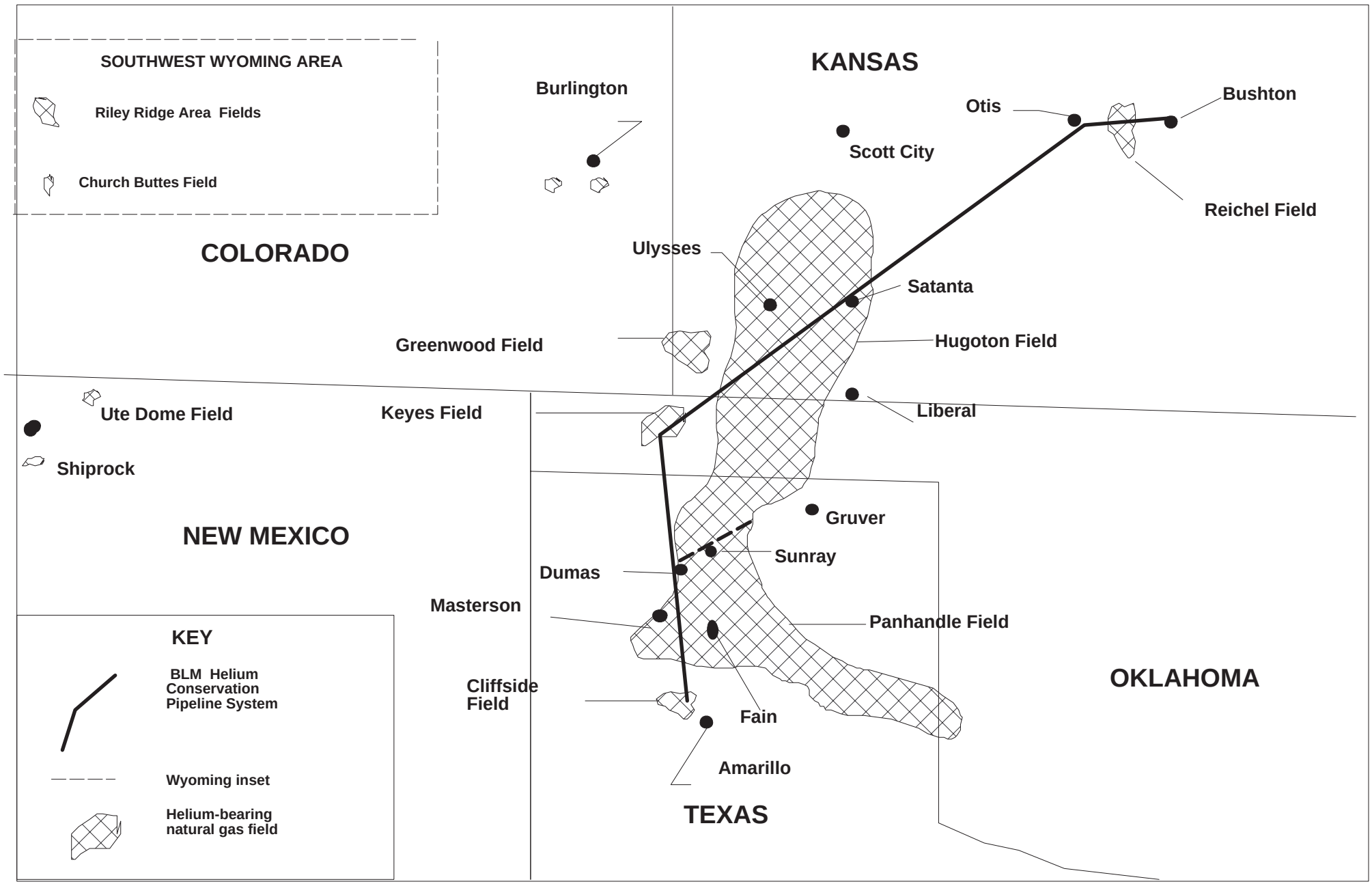
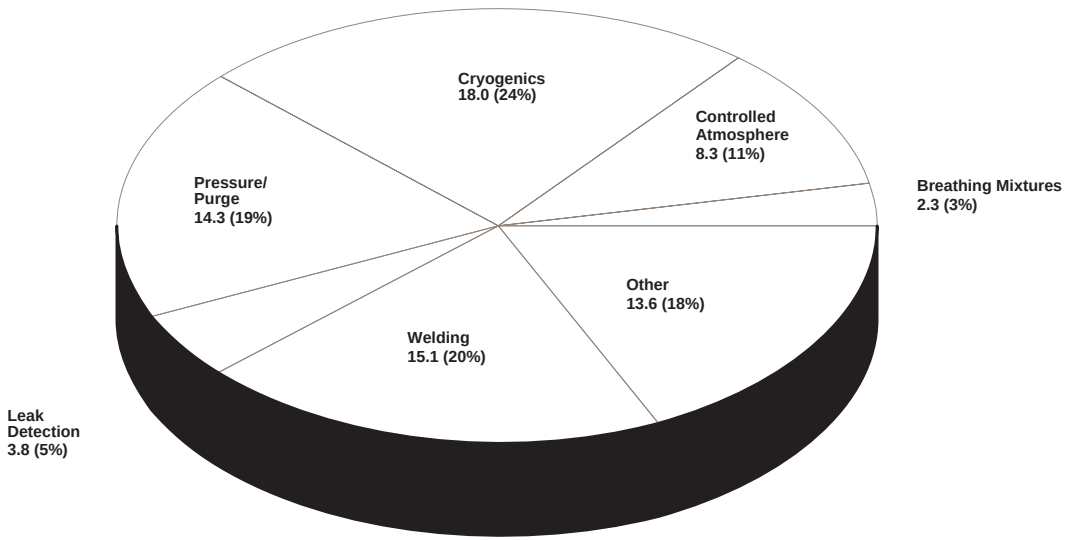


FIGURE 3

ESTIMATED HELIUM CONSUMPTION, BY END USE, IN THE UNITED STATES IN 1994

(Million cubic meters)



Estimated total helium used
(75.4 million cubic meters)