HELIUM

By Joseph B. Peterson[1]

Grade-A helium (99.995% or better) sales volume in the United States by private industry and the Bureau of Land Management (BLM) was 71.9 million cubic meters (2,592 million cubic feet) in 1996.[2] Grade-A helium exports by private producers were 22.8 million cubic meters (822 million cubic feet) for total sales of 94.6 million cubic meters (3,411 million cubic feet) of U.S. helium, about 1.5% less than that in 1995. The BLM price for Grade-A helium, f.o.b. plant, was $1.983 per cubic meter ($55 per thousand cubic feet), and bulk liquid helium was $2.524 per cubic meter ($70 per thousand cubic feet) on January 1, 1996, with additional costs for container services and rent.

Legislation and Government Programs

The Federal Helium Program was established to provide all Federal agencies with current and estimated future helium needs to carry out Government programs authorized and funded by Congress. The BLM's major helium customers were the Department of Defense (DOD), the National Aeronautics and Space Administration (NASA), and the Department of Energy (DOE).

In March 1996, Helium Operations was transferred to the BLM from the U.S. Bureau of Mines, which was closed in January 1996.

On October 9, 1996, the President signed the Helium Privatization Act of 1996 (Public Law 104-273). This legislation directs Helium Operations to discontinue production and sale of refined helium by April 9, 1998. Key components of the legislation are as follows:

- Cease production and sales of Grade-A helium not later than April 9, 1998, requiring Federal customers to purchase helium from private industry;
- Dispose of all helium production, refining, and sales-related assets not later than 24 months after helium refinery closing;
- Sell Federal reserves of crude helium in excess of 600 million cubic feet on or before January 1, 2005, and continuing to January 1, 2015. As of December 31, 1996, approximately 30 billion cubic feet of crude helium are to be sold;
- Continue operation of the helium storage system that includes the storage field and pipeline system for storage and distribution of both Government and privately owned crude helium; and
- Continue collection of helium royalty and fee sales for helium extracted from Federal lands.

While the legislation provides a maximum 18-month timeline to discontinue production and sales operations, the determining factor shall be the Federal demand for refined helium. If helium sales decrease significantly (i.e., NASA finds an alternate source for helium), then production would cease prior to April 9, 1998.

Production

In 1996, 20 privately owned domestic helium plants were operated by 14 companies. Thirteen of the privately owned plants and the BLM plant extracted helium from natural gas. All extraction plants except two use cryogenic extraction processes. The volume of helium recovered from natural gas increased 2% over that of last year, while total sales of U.S.-produced helium decreased 1.5% in 1996 from those of the previous year. All natural gas processed for helium recovery came from gasfields in Colorado, Kansas, Oklahoma, Texas, Utah, and Wyoming. Eleven private plants and the BLM plant purified helium this year. Pressure-swing adsorption is used for helium purification at 9 of the 11 private helium plants and at the BLM plant. The BLM also used cryogenic purification for backup. The BLM and eight private plants that produce Grade-A helium also liquefy helium. The plant operators and locations are Air Products Helium Inc., Hansford County, TX, and Liberal, KS; BOC Gases Inc., Otis, KS; Exxon Co., U.S.A., Shute Creek, WY; CIG Co., Keyes, OK, and Lakin, KS; Praxair, Inc., Bushton and Ulysses, KS; and Unocal, Moab, UT. Nitrotec's helium plants near Burlington, CO, 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 were developed by the BLM 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 BLM operations represent 100% of the total helium sales and recovery shown in table 2.

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[2]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 = 27.737 cubic meters at 101.325 kilopascals absolute and 15° C. One cubic meter at 101.325 kilopascals nad 15° C = 36.053 cubic feet at 14.7 psia and 70° F.

Domestic measured and indicated helium resources as of January 1, 1994, (the latest figures available) are estimated to be 13 billion cubic meters (469 billion cubic feet). The resources include measured reserves and indicated resources estimated at 6.7 billion cubic meters (241 billion cubic feet) and 0.9 billion cubic meters (32 billion cubic feet), respectively, in natural gas with a minimum helium content of 0.3%. The measured reserves included nearly 1 billion cubic meters (34 billion cubic feet) stored by the BLM 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 1.3 billion cubic meters (46 billion cubic feet). Indicated helium resources in natural gas with a helium content of less than 0.3% are estimated to be 3.9 billion cubic meters (140 billion cubic feet). Approximately 4.4 billion cubic meters (157 billion cubic feet) 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 BLM analyzed a total of 70 natural gas samples from 13 States during 1996 in conjunction with its program to survey and identify possible new sources of helium.

Consumption

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 BLM sales to Federal agencies and their contractors totaled 6.07 million cubic meters (219 million cubic feet) in 1996. Direct helium purchases by DOD, NASA, and DOE constituted most of the BLM Grade-A helium sales. Most remaining helium sales to Federal agencies were made through BLM contract distributors, who purchased equivalent volumes of BLM 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 1996 domestic consumption by end use was based on a 1995 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 continue to be 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 BLM helium conservation storage system, including the conservation pipeline network and Cliffside Field, totaled 970 million cubic meters (35.0 billion cubic feet) at yearend. The storage system contains crude helium purchased under contract by the BLM from 1962 to 1973 and privately owned helium stored under contract. Excess private helium is extracted from natural gas supplying fuel markets and stored by the BLM under contract. This privately owned crude helium is returned to the owners as needed for purification to supply private demand. During 1996, 36.7 million cubic meters (1,324 million cubic feet) of private helium was delivered to the BLM's helium conservation storage system and 21.2 million cubic meters (765 million cubic feet) was withdrawn for a net increase of 15.5 million cubic meters (558 million cubic feet) of private helium in storage. (*See table 4*.)

Transportation

All Grade-A gaseous helium sold by the BLM was shipped in modules (large gas cylinders), special railway tankcars, or highway tube semitrailers from either the Amarillo Helium Plant or the Exell Helium Plant located at Masterson, TX. The BLM 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 BLM price for Grade-A helium, f.o.b. plant, was $1.983 per cubic meter ($55 per thousand cubic feet) and bulk liquid helium was $2.524 per cubic meter ($70 per thousand cubic feet) on January 1, 1996, with additional costs for container services and rent.

Foreign Trade

Exports of Grade-A helium, all by private industry, decreased by 17.7% in 1996 to 22.8 million cubic meters (822 million cubic feet). (*See table 3*.) About 54% of the U.S. helium exports went to Asia, with Japan receiving about 84% of the Asian export. About 18% of the exported helium was shipped to Europe. Belgium, France, Germany, and the United Kingdom, collectively, received about 95% of the European exports. Other exports were as follows: about 13% to North America; about 4% to Australia-New Zealand, 2% to the Middle East; 7.3% to South America; about 1% to Africa; and the remainder to the Caribbean and to Central America. Although a very small quantity of helium was imported by the

United States in 1995, 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 capacity of helium, excluding the United States, was estimated to be 29 million cubic meters (1,045 million cubic feet). Most of the helium produced outside of the United States was extracted, in decending order of production, in Algeria, 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.

Argonne National Laboratory has developed magneto-hydrodynamic (MHD) propulsion systems 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; however, budget constraints have placed further MHD research on hold. One of the many benefits of this research has been the development of multidimensional MHD computer codes for analyzing flow development in and performance of MHD systems. Development of MHD 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 develops new uses for this equipment. The MRI equipment is providing accurate diagnoses of medical problems where exploratory surgery was previously required. A medical application being developed uses MRI to determine, through blood analysis, if a patient has any form of cancer. Experiments using laser polarized helium gas or a noble gas dissolved in the bloodstream have improved medical imaging techniques and could lead to extensive advances in medical diagnostics (Clark, 1996). For example, the technique could be used to detect pulmonary embolisms before life-threatening situations occur. The method could also be used to determine the relationships between brain functions and the effect stimuli have on blood flow to the brain, or it could be used to image blood vessels to determine various heart conditions.

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 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 and to obtain information on early structures in the universe. In the commercial market, several companies in addition to Goodyear continue to use "blimps" for advertising.

The United States and Russia have joined research efforts to build a nuclear reactor that will destroy the plutonium stockpiles at the Tomsk-7 production facility in Russia and to produce electricity for the district. Helium coolant sent through the reactor core will pick up heat energy from the fuel rods and transfer that energy directly to a turbogenerator to generate electricity. If successful, the helium-cooled reactor could become an important alternative energy source in the future. Superconducting magnetic energy storage (SMES) also is being investigated to provide power for 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 exciting research programs that use helium continue to push back the frontiers of science. For example, physicists have modeled the development of the universe using droplets of superfluid helium. By creating the conditions that cosmologists believe existed prior to the "big bang," scientists can theorize about the aftermath of that purported universe-creating explosion (Vergano, 1996).

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 ion tumor treatment, where large inert particles are required; (4) liquid helium-cooled superconducting microswitches, called Josephson junctions, which are much faster than conventional semiconductors and use less power; (5) "aneutronic" nuclear fusion, where nuclear energy is produced by fusion of deuterium and helium-3, results in few or no neutrons; and (6) helium-hydrogen breathing mixtures that enable deep-sea divers to reach depths below 580 meters (1,700 feet).

Outlook

The total market for U.S.-produced helium decreased 1.5% from the 1995 sales level. Market growth rate continues to flatten at less than 1% for the 5-year period 1992-96. In addition, market growth rate for private industry helium is also flat at about 1% for the 5-year period 1992-96.

In 1996, private industry supplied about 93.6% of the

domestic demand, while the Federal Government supplied the remaining 6.4%. Helium exports decreased 17.7% from those of 1995, accounting for 24.1% of U.S.-produced helium sales. Private industry supplied all of the U.S. helium exports. Strong growth in the Japanese helium market is expected to continue, and competition from foreign helium suppliers will provide increasing uncertainty for the global helium market. The sales outlook for helium remains slow in the Federal sector with cutbacks and elimination of programs that use and/or produce large volumes of helium. Helium sales in the private sector are expected to continue moderate-to-slow growth over the next 3 years. Use of high-temperature superconductor materials in electric motor windings and innovative applications of supercritical/cryogenic processing are expected to increase helium demand.

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TABLE 1
OWNERSHIP AND LOCATION OF HELIUM EXTRACTION PLANTS
IN THE UNITED STATES IN 1996

Category and owner or operator	Location	Product purity
Government-owned:		
Bureau of Land Management (BLM)	Masterson, TX	Grade-A helium. 1/
Private industry:		
Air Products Helium, Inc.	Hansford County, TX	Do.
Do.	Liberal, KS	Do.
BOC Gases Inc.	Otis, KS	Do.
CIG Co.	Keyes, OK	Grade-A helium. 1/
Do.	Lakin, KS	Crude helium. 2/
Exxon Co., U.S.A.	Shute Creek, WY	Grade-A helium. 1/
GPM	Hansford County, TX	Crude helium.
KN Energy, Inc.	Bushton, KS	Crude helium. 3/
Do.	Scott City, KS	Crude helium. 2/
Maxus Energy Corp.	Sunray, TX	Do.
Mesa, Inc.	Fain, TX	Do. 4/
Do.	Satanta, KS	Do.
National Helium Corp.	Liberal, KS	Do.
Nitrotec	Burlington, CO	Grade-A helium.
Do.	Cheyenne Wells, CO	Do.
Praxair, Inc.	Bushton, KS	Do. 1/
Do.	Ulysses, KS	Do. 1/
Trident NGL, Inc.	Do.	Crude helium.
Unocal	Moab, UT	Grade-A helium. 1/
Williams Field Services	Baker, OK	Crude helium.

1/ Including liquefaction.
2/ Lakin plant started production in August 1996.
3/ Output is piped to Ulysses, KS, for purification.
4/ Stopped production in May 1996.

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

(Thousand cubic meters)

	1992	1993	1994	1995	1996
Crude helium:					
Bureau of Land Management (BLM) total storage	(9,360)	(8,850)	(7,200)	(7,600)	(7,230)
Private industry:					
Stored by BLM	25,300	29,600	38800	36100	36700
Withdrawn	(17,900)	(16,400)	-19500	-23200	-21200
Total private industry storage	7,400	13,200	19,300	12,900	15,500
Total crude helium	(1,960)	4,350	12,100	5,300	8,270
Stored private crude helium withdrawn from storage and purified by the BLM for redelivery to industry	(510)	(638)	(610)	(69)	--
Grade-A helium:					
BLM sold	8,630	7,930	6610	7210	6060
Private industry sold	85,800	87,600	93800	88900	88600
Total sold	94,400	95,500	100,000	96,100	94,700
Total stored	(2,470)	3,710	11,500	5,230	8,270
Grand total recovery	91,900	99,200	112,000	101,000	103,000

1/ Negative numbers are enclosed in parenthesis ( ) to denote net withdrawal from the BLM's underground storage facility, a partially depleted natural gas reservoir in Cliffside Field near Amarillo, TX.
2/ Data rounded to three significant digits; may not add to totals shown.

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

(Million cubic meters)

	Volume		
Year	Domestic sales	Exports1/	Total sales
1992	63.7	30.7	94.4
1993	67.6	28.0	95.6
1994	75.4	25.0	100.4
1995	68.4	27.7	96.1
1996	71.9	22.8	94.7

1/ Source: Bureau of the Census.

TABLE 4
SUMMARY OF BUREAU OF LAND MANAGEMENT (BLM)
HELIUM CONSERVATION STORAGE SYSTEM OPERATIONS 1/ 2/

(Thousand cubic meters)

	1994	1995	1996
Helium in conservation storage system at beginning of period:			
Stored under BLM conservation program	885,000	878,000	870,000
Stored for private producers under contract	68,700	87,500	100,000
Total	954,000	965,000	970,000
Input to system:			
Net deliveries from BLM plants 3/	(7,200)	(7,600)	(7,230)
Stored for private producers under contract	38,800	36,100	36,700
Total	31,600	28,500	29,500
Redelivery of helium stored for private producers under contract 3/	(20,000)	(23,200)	(21,240)
Net addition to system 3/	11,500	5,300	8,260
Helium in conservation storage system at end of period:			
Stored under BLM conservation program	878,000	870,000	863,000
Stored for private producers under contract	87,500	100,000	116,000
Total	966,000	970,000	979,000

1/ Crude helium is injected into or withdrawn from the BLM's underground storage facility, a partially depleted natural gas reservoir in Cliffside Field near Amarillo, TX.
2/ Data rounded to three significant digits; may not add to totals shown.
3/ Numbers in parentheses indicate net withdrawl from storage.

TABLE 5
WORLD GRADE-A HELIUM PRODUCTION
CAPACITY, DECEMBER 31, 1996

(Million cubic meters)

	Capacity
United States 1/	114
Rest of world e/	29
Total e/	143

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

Figure 1

HELIUM RECOVERY IN THE UNITED STATES

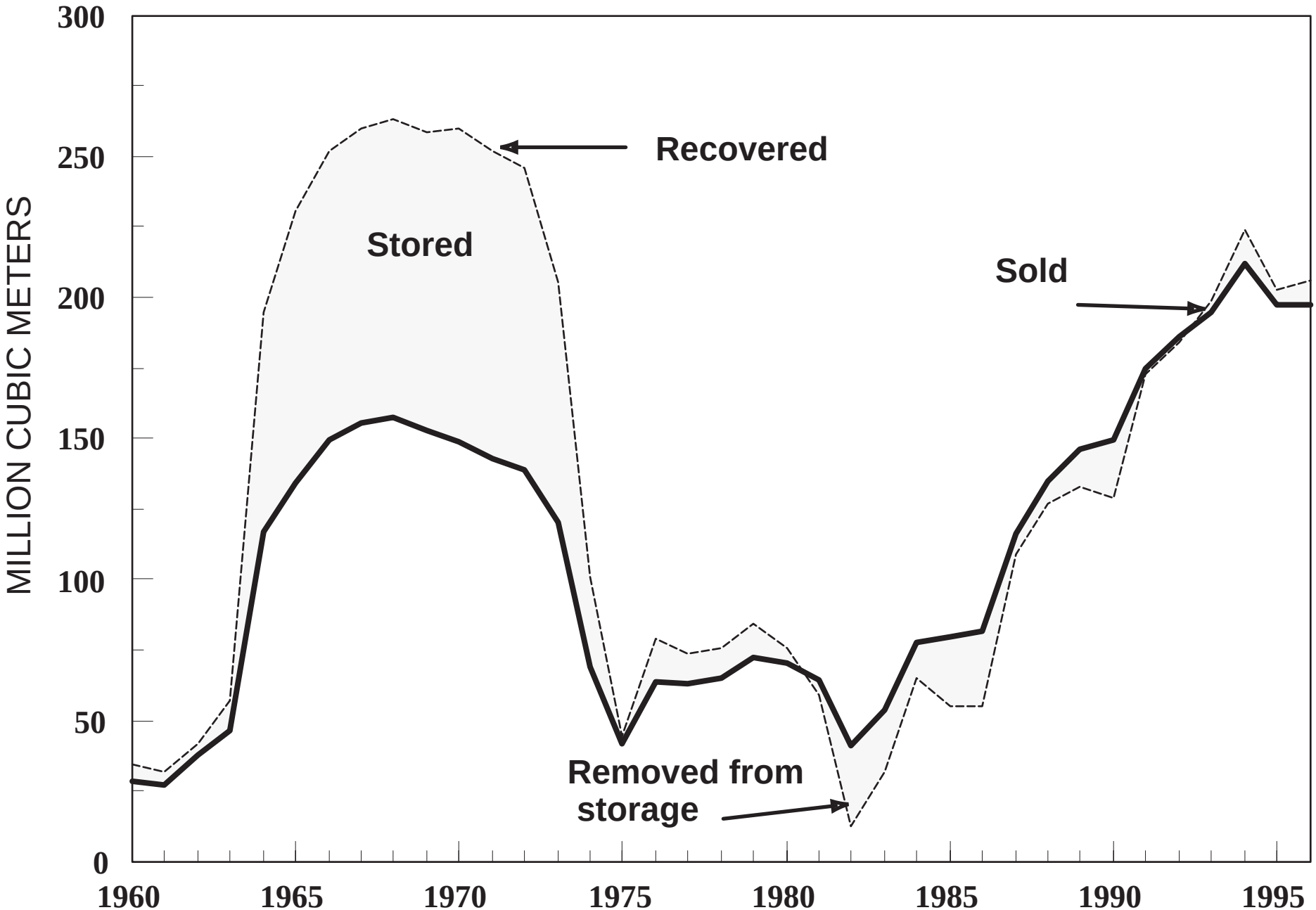


FIGURE 2

MAJOR U.S. HELIUM-BEARING NATURAL GAS FIELDS

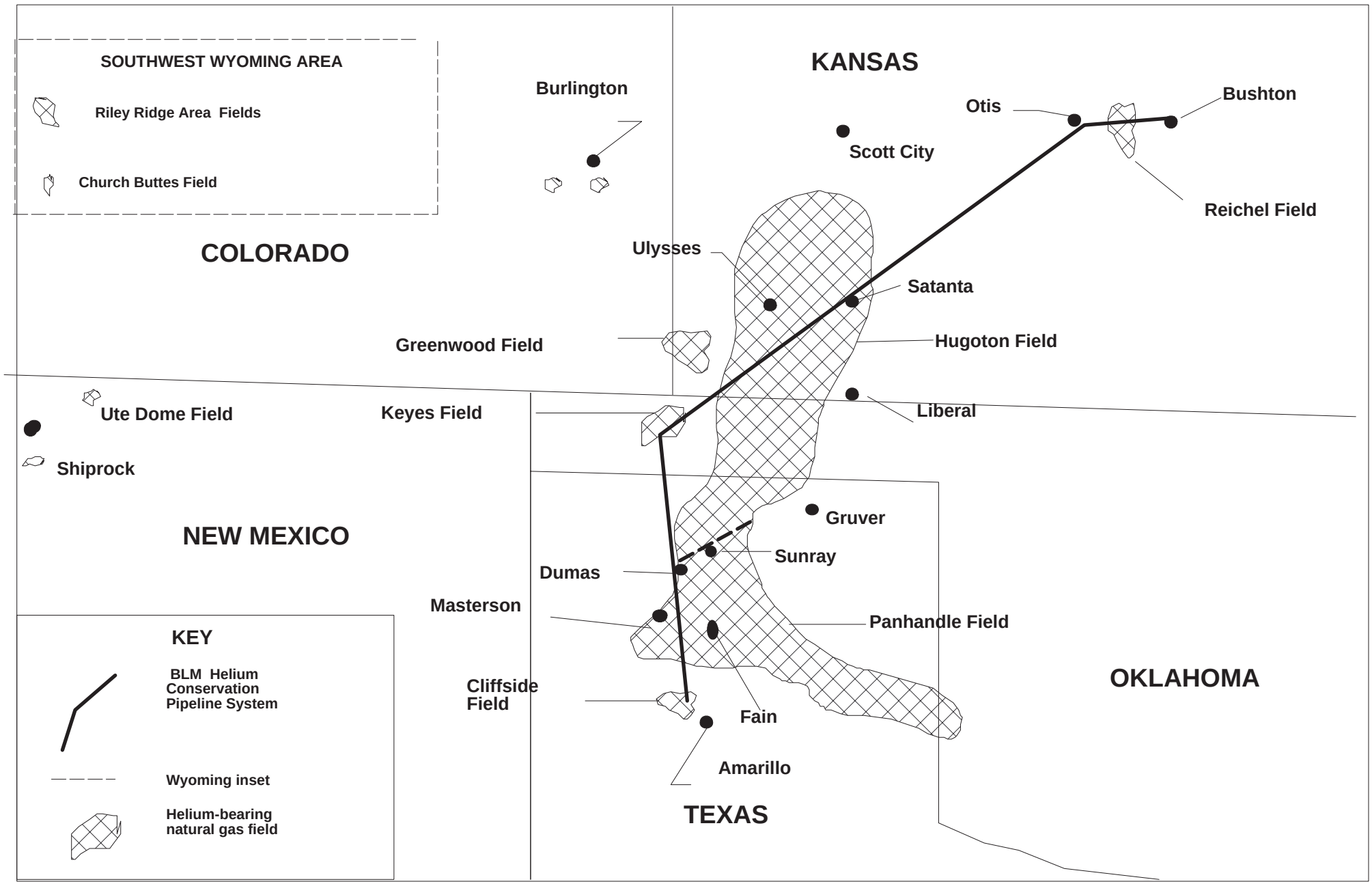
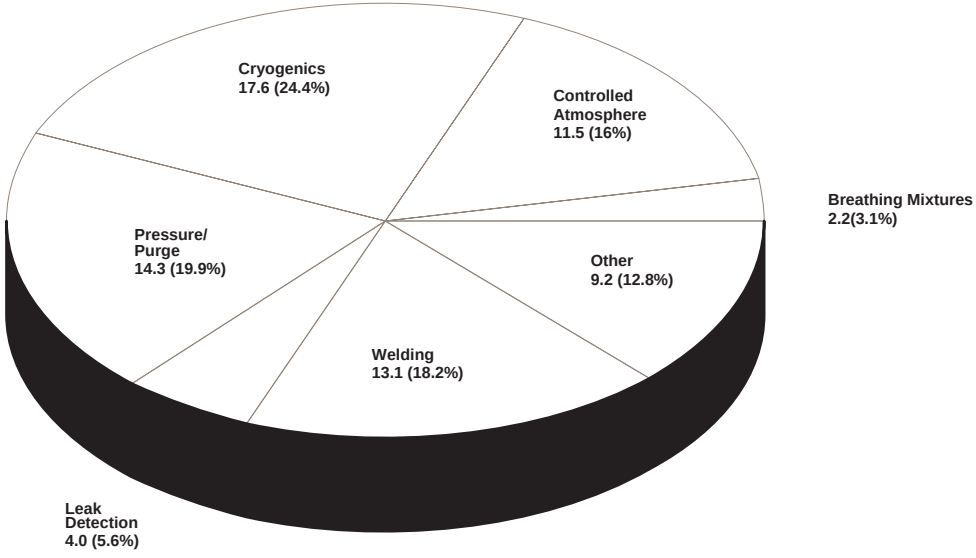


FIGURE 3
ESTIMATED HELIUM CONSUMPTION, BY END USE, IN THE UNITED STATES IN 1996
(Million cubic meters)



Estimated total helium used
(71.9 million cubic meters)