Helium: Up, Up & Away

"Who is buying helium and for what purpose, and why do we have long-term contracts on helium when there has not been extensive use of it for many, many years? We used to use it in the old dirigibles, but as I understand it, it is not used very much now . . ."
Congressman Chet Holifield (D-Cal.) in House floor discussions leading up to the 1973 cancellation of the U.S. helium conservation program.

The nation's helium reserves, key to many of the expensive 21st century energy technologies now being developed, are being wasted. Can we afford not to save them?

BY ROBERT EBISCH

"Helium," former astronaut Scott Carpenter once commented, "is an invisible passkey to the future." Unfortunately, the passkey is dissolving into thin air.

Just as the world begins moving into a new age of helium-based supertechnologies, the helium reserves of the United States—an estimated 718 billion cubic feet (Bcf) contained in natural gas deposits—are being rapidly lost to the atmosphere as the gas is pumped from the ground and used to heat homes and generate power for industry.

Fields now being exploited for natural gas, representing almost 85 percent of the U.S. helium reserve as measured at the beginning of 1977, could be essentially exhausted within 20 to 30 years, according to the National Research Council.

The waste would excite little protest if World War I observation dirigibles had been the zenith of helium's utility, but the federal government has spent and will continue to spend billions on the development of fusion reactors, breeder and high-temperature gas reactors, high-temperature gas turbines, high-powered lasers, magnetically levitated transport systems, advanced energy conversion cycles and superconducting devices for energy generation, transmission and storage—all of them dependent on helium.

"DOE is currently investing $300 million a year in research and development of technologies that will be useless in less than 40 years if we fail to conserve helium today," warns Congressman John Dingell (D-Mich.). "As things stand now, by the year 1985, the U.S. will not be able to meet its demand from current production, and by the year 2017 we will have exhausted our reserves as well."

A national reserve of 718 Bcf—as estimated by the Potential Gas Committee of the Colorado School of Mines—appears sizable in comparison with the present consumption of about one Bcf per year. But only 198 Bcf are actually proven resources. Another 153 Bcf are "probable," expected to appear in extensions of existing gas fields. The remaining 367 Bcf fall in the categories of "hypothetical" and "speculative," which means they may be contained in natural gas deposits that have not yet been discovered.

Further, so extensive are the technologies that helium may make possible that even if all 718 Bcf were "proven resources," it would serve only as the basis of a 60- to 90-year interim during which substitutes, or cheaper ways of extracting helium from the atmosphere (about 1,000 times the cost of extraction from natural gas), might be identified. "There are so many developments that one needs to look at," says Bascom Birmingham, director of the National Bureau of Standards' Boulder, Colo., laboratories. "If even two or three of them go forward, all the helium we have in reserve may be needed."

Three technologies alone—fusion, superconducting transmission and storage of electricity—could require more than 600 Bcf of helium between now and the year 2050, according to an Argonne-NSF Advisory Committee study (ANL/EE-75-2).

The cause of this helium gluttony is superconductivity, the phenomenon in which the free electrons of metals at a sufficiently low temperature (about −255°C and −267°C respectively for the preferred superconducting alloys niobium-tin and niobium-titanium) form what are called "Cooper pairs" and cease to be scattered by the metal atoms. In macroscopic terms this means that the metal becomes superconducting, losing all resistance to the flow of electrical current. In technological and economic terms it means a bonanza, because tremendous currents can be put through superconducting wires with no energy loss to resistance and no need for energy expenditures in cooling.

Helium, with a melting point of −272°C, is the only element that remains fluid at superconducting temperatures and thus the only means of cooling conductors (hydrogen might be used were it not dangerously explosive).

Helium is, in other words, an absolute necessity for cooling the superconducting magnets that must be used for power-generating tokamak fusion reactors (SN: 8/19/78, p. 116), for superconducting energy transmission and for storage.

About 13 percent of electrical energy currently produced is lost in transmission and distribution. Such loss can be significantly reduced by superconducting transmission lines such as the 100-meter experimental line at Brookhaven National Laboratory. Currently the focus of U.S. research, the line consists of three flexible niobium-tin cables capable of carrying 1,400 megawatts, the output of a good-sized nuclear power plant, through a pipe scarcely more than a foot in diameter.

A research group headed by engineering professor Roger Boom at the University of Wisconsin has developed a scheme to store excess power in a ring of superconducting metal the size of a football stadium, buried several hundred feet underground to reinforce it against internal magnetic stresses. Electrical consumption switched into the ring during hours of low consumption — at night, for example — would travel in a circle until the hours of high demand, when it could be drained off as needed.

"There might be about 50 of them located around the country," according to Boom. "They would store between 10,000 and 50,000 megawatt-hours of electricity from a statewide area [for comparison, the peak demand of Chicago is about 1,400 megawatts] and each would require as much as 3.85 Bcf of helium."

Not all superconducting technologies will consume helium on such a grand scale. A 1,000-megawatt magnetohydrodynamics (MHD) unit might require no more than about 50 thousand cubic feet (Mcf) of helium. MHD is a process in which white-hot and electrically conducting gases — exhaust from a coal furnace, for example — are directed at near-sonic speeds through a magnetic field, producing a voltage that can be used to drive an external circuit. The exhaust gases, reduced only a few hundred degrees in temperature, can then be passed through a heat exchanger, producing steam to drive a conventional electrical generator.

According to NASA's 1976 Energy Conversion Alternatives Study, MHD appears to offer an overall power plant efficiency of more than 50 percent, compared with 34 percent for conventional coal-fired plants and 25 to 30 percent for nuclear plants. But MHD becomes economically feasible only with superconducting magnets.

MHD research is underway at a number of locations, with the greatest U.S. effort focusing on a 50-megawatt test unit at DOE's Component Development and Integration Facility in Butte, Mont. Re-

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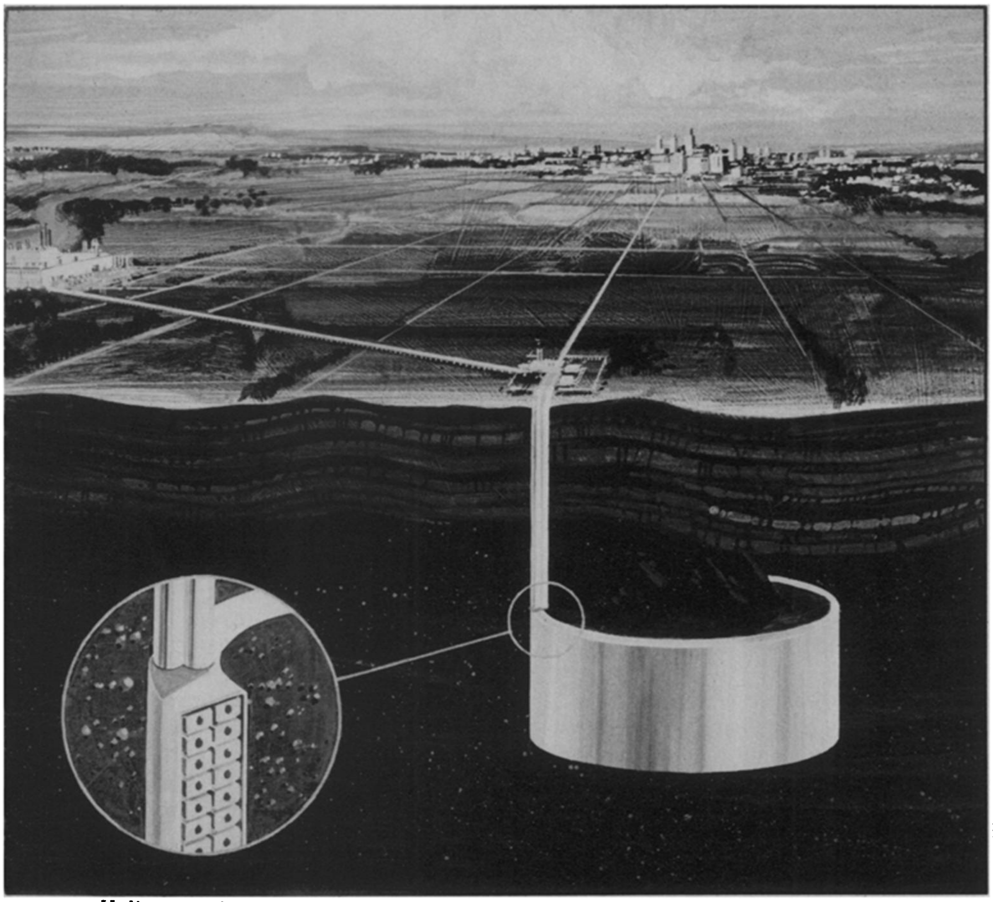

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Helium-cooled rings of metal would store up to 50,000 megawatt-hours of electricity.

searchers are expecting to build a complete 250-megawatt MHD pilot plant by the mid-1980s. Eventually, MHD may be a part of between 40 and 100 percent of all new power plants, according to the Electric Power Research Institute (EPRI).

They won't be the only part to be superconducting. In January of this year, Westinghouse Electric Corp. was awarded an EPRI contract to design and manufacture a 300-megawatt turbogenerator with superconducting windings for installation in an operating power plant by 1983. Superconducting generators of 250 to 1,250 megawatts could begin replacing conventional power plant generators by the early 1990s, according to Westinghouse, at a cost savings of up to 20 percent.

Superconducting magnets have also opened a new era of high-energy physics by enabling particle accelerators to control more powerful beams. Japanese and German groups are developing high-speed trains that will be levitated and propelled by superconducting magnets. Compact, superconducting magnetic memory systems may be in use in high-capacity computers by 1985. Superconducting magnets for the magnetic separation of lower grade ores or tailings have been under development for years. They may be necessary as the richer iron reserves are depleted. And one scientist has predicted that water purification may be one of the first large-scale applications of superconductivity.

Helium will find increasing use in high-powered lasers for defense, medicine and laser fusion, and in lighter-than-air cargo ships. Helium's high thermal conductivity and the fact that it is relatively invisible to radiation will make it a valuable medium of heat exchange in nuclear reactors.

And then there are the more familiar, "dissipative" uses that release helium to the atmosphere as a matter of course, including welding, chromatography, synthetic breathing mixtures for deep diving and space activities, leak detection, and pressurizing and purging of vessels. These account for most of today's helium demand. A single gas chromatograph, for example, requires only a small volume of helium, but the cumulative effect nationwide is attested to by the 35 million cubic feet used for this purpose in 1975.

"It is conceivable," says the NRC, "that dissipative uses alone could, if permitted, exhaust the present helium stockpile before the inventory demand of the new technologies develops."

Meanwhile, the United States is recovering just over one Bcf of helium each year and losing about 15 Bcf. The House Subcommittee on Energy and Power has estimated that during the next 16 years the United States will lose 54 Bcf of recoverable helium, the equivalent of 150 percent of the existing national stockpile of 39 Bcf now stored underground in the Cliffside facility, a partially drained natural gas deposit in Texas.

"The only way to stop such waste," asserts Dingell, "is to enact a Federal program that deals with the economic and legal barriers to helium conservation and requires that this invaluable element be preserved for future generations. The total cost of this program to the Federal government over the next six years would be about $500 million, half of which will be recovered by 1990 and half of which will be recovered when the helium is sold."

Dingell's remarks opened the second of three public hearings on HR 2620, "The Helium-Energy Act of 1979," on June 11. The House bill, introduced last March, is intended to forestall a helium shortage to at least 2040 and possibly until 2070.

Helium — formed deep within the earth by radioactive decay of the elements uranium and thorium over billions of years and trapped as it rises toward the surface beneath the same dome-like geological formations that trap natural gas — is today being extracted from only two of the nation's hundreds of natural gas streams, and those two streams are helium-rich (concentrations of more than .3 percent helium). HR 2620 would mandate helium extraction not only from all helium-rich natural gas but also from the helium-lean deposits (as low as .1 percent and possibly lower), which actually hold the bulk of the world's helium supply.

The federal government would bear only the costs of storage and transportation from the wellhead to storage. Companies transporting or selling the natural gas would be required to extract the helium, and would be allowed to pass the cost on to the natural gas consumer.

There are those, however, who think the price will be too high. Ray Munnerlyn, chief of the Bureau of Mines' Division of Helium, explains, "Under HR 2620 practically every helium gas stream in this country would have to be processed. If the Secretary of Energy took HR 2620 to the letter, it would require the construction of hundreds of helium extraction plants." One of HR 2620's provisions would transfer control of the helium program from the BOM to the Secretary of Energy.

Private industry is also reluctant; they have been burned in the past. The 39 Bcf now in storage is mostly a holdover from the last federal helium conservation program begun in 1960. In the early 1960s four companies entered into 22-year helium-purchase contracts with the federal government, built extraction plants and began producing helium for storage at Cliffside.

At that time, the Bureau of Mines was the sole supplier of helium to both the government and public markets at the legislated price of $35/Mcf. Between 1961 and 1968, however, 12 additional private helium extraction plants were built and the market price of helium fell to $25/Mcf. Federal sales fell off and the BOM program went deep into debt.

In 1973, the Nixon administration canceled the helium purchase contracts as an

Continued on page 56

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uble minerals are found that are naturally, inexorably bound to radioactive elements. The mineral pollucite, for example, naturally binds cesium; monazite holds plutonium; feldspar snares strontium. By matching the wastes with a mixture of the appropriate minerals, the most insoluble solid forms possible can be made. Preliminary tests of the stability of ceramics look good, but critics warn against problems such as radiation damage and subsequent weakening of the crystalline structure.

In addition, such ceramic-bound wastes might be most stable in rock types other than salt, and that combination more stable than glass in salt. Many critics, including Luth, the NAS and the USGS, favor more research on basalts and granites (both formed from molten rock), tuffs (solidified volcanic ash) and shales (muds that become rock by high temperature and pressure) as geologic hosts. Though all these rocks fracture, which can allow the entrance of water, all, in varying degrees, absorb radioactive elements; salt does not. This ability to retard the dispersion of radioactive elements, therefore, may outweigh salt's advantages. Moreover, a ceramic waste form could be adapted to enhance a rock type's natural properties. "Best fit" might be the ultimate disposal solution: "[T]ailor our garbage to suit the needs of the geologic host," says Luth.

Such a tailor-made approach may be a long way off; DOE and its predecessors have carried only minimal projects in alternative host rocks and waste forms. But according to some observers, the recent scientific criticism seems to be taking. Of importance, the recent 14-agency review group report represents an acknowledgement of past program inadequacies. DOE has begun to broaden some programs; funding has been stepped up for studies in basalt and tuffs, and an increase of $10 million has been allocated for alternative waste forms in 1980. In addition, an "Earth Science Technical Plan" — a joint project of the USGS and DOE — will "develop a program of research and development to resolve the remaining earth-science problems" of geologic disposal, according to a January draft report. And combined with political threats that may stall or kill WIPP and nix the 1985 goal for a commercial repository (see p. 38), such actions may allow the undernourished alternative programs to fatten up. Despite the apparent progress, some critics are reluctant to release their fingers from DOE's throat. Says Terry Lash, attorney for the Natural Resources Defense Council: "There's some progress, but so little, you can't take hope from it." Others are more optimistic. Former critic Luth says, "They still have to get their cards in order and their homework done [on HLW]. . . . But now I can see a light at the end of the tunnel. Three to five years ago, all I could see was a big black hole." □

. . . Crude

gins necessary to make capital-intensive investments for plant changes. And those changes are necessary to adapt a plant from refining light, clean crudes to the more complicated processing of dirtier and heavier crudes. As a result, a shortfall of light crudes can force refiners to run at partial capacity regardless of how much heavy oil is available.

Exemption from the proposed windfall-profits tax is advocated by almost all heavy-oil supporters. The tax would virtually wipe out any advantage decontrol could offer, particularly for thermal-recovery projects, they charge.

But things are looking up. For instance:

- In his energy address on Monday, President Jimmy Carter called for the immediate decontrol of heavy oil (p. 38).
- Two last-minute changes prior to House passage of the Moorhead bill (SN: 6/30/79, p. 421)—which offers $2 billion in subsidies for government purchases of synthetic fuels — amended the definition of synfuels to include heavy oils.
- In response to popular demand, Barnea has announced plans for a second international heavy crude and tar sands conference. The United States has offered to host it, probably some time after the next presidential election, he says.
- On the recommendation of a working group at the Edmonton meeting, UNITAR will consider establishing a heavy-crude and tar-sands information center. Its first project would be publication of an international "who's who" in heavy oils. According to Barnea, the Alberta government has already pledged that if UNITAR goes through with the venture, it will immediately make available $10,000.

While doing research in connection with planning the Edmonton meeting, Barnea asked an oil company executive for data on the occurrence of heavy crude in the United States. He recalls being surprised when he was told, "Look, we're all hunting around to get leases on heavy crude and you want us to give you that? You won't get it from any company." Subsequent inquiries proved the oil man right. They've got the message, Barnea says. "I think the coming task now is to bring that message to Washington." □

. . . Helium

austerity measure. Since helium production was then about seven times the demand, this left the four government contractors with no market. They began releasing the helium to the atmosphere and filed suits against the government.

Private companies have their reservations about HR 2620. Long-term government contracts have been canceled in the past, and the 25-year contracts suggested under HR 2620 may not be long-term enough for a helium market to have developed from the new technologies. The government's large helium store represents a potential threat to future markets. Recent court decisions have raised the possibility that helium extractors may have to pay natural gas producers and landowners for part of its value.

Sometime before fall, HR 2620 will be reported in the House and may pass there, according to Michael Kitzmiller, counsel to the Subcommittee on Energy and Power. Kitzmiller refuses to speculate on the bill's changes, adding, "Every year somebody introduces a bill that would rehabilitate the helium program and every year it doesn't happen. But there is a lot of enthusiasm for the bill in the Senate."

BOM Helium Division chief Ray Munnerlyn disagrees: "It's our impression from hearing the testimony that HR 2620 has very little support outside the subcommittee."

The situation of helium reserves today has been compared to that of natural gas between 1930 and 1960. During that period the United States flared or vented about 119 trillion cubic feet (Tcf) of natural gas, regarding it merely as a byproduct of petroleum production. 119 Tcf equals 58 percent of proven U.S. reserves as of 1977. Had this waste been prevented, the United States would be in a better energy situation today. Will future generations view helium in the same manner?

"You've spent a billion dollars so far on fusion," says Charles Laverick, a consultant formerly with Argonne National Laboratory and an insistent presence at helium policy gatherings. "You'll have spent $20 billion on fusion by the time you get it and, if things continue as they've been going, you'll have no helium." □