Helium, when will it run out?

QFS2009

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Summary

- History of helium production and the US reserve
- Uses of helium
- Outlook on reserve, production and price.
- Strategies to extend the availability of helium into the distant future and to reduce impact of price hike and uncertain supply to the low temperature community.
- Current He-3 crisis.

History, I

- In 1903, helium gas (2%) was found in a natural gas field in Dexter, Kansas. Helium of such concentration was found in a number of other gas fields in the great plains in US.

- It was used in 1920s as lifting gas in military dirigibles. The 1925 helium act of US Congress transferred the production responsibility of helium from Navy to the Bureau of Mines (BOM, now it is called Bureau of Land Managements, BLM). Production of helium greatly expanded during WW II. More plants were started including one near Amarillo (TX) at the Cliffside Field.

- Significant civilian use of helium began after explosion of Hindenburg in 1938.

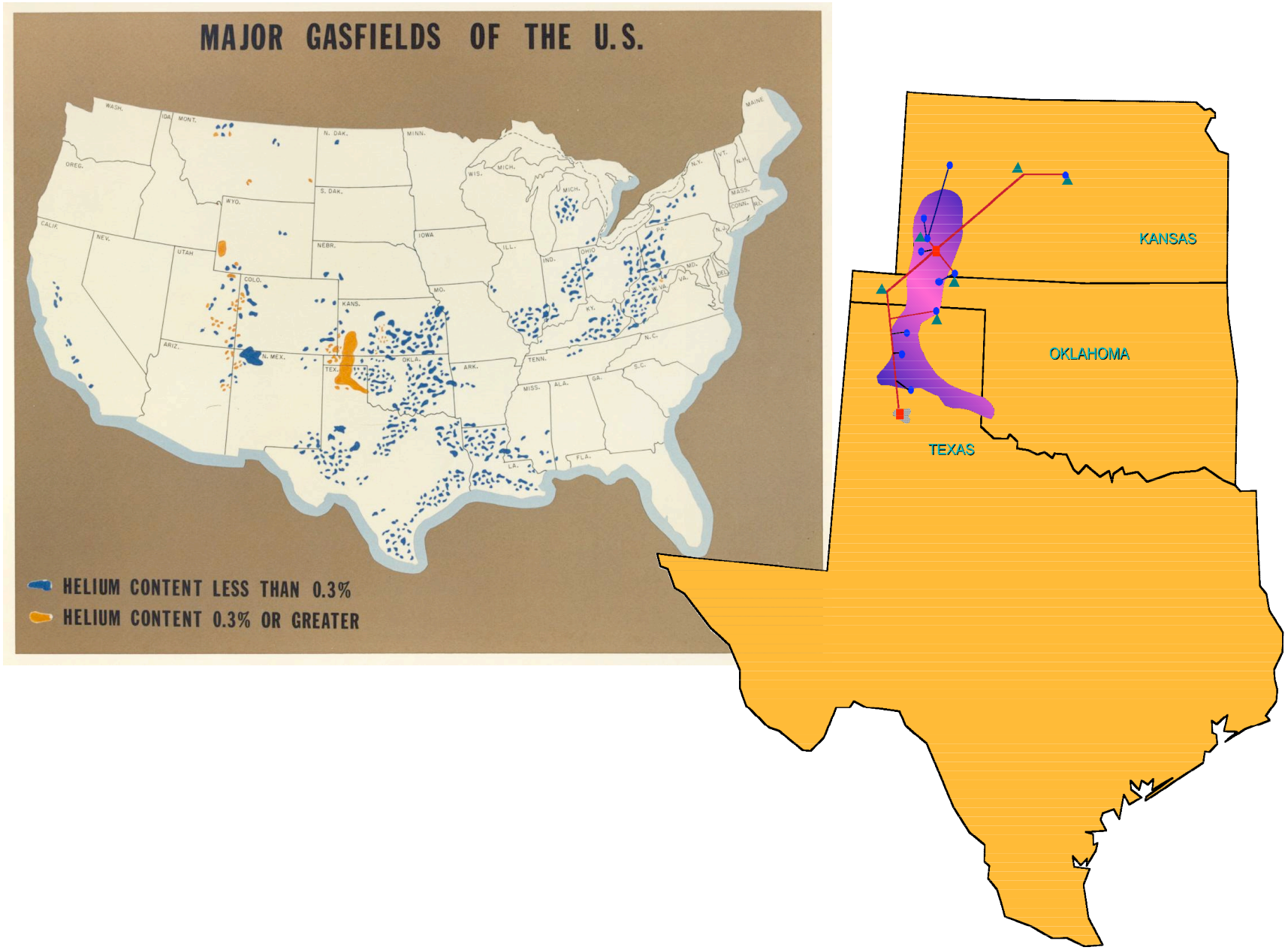
History, II

•The rocket program during the cold war expanded helium production program further.

•In 1960, Congress amended the 1925 helium act and entered long term (~25 yrs) contracts to buy helium from commercial natural gas producers (Air Product, Linde (BOC) and Praxair) and stockpile it at the Bush Dome reservoir near the Cliffside field.

• After selling the 'contracted' quantity to BOM/BLM, the gas producers sell the gas to the public and store the extra at the Bush Dome through a pipe line network centering near Cliffside (Amarillo,TX) but extended to a number of gas fields.

• To facilitate the shipping of helium, liquefaction plants were also built at Cliffside.


MAJOR GASFIELDS OF THE U.S.
HELIUM CONTENT LESS THAN 0.3%
HELIUM CONTENT 0.3% OR GREATER
KANSAS
OKLAHOMA
TEXAS

History, III

By 1980, the total helium gas stockpile exceeded 1 billion ($1X10^9$) m^3 =1.3 billion liters of liquid. Note: current annual world wide annual consumption of helium is $1.7x10^8$ m^3 (US uses 50%).

The 1996 helium act instructed BOM to sell helium gas, with minimal disruption to the market until all but $1.7X10^7$ m^3 remains at the Bush dome by 2015.

A NAS study(co-chaired by John Reppy was carried out in 2000 to evaluate the effect of the 1996 Act. It was concluded that with the then current usage and production and also the commercial and BLM prices , there will be a surplus of helium in the foreseeable future.

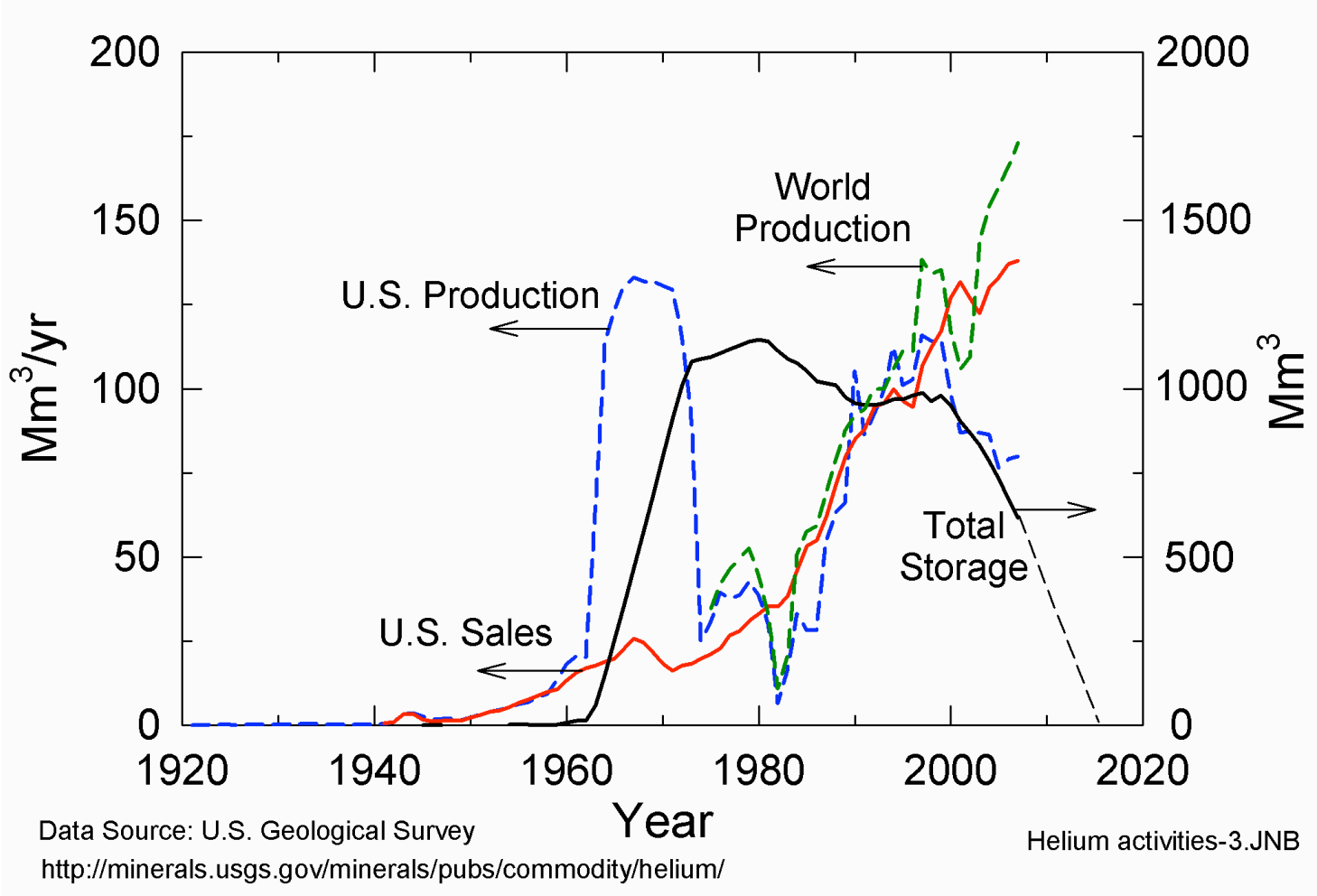
The study did not raised concern about the selling of the BLM stockpile by 2015 but advised future studies.

History, IV

The picture changed shortly after the first helium report was released, with rapid rise in usage and (commercial) price increase. Shortage and disruption of supply were experienced world wide in 2006 and 2007.

A new NAS study was commissioned in 2008 (with Bob Richardson as co-chair) Members include geologists, economists, consultants for helium gas industries, representatives from NASA, National Labs, cryogenic experts from particle accelerators, and your colleagues,(Allen Goldman, Moses Chan, Mark Thiemens (UCSD) to revisit the issue of the impact of selling off the helium stockpile. Report will come out next year.

Helium Resources



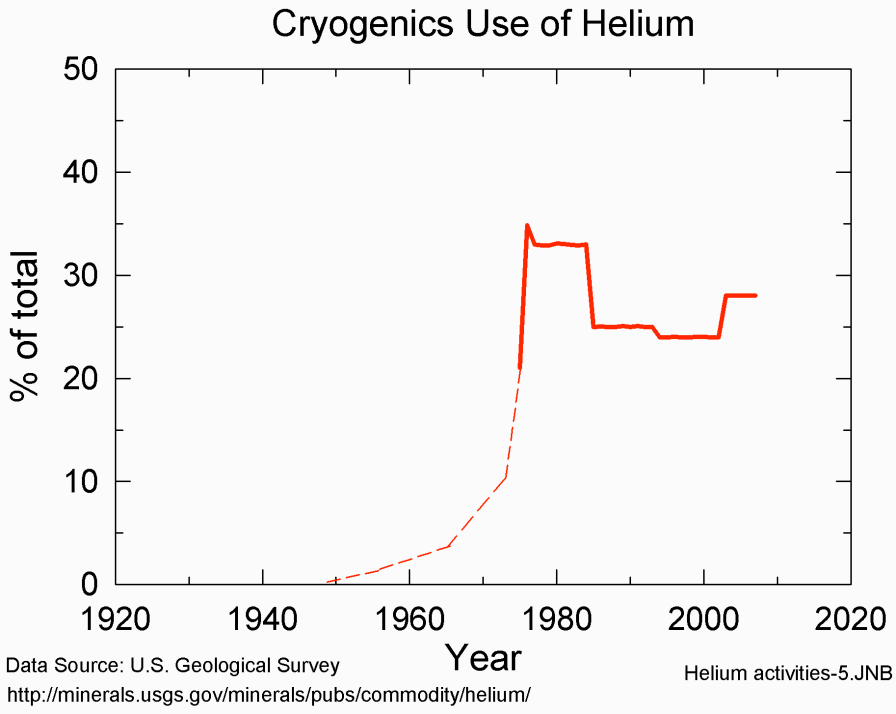
Currently US produces 5/6 and uses 1/2 of all the global helium.
Helium usage in US is tapering off, but increasing elsewhere.;
$1m^3$ of gas is ~1.3 liter of liquid.; World annual usage is ~170 Mm^3 or 6Bscf.

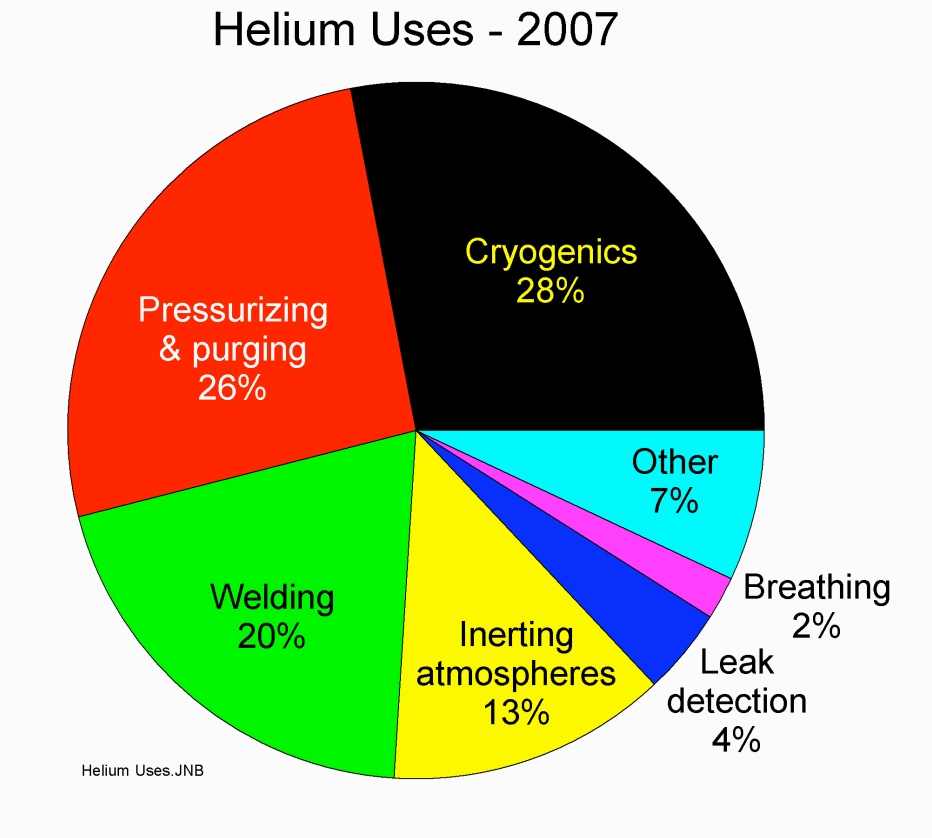
FY 2007 Worldwide Helium Capacity and Actual Production (RMW Solutions, 2008)

COUNTRY	OWNER/OPERATOR	LOCATION(S)	CAPACITY [1] bscf/yr	ACTUAL [2] bscf/yr
U.S.	Air Products[3]	Hansford, TX; Liberal, KS	1.390	
	Praxair[3]	Bushton, KS; Ulysses, KS	1.300	
	Linde[3]	Otis, KS	1.000	
	Keyes Helium[3]	Keyes, OK	0.160	
	TOTAL, BLM System		**3.850**	**3.515**
	ExxonMobil	Shute Creek, WY	1.660	1.265[4]
	EnCana	Moab, UT	0.130	0.035
	Duke Energy	Ladder Creek, CO	0.430	0.095
	Shiprock Helium	Shiprock, NM	0.025	0.025
	TOTAL U.S.		**6.095**	**4.935**
ALGERIA	HELIOS	Arzew	0.665	
	HELISON	Skikda	0.570	
	Total, Algeria		1.235	0.665
RUSSIA	CRYOR	Orenberg	0.285	0.256
POLAND	KRIO	Odolanow	0.140	0.091
QATAR	Qatar/ExxonMobil JV	Ras Laffan	0.570	0.256
	TOTAL NON U.S.		**2.230**	**1.268**
	TOTAL WORLDWIDE		**8.325**	**6.203**

[1] 95 percent of nameplate capacity unless identified otherwise.
[2] Actual helium refined in Fiscal Year 2007.
[3] These processing plants are connected to the BLM pipeline.
[4] Shute Creek (2008)

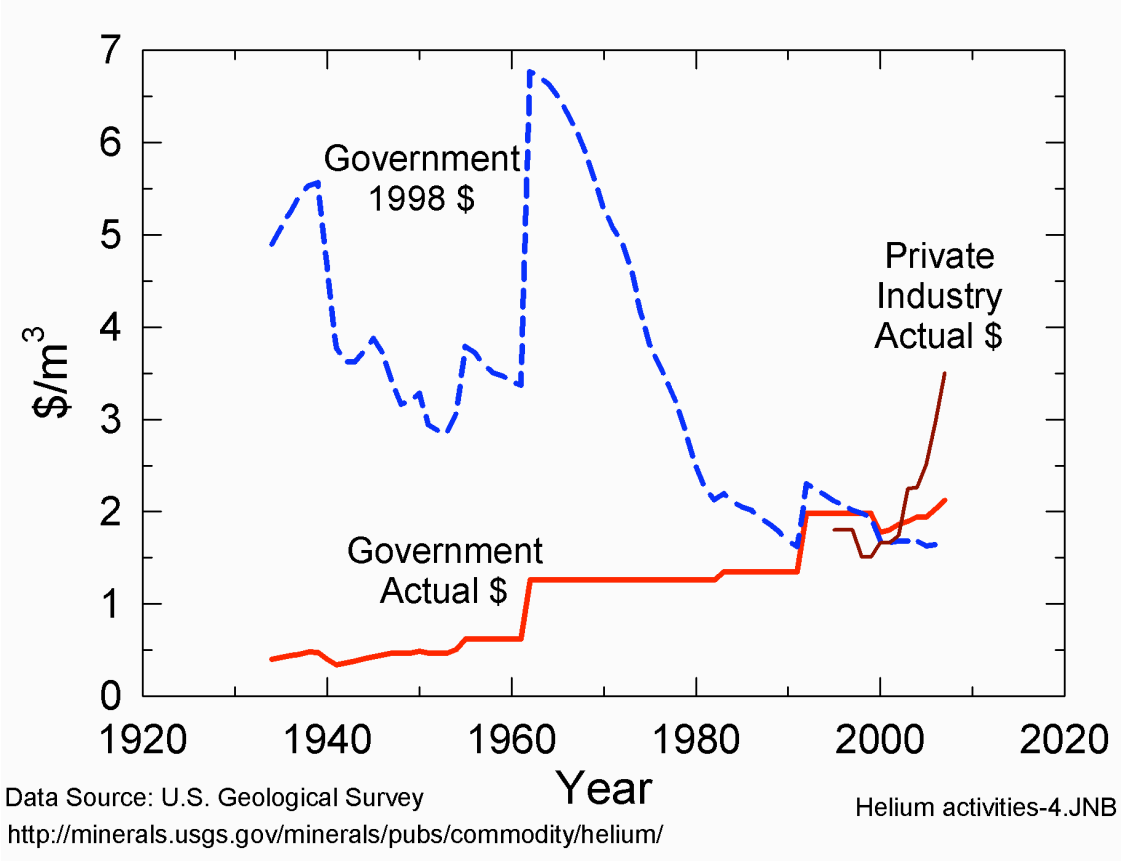
Helium Uses in US





Most (?) of cryogenics use is for MRI (growing rapidly.) Superconducting magnet is also used in industrial processes.
Scientific cryogenic use of helium is about 3%; 2.7million m^3 or 3.5 million liters of liquid helium ; this includes superconducting magnet in accelerators. ;
Other significant uses are lifting gas (party, parade and weather balloons); Chromatography; NASA and DOD rocket program uses ~8%; potential new use of helium gas as coolant in High Temperature (Nuclear) Reactor.

Helium Prices



Note: US government agencies (NASA, DOD, DOE labs) buy helium at the price that BLM sells to the helium vendors; shipping and handling is extra. This in-kind program is (at least currently) not available to grantees of NSF.

Retail price in US is $7+/- $2 per liter; roughly double of that 1 year ago.

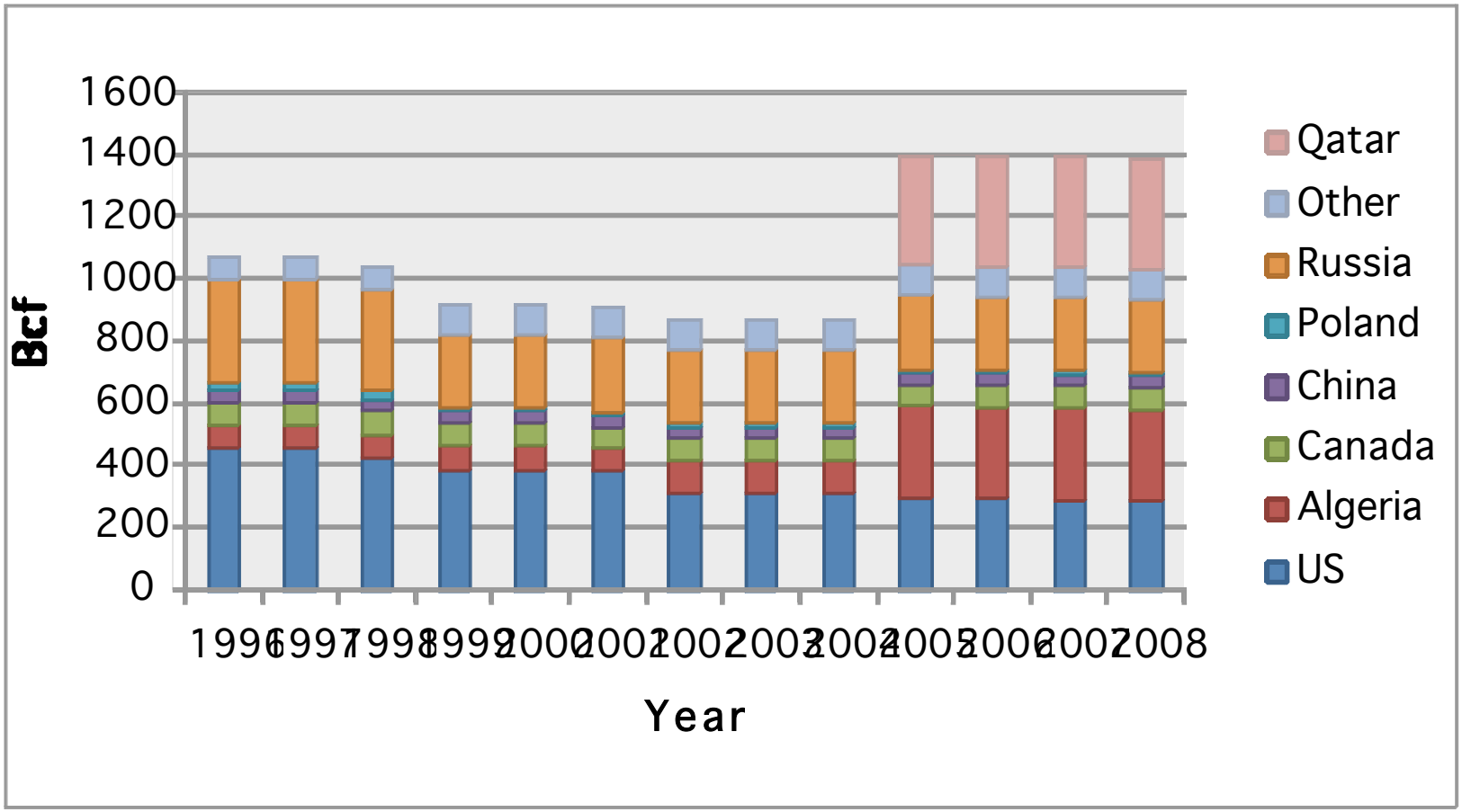
2007 Worldwide Helium Summary: Helium Refined and Reserve Estimates in bscf.

Country	Helium Refined[1]	Reserves[1]	Reserve base[1]
US	5.0	120	300
Algeria	0.7	65	300
Australia	--	6.9[2]	6.9[2]
Canada	--	0.0	72
China	--	0.0	40
Indonesia	--	14.[2]	14.[2]
Poland	0.1	0.9	10
Qatar	0.2	360[3]	360
Russia	0.2	61	240
Other	--	0.0	100
Total	**6.2**	**450**	**1,400**

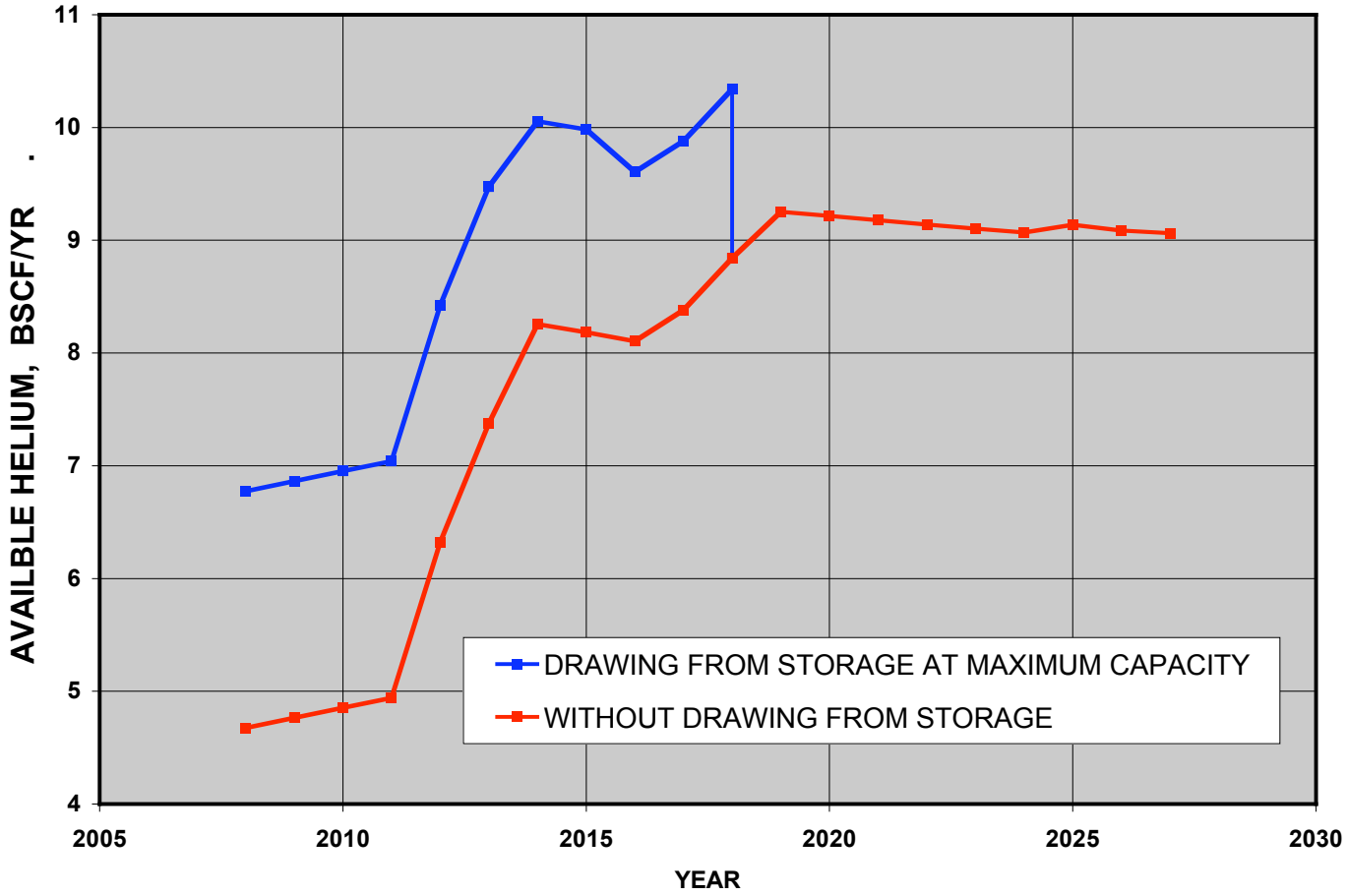
Bscf= billion standard cubic ft; $1ft^3 = 0.0283\ m^3$,

At the current rate of usage, we will use up the readily available (US) helium In 20 years and not so readily available world reserve in 75 yrs.

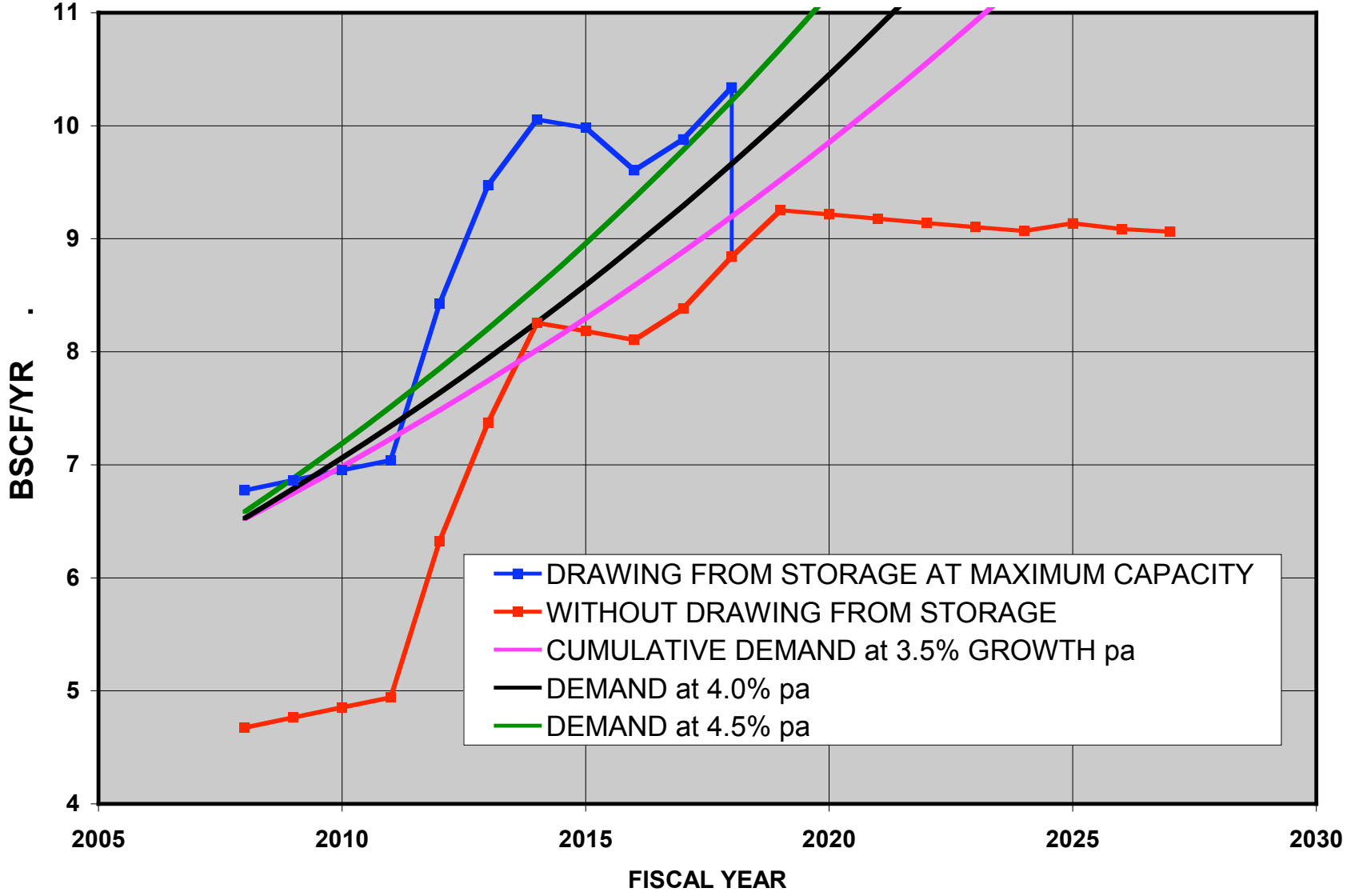
How much do we have?
And where is it ?



Worldwide Projected Helium Production Capacity with and without withdrawal from Federal reserve at Bush Dome



World wide projected demand and capacity with and without Bush dome



Outlook

- The quantity of liquid helium used in low temperature labs is insignificant(<1%) as a fraction of helium market. But it is crucial on scientific, technological grounds. There is no replacement for liquid helium.

- The tapering of production of helium in US fields and the halt in the selling of BLM stockpile will reduce the total US production of helium; usage in helium particularly in Asia (just prior to current economic downturn) has been going up rapidly. This means increase in the price and also instability in the supply chain. The production of helium in Algeria and Qatar should reach full capacity by 2012 which should help the supply chain. The current economic downturn will temper the shortage for a couple of years.

Outlook

- The continue price increase will reduce un-necessary use of helium (eg welding applications in US may switch to argon, balloons may(?) switch to nitrogen-hydrogen-helium mixture) and encourage recycling(e.g in leak checking, industrial purging use in semiconductor and optical fiber production and also in cryogenic applications). Note that current 'retail' price of helium gas in US is ~3.5 times that of hydrogen and argon; ~ $12 per m^3 for helium.

  However, other strategic uses (e.g. heat exchange in nuclear reactors) may increase.

- Low temperature labs with low helium consumption and without standard gas recovery and liquefier system will have the most serious impact of uncertainties in supply and price hike. What are the options to reduce the impact? Pulse tube coolers

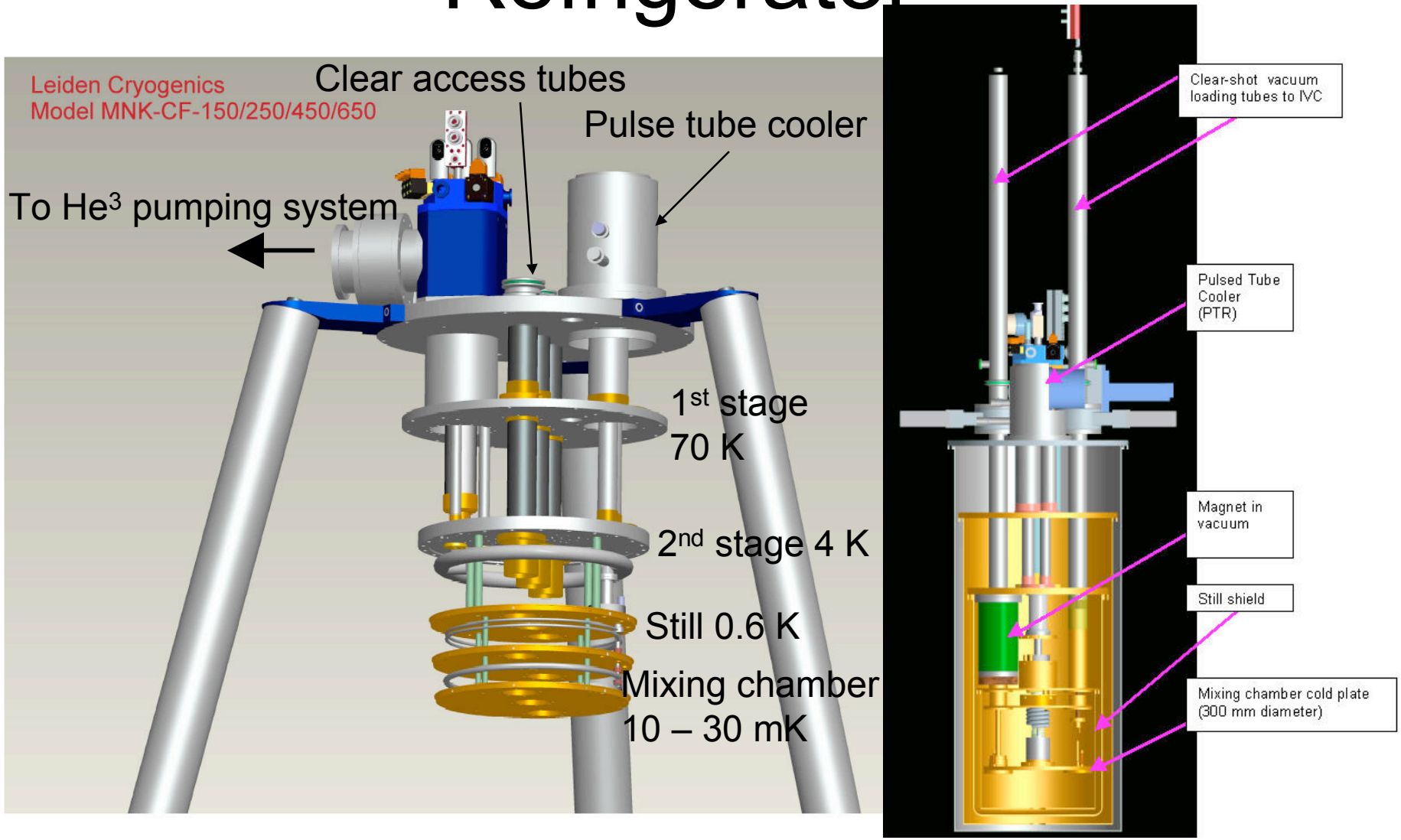
  1) Cryogen free (dry) system
  2) Cryostat with re-condensers
  3) Modular liquefiers (~$95,000), but
     where can one find the 95k?

What can be done?

(If we are in charge?)

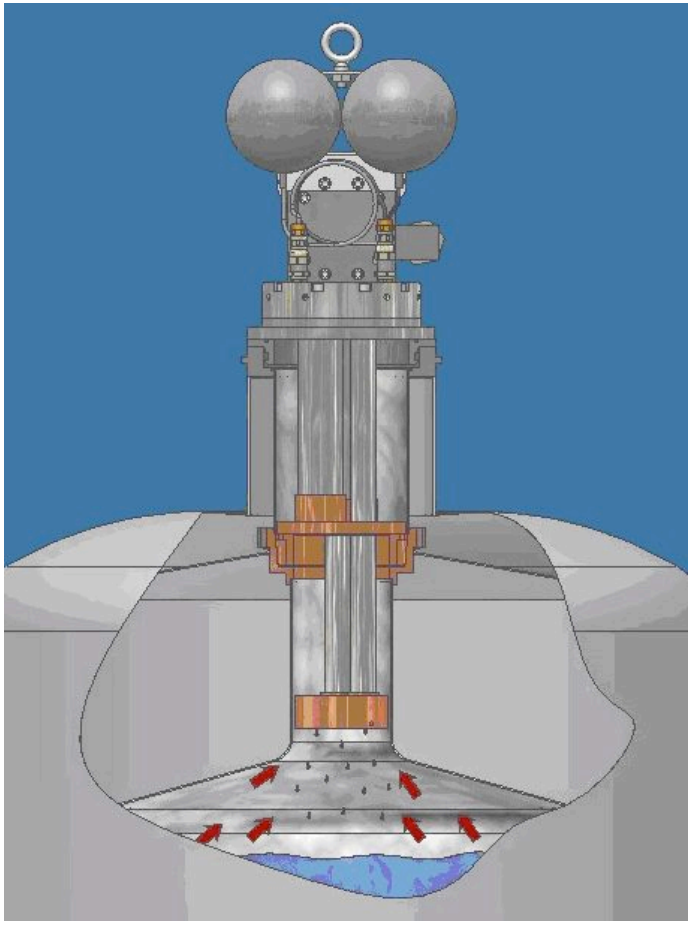
- The sale of the US helium reserve should be slowed down and then halted so that a substantial (permanent) reserve is maintained.[But this will/may require new legislation by the US Congress]
- Grantees of NSF and other agencies should ‘enjoy’ the same government contracted price of reserve helium from the vendors.
- Dedicated ‘liquid helium’ budget for grantees.
- NSF and other gov’t agencies that support projects that use helium should initiate programs to provide support for grantees to acquire systems to recycle helium and to acquire cryogen free cryostats.
- Other ideas?

Cryogen-Free Dilution Refrigerator

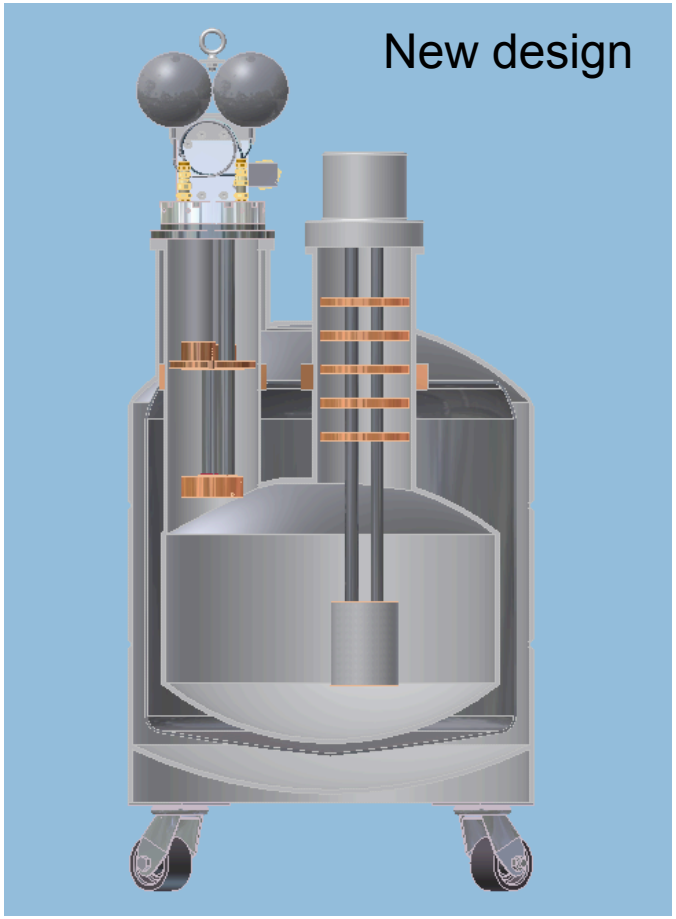


Drawings courtesy of Leiden Cryogenics

Pulse Tube Recondenser



15 L/day

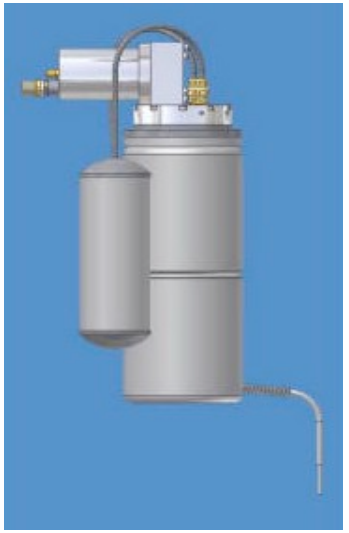


~20 L/day for 1 W PT cooler

Courtesy: Cryomech

Pulse Tube Helium Liquefier

12-18 liters per day of LHe
7.2 kW input (12 L/day)
10.7 kW input (18 L/day)



10 L/day

New

Photos courtesy of Cryomech

Current He-3 Crisis

- Cryogenic companies (and individual scientists) are experiencing difficulty buying He-3 in the last few months.

- When it was available, the price was ~1000 US dollars per liter; a increase of 10-12 times in one year.

- Reason for the crisis?

  The problem stems from the fact that a large number of neutron detectors(up to 70 liters of He-3 per detector) are being built by US government (only?) to look for illegal transport of radioactive materials (Uranium and Plutonium ?).

What can we do as a community?

Gather and confirm information,

(1) How much He-3 is released per year by US DOE (and Russia?)
(10,000 liters by US DOE? and similar amount by Russia?)
How much He-3 is needed by US and other governments to build neutron detectors? (US:20,000 liters per year? for how many years?)
Is there a better 'substitute' (e.g. solid state device) neutron detector.

(2) How much He-3 is needed for cryogenic purposes per year
(~5000 liters? ~100 new DR and He-3 cryostats per year, 3000 liters;
2000 liters for replacement needs?)

What should we do?

(1) In US: Appeal to the DOE Office of Science for immediate short term 'release' and long term allocation of He-3 gas for cryogenic use.
Recommendation of a comprehensive study of the He-3 'problem'

(2) Similar (?) action in Russia?