US Government Approach to Addressing the He-3 Shortage

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Abstract:

The United States is facing a shortage of helium-3 (He-3), which is an essential material for current generation nuclear safeguards and radiation detection equipment. The U.S. stockpile of He-3 came as a byproduct from the U.S. nuclear weapons program. Since the end of the cold war, this surplus has not been recharged, due to the nuclear weapons draw down. With the increased concern over nuclear terrorism, the demand for He-3 has increased dramatically. At current consumption rates, ^{3}He supply is predicted to meet only a small percentage of the projected demand per year.

Recent coverage in the scientific press has also highlighted the shortage, focusing on the potential impact on scientific research due to the increased demand. He-3 is not only used in neutron detection, but also for cryogenic applications, medical diagnostics, oil and gas exploration and other areas.

The White House is leading an interagency effort, involving the Departments of Commerce, Defense, Energy, Homeland Security, and State, to conserve existing He-3 stocks, develop additional supplies, and develop alternative technologies. This paper reviews the comprehensive approach being taken to address the He-3 shortage via: (1) Policy and International Engagement, (2) Supply, (3) Demand, and (4) Technology.

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Introduction:

The United States is facing a shortage of helium-3 (He-3), which is an essential material for current generation nuclear safeguards and radiation detection equipment. The U.S. stockpile of He-3 came as a byproduct from the U.S. nuclear weapons program. Since the end of the cold war, this surplus has not been recharged, due to the nuclear weapons draw down. However, the demand for He-3 has increased dramatically. At current consumption rates, ^{3}He supply is predicted to meet only a small percentage of the projected demand per year.

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Historic He-3 Production and Use

He3 is a non-radioactive and non-hazardous isotope of helium. It is rare in nature and currently manufactured rather than extracted. The US inventory of He-3 is created exclusively through the β^- decay of tritium, which is a gas that is used in nuclear weapons. New He-3 comes from the 5.5% of the tritium stockpile that decays annually.

In the past, He-3 was considered a waste product of the U.S. weapons tritium production, and has been made available to the DOE Isotope Program since the 1980s. DOE's Isotope Program distributes He-3 obtained as a byproduct of nuclear weapons dismantlement and refurbishment. Between 1980 and 2003, DOE accumulated an inventory of approximately 260,000 liters of He-3 from tritium reprocessing. Meanwhile, current US production of He-3 is approximately 8000 liters/year.

In the aftermath of the September 11, 2001 attacks, interest in development and installation of radiation monitoring systems at ports and border crossings in the US and around the world grew. He-3 has a high absorption cross section for thermal neutrons and is a converter gas in neutron detectors. This makes the gas extremely attractive to the neutron scattering community who has the largest demand for He-3 currently.

Besides its use in neutron detection, the unique properties of He-3 make it a critical material for ultra-low temperature research. Dilution refrigerators, for example, allow temperatures as low as a few thousandths of a degree Kelvin to be achieved. Another attribute of He-3 is its ability to be polarized, useful for lung imaging in pulmonary research. Oil and gas exploration is another area of potential growth wherein a He-3 based detector can be installed coaxially with the drilling mechanism, allowing operators to determine soil properties while drilling.

Additional supplies have also historically come from Russia. However, in that last two years, they have sharply curtailed sales into the world market.

As a result of the increased interest in neutron detection, along with its other commercial uses, sales of He-3 sharply increased, drawing down available supply. A typical radiation portal monitor contains approximately 30 liters of He-3 gas. Plans called for deployment of thousands of such monitors within the US and overseas, with a projected need of 77,000 liters. A neutron spallation facility can use as much as 30,000 liters in a single system and the neutron scattering community anticipates a future need of as high as 105,000 liters. Since 2003, over 258,000 liters of US gas has been released for use. US Government agencies recognized the impending shortfall and in summer 2008 began scoping out the problem.

Addressing the problem

In March 2009, an informal interagency team was established to better understand total USG requirements for He-3 and the scope of the problem. The interagency team consisted of representatives from the Departments of Commerce, Defense, Energy and Homeland Security, the largest users. From this initial data collection effort, it became apparent that, without constraints, long term needs were a factor of ten greater than supply. In order to address this discrepancy, the interagency team divided the problem into four working groups: Policy, Demand, Supply, and Alternative Technology.

- The Policy Working Group identifies the policy and procedural issues associated with the interagency activities to address the identified ^{3}He shortage. Based on available legal authority for managing the allocation of ^{3}He, develop draft policies, and procedures associated with the current and projected use of ^{3}He for Government and non-government applications.

- The Demand Working Group projects demand and suggest priorities across the Government and non-government enterprises associated with use of ^{3}He gas. This working group shall ascertain current and future demand of purified ^{3}He gas estimated for current year and future years.

- The Supply Working Group investigates and analyzes potential sources of $^{3}_{2}$He to assist the DOE/NNSA in finding increased amounts of $^{3}_{2}$He gas for distribution in the future.

- The Technology Working Group investigates alternative technologies to ^{3}He based neutron detectors and disseminates the information to Government agencies.

In July 2009, the White House National Security Staff (NSS) formed an Interagency Policy Committee (IPC), with broad federal representation, to investigate strategies to decrease overall demand for ^{3}He, increase supply, and make recommendations to optimally allocate existing supplies. The working groups report their findings and

recommendations to the IPC that makes the final decisions. Working Group and NSS guidance resulted in an approach that looks at resolving the problem in the near (1-2 years), medium (2-4 years) and long term.

In the near term all users were requested to re-analyze their use of He-3 and to look at ways to reduce those needs. Several projects that were running behind schedule, for example, were identified and He-3 allocation deferred. Programs were asked to inventory and identify stores of He-3 that were no longer needed resulting in the immediate discovery of several hundred liters of addition gas.

In the medium term, focus is on identifying potential new sources of He-3, such as at heavy water reactors and possible separation of He-3 from He-4 reserves. Since the water in heavy water reactors gain tritium over time, if detritiation is done and the tritium stored, He-3 will grow with time. In addition, commercially available alternative detector technologies, not reliant on He-3 (such as B-10), are also being identified and tested. As will be discussed during the course of this session, industry is already working with users on testing and certification of such alternatives. In the medium term, we also need to have a strong understanding of the enduring need for He-3 so as to best match the need with the supply.

Long range goals include a reliable supply of He-3 and broad range of alternative detectors that match technical needs for such diverse applications as portal monitoring and material accountability.

Management Strategy for Remaining He-3

In the near term, the allocation strategy is:

1. Defer further allocation of He-3 for portal monitors, beginning in FY10.
2. The USG will not support allocating He-3 for new initiatives that would result in an expanding He-3 infrastructure.
3. In considering He-3 requests, DOE-OS should rank the requests according to the following priorities.
    a. Those programs requiring the unique physical properties of He-3 have first priority.
    b. Those programs that secure the threat furthest away from US territory and interests have second priority.
    c. Those programs for which substantial costs have been incurred will have third priority.

The Programs are also working towards accelerating deployment of non-He-3 detectors, while seeking additional supply from heavy water reactors and a strong recycling effort.

As will be discussed during the course of this session, in the near term the most promising technologies lie in Boron based detectors, such as B-10 and BF3. Lithium-

doped fibers also hold strong promise. In the longer term, solid-state and/or scintillator detectors look to become commercially available.

The supply/demand imbalance is not just a US issue and cannot be resolved just by the US. We have reached out to potential supplier partners as well as the IAEA and requested their assistance to address and resolve this issue. IAEA support is especially needed in satisfying safeguards requirements that in the past have relied on He-3 detectors. The US has requested the IAEA to contact countries who may have He-3 and ask that the material be made available to support safeguards efforts. We are also looking to work with the IAEA in the development and testing of non-He-3 detection systems.

Impact on Remaining Supply

Figure 1 shows the projected US Supply and Demand of He-3 before action was taken to address the supply/demand imbalance. In this scenario, unconstrained use of He-3 would have depleted remaining supply as early as FY2010, but certainly by FY2011. The efforts to prioritize allocations have provided us with time to address the shortfall and resolve it for the longer term.

Figure 1: Projected US Supply and Demand (Without Action)

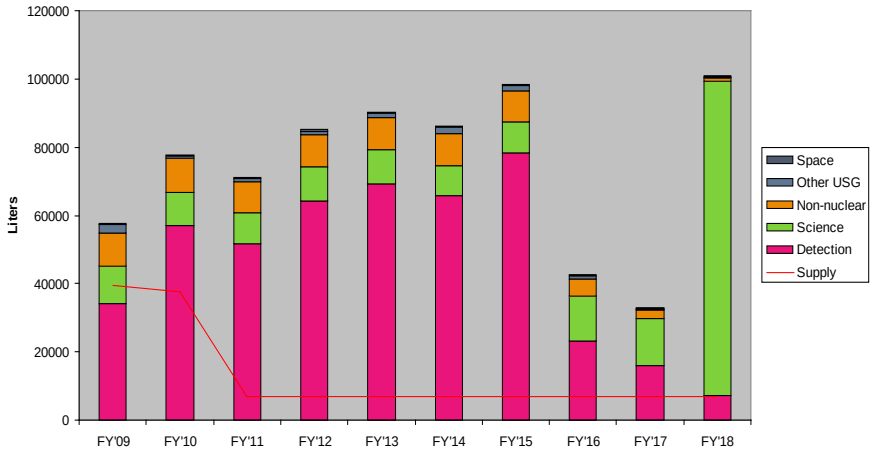
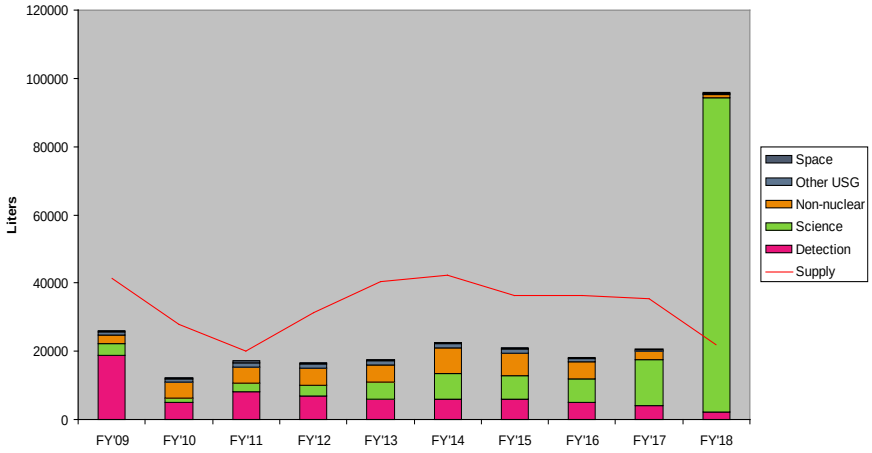


Figure 2, shows that our efforts will allow us time to identify and obtain new supply while satisfying needs of users for whom alternatives are further down the road.

Figure 2: Projected US Supply and Demand with Mitigation



Conclusion:

There is a critical shortfall in the availability of He-3. The US Government agencies are cooperating to bring supply and demand into balance while supporting essential uses for which there are no alternatives. The shortage cannot be resolved by the US alone, but requires a global effort. Organizations such as the INMM must also play an active role in information sharing on detector development and best practices for use.