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Report to Congressional Requesters

May 2011

MANAGING CRITICAL ISOTOPES

Weaknesses in DOE's Management of Helium-3 Delayed the Federal Response to a Critical Supply Shortage

GAO

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GAO-11-472

Highlights

Highlights of GAO-11-472, a report to congressional requesters

Why GAO Did This Study

Helium-3 gas is a key component of equipment used at ports and border crossings to detect radiation and prevent the smuggling of nuclear material into the United States, among other uses. The National Nuclear Security Administration (NNSA), a separate agency within the Department of Energy (DOE), extracts helium-3 and controls the inventory. Since 2003, NNSA has made helium-3 available for sale to DOE's Isotope Development and Production for Research and Applications Program (Isotope Program). After September 11, 2001, demand increased for radiation detection equipment, and in 2008, the federal government learned that it faced a severe domestic shortage of the gas. GAO was asked to review DOE's management of helium-3 to (1) determine the extent to which the federal government's response to the helium-3 shortage was affected by DOE's management of helium-3; (2) determine the federal government's priorities for allocating the limited supply of helium-3; and (3) describe the steps that the federal government is taking to increase the helium-3 supply and develop alternatives to helium-3. GAO reviewed DOE and NNSA documents and interviewed cognizant agency officials.

What GAO Recommends

GAO recommends, among other things, that DOE clarify whether the stewardship for those isotopes produced outside the Isotope Program, such as helium-3, rests with the program or another DOE entity. DOE stated that it understands and can implement these recommendations.

View GAO-11-472 for key components.
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May 2011

MANAGING CRITICAL ISOTOPES

Weaknesses in DOE's Management of Helium-3 Delayed the Federal Response to a Critical Supply Shortage

What GAO Found

The federal government's awareness of and response to the helium-3 shortage was delayed because no DOE entity had stewardship responsibility for the overall management of helium-3—a by-product of the radioactive decay of tritium, a key component of the U.S. nuclear weapons program. Although the Isotope Program's mission includes selling isotopes and providing related isotope services, senior program officials said that they interpret this mission to exclude helium-3 and 16 other isotopes that the program sells but whose supply it does not control. As a result of this weakness in DOE's management of helium-3, officials at the Isotope Program and NNSA did not communicate about the helium-3 inventory or its extraction rate. According to NNSA and Isotope Program officials, they communicated with each other about how much helium-3 to sell each year and at what price but not about the size of the helium-3 inventory or extraction rate because NNSA generally treated this information as classified, due to concerns that the helium-3 inventory could be used to calculate the size of the U.S. tritium stockpile. NNSA and Isotope Program officials told GAO that this lack of communication contributed to the federal government's delayed response to the helium-3 shortage. The standards for internal control in the federal government state that information should be communicated to management and others within a time frame that enables them to carry out their responsibilities. Further, without stewardship by a DOE entity, key risks to managing helium-3, such as the lack of complete information on the production and inventory of helium-3, were not identified or mitigated. The federal standards for internal control state that management should assess the risks faced from external and internal sources and decide what actions to take to mitigate them.

Facing this critical shortage of helium-3, DOE and other federal agencies are collaborating to bring supply and demand into balance. Specifically, in July 2009, an interagency policy committee was formed, which halted allocations of helium-3 for domestic radiation detection equipment and established three priorities for allocating helium-3: (1) applications for which there are no alternatives to helium-3 have first priority (e.g., research that can be achieved only with helium-3); (2) programs for detecting nuclear material at foreign ports and borders have second priority; and (3) programs for which substantial costs have already been incurred have third priority (e.g., a DOE research facility that conducts physics research).

To increase the supply of helium-3, the federal government is, among other things, pursuing other sources and developing alternatives. Specifically, NNSA is in discussions with Ontario Power Generation (OPG), a power company in Ontario, Canada, to obtain helium-3 from its stores of tritium. OPG has accumulated tritium as a by-product of producing electricity using a type of nuclear reactor not found in the United States. Also, federal agencies and private companies are researching alternative technologies to replace helium-3 in several applications to decrease demand.

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Abbreviations

cGMP	current good manufacturing practices
DHS	Department of Homeland Security
DOD	Department of Defense
DOE	Department of Energy
Isotope Program	Isotope Development and Production for Research and Applications Program
MOU	Memorandum of Understanding
NIH	National Institutes of Health
NIST	National Institute of Standards and Technology
NNSA	National Nuclear Security Administration
OPG	Ontario Power Generation

GAO
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United States Government Accountability Office
Washington, DC 20548

May 12, 2011

The Honorable Brad Miller
Ranking Member
Subcommittee on Energy and Environment
Committee on Science, Space, and Technology
House of Representatives

The Honorable Donna Edwards
Ranking Member
Subcommittee on Investigations and Oversight
Committee on Science, Space, and Technology
House of Representatives

Helium-3 gas is a critical component of radiation detection equipment, including radiation detection portal monitors that are used to screen cargo and vehicles at ports and border crossings around the world to prevent nuclear material from being smuggled into the United States. For example, the Department of Homeland Security (DHS) has deployed over 1,400 radiation detection portal monitors containing helium-3 at U.S. ports and border crossings. In addition, helium-3 is used in various industrial applications, such as oil and gas exploration and road construction, and in research applications, including physics research requiring ultra-low temperatures that can only be achieved using helium-3. Until 3 years ago, the United States' helium-3 supply was viewed as sufficient to meet demand. Outside the United States, Russia has been the only other major source of commercially available helium-3. But in 2008, the federal government abruptly learned that it faced a severe shortage of helium-3. At the same time Russia has curtailed its sales of helium-3, indicating that its supply is also waning. Because of this global shortage, no future deployments of radiation detection portal monitors containing helium-3 are planned in the United States.

Helium-3 is a byproduct of the radioactive decay of tritium,[1] a key component of the nation's nuclear weapons that is used to enhance their power. The U.S. tritium stockpile is maintained by the National Nuclear

[1]Tritium radioactively decays into helium-3 at an annual rate of 5.5 percent. For further information about tritium production, please see GAO, *Nuclear Weapons: National Nuclear Security Administration Needs to Ensure Continued Availability of Tritium for the Weapons Stockpile*, GAO-11-100 (Washington, D.C.: October 7, 2010).

Security Administration (NNSA), a separately organized agency within the Department of Energy (DOE).[2] In maintaining this tritium stockpile, NNSA removes the helium-3 that accumulates as tritium decays because the helium-3 can diminish the effectiveness of the nuclear weapons. In the past, NNSA and its predecessor agencies considered helium-3 to be a waste product of the weapons program and vented it to the atmosphere. From about 1980 through 1995, and again from 2003 through 2008,[3] NNSA provided helium-3 to DOE's Isotope Development and Production for Research and Applications Program (Isotope Program) to sell. The Isotope Program's mission is to produce and sell isotopes and related isotope services, maintain the infrastructure required to do so, and conduct research and development on new and improved isotope production and processing techniques.[4] DOE's Isotope Program produces and sells about 200 isotopes, though it does not control the supply—that is, the production or inventory—of all the isotopes it sells, such as helium-3, which is extracted from tritium by NNSA.

With the end of the Cold War, the United States has been reducing the number of nuclear weapons in its stockpile, resulting in less tritium and, therefore, less helium-3. In the aftermath of the September 11, 2001, terrorist attacks, however, demand for helium-3 increased due to the deployment of radiation detection portal monitors at ports and border crossings in the United States and other countries to prevent the smuggling of nuclear material. Thousands of such portal monitors were deployed across the United States and overseas, and more are planned to be deployed. Additionally, large quantities of helium-3 have been used in the last 10 years by research facilities in the United States and internationally for large-scale physics research applications, and more is needed for this research to continue. Overall, this decreasing supply during a period of increasing demand resulted in a shortage of helium-3.

[2]Congress created NNSA as a semiautonomous agency within DOE under title 32 of the National Defense Authorization Act for Fiscal Year 2000 (Pub. L. No. 106-65, § 3211, 113 Stat. 957 (1999)). NNSA is responsible for the management and security of the nation's nuclear weapons, nonproliferation, and naval reactors programs.

[3]The Isotope Program did not sell helium-3 from about 1995 through 2001 because helium-3 was being stockpiled for use in NNSA's Accelerator Production of Tritium project. During this time, Russia was the primary source of commercially available helium-3.

[4]Isotopes are chemical elements or varieties of a given chemical element with the same number of protons but different numbers of neutrons (e.g., helium-3 has one less neutron than helium-4, the helium isotope that is commonly used in party balloons).

In June 2008, a contractor alerted DHS that the contractor was unable to obtain a sufficient amount of helium-3 to fulfill its contract to provide radiation detection portal monitors. DHS contacted the Isotope Program to inquire about the helium-3 supply, and in September 2008, DOE responded to this sudden awareness of the shortage by suspending its helium-3 sales through public auction, which was the vehicle through which the Isotope Program sold helium-3. In March 2009, DHS, the Department of Defense (DOD), DOE, and NNSA formed an integrated project team to collect and analyze information and make recommendations to senior management at these departments on actions to be taken to address the shortage. The overall shortage of helium-3 raises concerns about the United States' ability to provide a sustainable supply of helium-3 for national security and research applications. In this context, you asked us to review DOE's management of helium-3. Our objectives were to (1) determine the extent to which the federal government's response to the helium-3 shortage was affected by DOE's management of helium-3; (2) determine the federal government's priorities for allocating the limited supply of helium-3 to various users; and (3) describe the steps that the federal government is taking, if any, to increase the helium-3 supply and develop alternatives to helium-3.

Scope and Methodology

To determine the extent to which the federal government's response to the helium-3 shortage was affected by DOE's management of helium-3, we reviewed the DOE Isotope Program's strategic planning documents, helium-3 sales data, and information on NNSA's inventory of helium-3. We also interviewed officials at DOE, DOE's Savannah River Site, NNSA, and DHS, as well as representatives from Linde[5] and GE Reuter-Stokes, the two principal companies that purchased helium-3 from the Isotope Program. Also, we used the federal standards for internal control to assess DOE's management of helium-3.[6] To determine the federal government's priorities for allocating the limited supply of helium-3 to various users, we reviewed documents of the integrated project team. We also reviewed the helium-3 allocation decisions, criteria, and process of the interagency policy committee convened in 2009 by the National Security Staff, which

[5]Linde acquired Spectra Gases, one of the principal buyers of helium-3, in 2006; Spectra Gases changed its name to Linde in 2009.

[6]GAO, *Standards for Internal Control in the Federal Government*, GAO/AIMD-00-21.3.1 ("Green Book") (Washington, D.C.: November 1999).

report to the National Security Advisor,[7] to oversee the integrated project team and make policy decisions to manage the helium-3 shortage. The policy committee is a multi-agency committee consisting of key agencies and departments that use helium-3 applications to support their missions, including the Department of Commerce's National Institute of Standards and Technology (NIST), DOD's Defense Threat Reduction Agency, the Department of State, DOE, and DHS. We also interviewed officials at NIST, the Department of Health and Human Services' National Institutes of Health (NIH), DHS, DOD, DOE, DOE's Oak Ridge and Pacific Northwest National Laboratories, and NNSA, as well as National Security Staff. To describe the steps that the federal government is taking, if any, to increase the helium-3 supply and develop alternatives to helium-3, we reviewed feasibility studies that presented options for alternative sources and recycling unused equipment and interviewed representatives from Ontario Power Generation, a Canadian power company. We reviewed research and documentation, including test results, on alternatives to helium-3 that are being developed by companies and interviewed representatives from these companies and officials at DHS, DOD, DOE, NIH, NIST, NNSA, and Oak Ridge National and Pacific Northwest National Laboratories. We conducted this performance audit from April 2010 to May 2011, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

The unique physical properties of helium-3 have led to its use in a wide variety of national security, scientific, industrial, and medical applications. Helium-3 is widely used for detecting nuclear material and safeguarding nuclear weapons because, among other things, of its ability to efficiently absorb neutrons. In radiation detection equipment, helium-3 is used to detect neutrons that are emitted by nuclear material. In radiation detection portal monitors, long, thin metal tubes are filled with helium-3; neutrons passing through these tubes react with the helium-3, creating charged particles that are detected by the monitors. Also, as a nontoxic gas that is

[7]The National Security Staff, established under the National Security Advisor, support all White House policymaking activities related to international and homeland security matters.

not absorbed by the human body, helium-3 is used in magnetic resonance imaging (MRI) to research pulmonary disorders, such as chronic obstructive pulmonary disease.[8]

Helium-3 is rare because it is currently extracted solely as a byproduct of the radioactive decay of tritium. During the Cold War, the United States produced tritium in nuclear reactors and stockpiled it for the nuclear weapons program. Helium-3 is also available from natural sources, such as subterranean natural gas deposits, but it has not been pursued commercially in the past because it is found in very low concentrations. NNSA and its predecessor agencies produced tritium at the Savannah River Site K-reactor in South Carolina and purified tritium by removing helium-3 at the Mound Plant, a weapons research laboratory in Ohio. Following the end of the Cold War, as the United States reduced its nuclear weapons stockpile and ceased producing tritium, its inventory of helium-3 decreased commensurately. In 1988, DOE shut down the K-reactor for safety reasons and, in 1995, closed the Mound Plant, thus eliminating the U.S. government's large-scale ability to produce and purify tritium. NNSA has been able to meet the tritium needs of the nuclear weapons program by maintaining the existing stockpile and recycling tritium from dismantled nuclear warheads.

To maintain the current tritium stockpile, NNSA extracts helium-3 from tritium on a daily basis and stores the helium-3 in pressurized cylinders at the Savannah River Site. To remove trace amounts of tritium and other impurities, NNSA ships these cylinders of helium-3 to Linde in New Jersey, which operates the only commercial facility in the United States licensed by the Nuclear Regulatory Commission to purify helium-3 of trace amounts of tritium. While NNSA's helium-3 inventory at the Savannah River Site is constantly changing, as of early February 2011, it was almost 31,000 liters. NNSA estimates that about 8,000 to 10,000 liters of helium-3 will be made available per year from the current tritium stockpile. Like the United States, Russia extracts helium-3 from its tritium stockpile. According to National Security Staff documentation and representatives of Linde, Russia has curtailed its sales of helium-3, indicating that its supply is likely waning.

[8]Chronic obstructive pulmonary disease, commonly referred to as COPD, is a lung disease in which the lungs are partially blocked, making it difficult to breathe. In this type of research, a patient inhales helium-3 during the MRI so that doctors may get a clear view of the entire pulmonary structure.

Isotope production and distribution has been a long-standing mission of DOE. DOE's Isotope Program provides isotopes to support the national need for a reliable supply of isotopes used in medicine, industry, and research. DOE transferred the Isotope Program to DOE's Office of Science from DOE's Office of Nuclear Energy starting in fiscal year 2009. In anticipation of this transfer, in August 2008, the Isotope Program organized a workshop to discuss the nation's needs for isotopes, and identified those isotopes with supply challenges. As noted in the workshop summary report, the workshop assembled, for the first time, stakeholders from all the different areas of the diverse isotope community to discuss the nation's current and future needs for isotopes and to consider options for improving the availability of needed isotopes.[9] The workshop enabled the Isotope Program to discuss and develop program priorities, including those isotopes, such as helium-3, that were in short supply. This workshop identified 12 isotopes, including helium-3, that faced supply challenges and had less than 3 years before their supplies at that time were completely consumed.

In August 2003, the Isotope Program signed a Memorandum of Understanding (MOU) with NNSA to make available an initial 103,570 liters of helium-3 for sale, followed by at least 10,000 liters of helium-3 per year from 2004 through 2008. At the time the MOU was signed, NNSA's inventory of helium-3 was estimated at about 260,000 liters. Following this agreement, the Isotope Program held a series of public auctions to sell helium-3. A public auction process was used, according to program officials, to encourage competition. The Isotope Program and NNSA determined the quantity and minimum price of helium-3 for each auction; the price was set to recover the costs to extract helium-3 and the administrative costs of selling it. Linde and GE Reuter-Stokes, a company that manufactures helium-3 tubes for radiation detection portal monitors and other neutron detection applications, have been the two buyers of helium-3 who participated in the Isotope Program's public auctions. From 2003 through 2009, the Isotope Program sold, or NNSA transferred, more than 209,000 liters of helium-3—an average of almost 30,000 liters of helium-3 per year, as shown in table 1. Given NNSA's capacity to extract between 8,000 and 10,000 liters of helium-3 annually, this rate of sale exceeded the extraction rate and decreased the inventory.

[9] DOE, *Workshop on the Nation's Needs for Isotopes: Present and Future*, DOE/SC-0107 (Rockville, Maryland, December 2008).

Table 1: Quantities of Helium-3 Sold or Transferred from 2003 through 2009

Date sold	Customer	Quantity (liters)
March 2003	Spectra Gases[a]	7,826
February 2004	G.E. Reuter-Stokes	95,791
June 2005	Spectra Gases[a]	23,310
July 2006	Spectra Gases[a]	26,963
August 2008	DOE Spallation Neutron Source (interagency transfer from NNSA)	34,325
January 2009	Lind[e]	10,585
	G.E. Reuter-Stokes	11,088
Total		**209,888**

Source: GAO analysis of NNSA and Isotope Program data.

[a]Spectra Gases was acquired by Linde in 2006 and changed its name to Linde in 2009.

Following the terrorist attacks of September 11, 2001, the demand for helium-3 nearly tripled, because of the increased focus on radiation detection applications. Specifically, DHS's Radiation Portal Monitor program, NNSA's Second Line of Defense program, and DOD's Guardian program all use helium-3 in radiation detection portal monitors deployed at domestic and foreign ports, border crossings, and military installations. DHS alone has deployed over 1,400 radiation detection portal monitors domestically. The largest demand for helium-3 has historically been for homeland security and scientific research, but demand for other applications, such as in MRIs for lung research, has also increased.

Federal Response to the Helium-3 Shortage Was Delayed by Weaknesses in DOE's Management of Helium-3

The federal government's awareness of and response to the helium-3 shortage was delayed because no DOE entity had stewardship responsibility for the overall management of helium-3. As a result of this lack of stewardship responsibility, officials from DOE's Isotope Program, which sold helium-3, and NNSA, which extracted it from tritium, did not communicate about the helium-3 inventory or its extraction rate. Without stewardship responsibility, key risks to managing helium-3, such as the lack of understanding of the helium-3 inventory and the demand for helium-3, were not identified or mitigated by either entity.

Officials from DOE's Isotope Program and NNSA Did Not Communicate about the Helium-3 Inventory or Its Extraction Rate

While the Isotope Program's mission includes selling isotopes and providing related isotope services, senior program officials said that they interpret this mission to exclude helium-3 and other isotopes that the program sells but whose supply it does not control. Accordingly, Isotope Program officials noted that the program sold and distributed helium-3 solely as a courtesy to NNSA, not because it was a core part of the program's mission or because it believed it had a stewardship responsibility to do so. NNSA officials also noted that helium-3 stewardship was not part of NNSA's mission of managing the nation's nuclear weapons. Without such stewardship responsibility, NNSA and Isotope Program officials did not communicate about the helium-3 inventory or its rate of extraction.

The Isotope Program's management of helium-3 sales was hampered by this lack of communication regarding the size of the helium-3 inventory and the rate at which helium-3 is extracted from tritium. Prior to selling helium-3 at public auction, officials from the Isotope Program and NNSA communicated with each other regarding how much helium-3 would be available to sell that year and the minimum price for which it would be sold at auction. However, Isotope Program and NNSA officials did not discuss the size of the helium-3 inventory, how much was being added to the inventory each year, or how quickly the inventory was being depleted. Additionally, NNSA officials did not inform Isotope Program officials when they transferred more than 34,000 liters of helium-3 in August 2008 to DOE's Spallation Neutron Source, a physics research facility at the Oak Ridge National Laboratory that uses helium-3 in large-scale neutron detectors. This transfer—more than what the Isotope Program sold per year, on average from 2003 to 2009—greatly reduced the helium-3 inventory, but NNSA officials did not inform Isotope Program officials about it until after the transfer was completed. Despite the helium-3 inventory being greatly reduced, in September 2008 the Isotope Program and NNSA renewed their MOU to continue selling helium-3 for an additional 5 years without discussing the size of the helium-3 inventory or the rate at which sales and large transfers—such as the one to DOE's Spallation Neutron Source—were reducing the inventory.

Helium-3 inventory and production information was not shared between officials at the Isotope Program and NNSA because, according to NNSA officials, this information was generally treated as classified by NNSA out of concern that the inventory and annual extraction rate could be used to calculate the size of the U.S. tritium stockpile, which is classified. In describing the situation, Isotope Program officials stated that they did not have the requisite "need to know" to gain access to this information, and consequently, did not discuss it. In other words, Isotope Program officials did not believe that they needed complete information on the size of the helium-3 inventory or how much was being added to the inventory each year in order to carry out the program's mission because helium-3 does not fall within its mission. One of the standards for internal control in the federal government—information and communications—states that information should be recorded and communicated to management and others within an entity in a form and within a time frame that enables them to carry out their responsibilities.[10] The lack of communication between NNSA and Isotope Program officials was not consistent with this standard. Isotope Program and NNSA officials told us that this lack of communication contributed to the government's delayed response to the helium-3 shortage. NNSA officials acknowledged the ambiguity about what information can be communicated about the helium-3 inventory and, in January 2010, issued a memorandum to clarify and broaden what information about helium-3 can be shared publicly. As a result, NNSA now reports that 8,000 to 10,000 liters of helium-3 will be made available per year.

Without Stewardship Responsibility, Key Risks to Managing Helium-3 Were Not Identified or Mitigated

Senior Isotope Program officials said that they did not identify and mitigate key risks to managing helium-3 sales because, unlike most isotopes that the program sells, officials do not consider stewardship of helium-3 to be part of the program's mission. Specifically, these Isotope Program officials did not consider their lack of understanding of the helium-3 inventory or the demand for helium-3 as risks to managing helium-3 sales. According to these officials, for those isotopes that are included in its mission—the isotopes that it produces—the Isotope Program developed strategic planning documents and generally updated these documents on an annual basis. We reviewed the Isotope Program's strategic planning documents and found examples where the program assessed risks to isotopes that it produces and sells. The Isotope Program, however, did not perform strategic planning for helium-3, including assessing risks, because program officials do not consider stewardship of helium-3 to be part of the program's mission. For those isotopes that the Isotope Program sells but whose supply it does not control, such as helium-3, Isotope Program officials told us that they see their role as a conduit that sells these isotopes to customers as a courtesy. There are 17 isotopes, including helium-3, that the program sells but, according to

[10] GAO/AIMD-00-21.3.1.

program officials, does not have stewardship responsibility for because the Isotope Program does not control their supply. For example, lithium-6, which is used in neutron detection applications and battery research, is sold by the Isotope Program, but its supply is controlled by NNSA.

Although program officials do not consider helium-3 to be part of the program's mission, it nonetheless collected information in order to forecast demand. To do this, the Isotope Program recorded the number of telephone inquiries from potential customers and the volume of helium-3 discussed. Because it does not view helium-3 as a part of its mission, program officials said that the Isotope Program did not take proactive steps to solicit information to better understand future demand. For example, according to representatives, the Isotope Program did not solicit information from Linde, the company that had purchased or purified nearly all the helium-3 in the United States, which gave Linde a more complete understanding of the historical and future demand for helium-3. In tracking telephone inquiries, the Isotope Program's records show that it received nine telephone calls in 2008 from customers who were interested in acquiring 1,226 liters of helium-3. In contrast, according to Linde documentation, based on its actual use, the demand for helium-3 in 2008 was nearly 60,000 liters. Linde representatives also noted that the Isotope Program did not seek demand-related information from Linde until after the shortage was realized.

Isotope Program officials told us that forecasting the demand for isotopes is very difficult because demand for isotopes can quickly change. Because of its effect on isotope inventories, changing demand is a risk to the program's management of the sale of all isotopes. One of the federal standards for internal control—risk assessment—states that management should assess the risks faced entity-wide, and at the activity level, from both external and internal sources, and that once risks have been identified, management should decide what actions should be taken to mitigate them. Risk identification methods may include, among other things, forecasting and strategic planning, and consideration of findings from audits and other assessments. A DOE advisory committee has also noted the importance of understanding demand for isotopes. In August 2008, DOE tasked its Nuclear Science Advisory Committee with establishing a standing subcommittee to research the needs and challenges of the Isotope Program and make recommendations to address them. According to the subcommittee report, for the Isotope Program to be efficient and effective, it is essential that it accurately forecasts the demand for isotopes.[11] The report noted that the "ability of the program to predict demand for certain isotopes needs vast improvement." It went on to recommend that the program "maintain a continuous dialogue with all interested federal agencies and commercial isotope customers to forecast and match realistic isotope demand and achievable production capabilities."

Isotope Program officials told us that they are considering convening a workshop, possibly in the summer of 2011, with federal agency stakeholders to discuss supply and demand of all isotopes that are produced or sold by the Isotope Program. According to the Director of the Facilities and Project Management Division, which manages the Isotope Program, while the program does not consider this role a part of its mission, it is volunteering to convene this workshop to be helpful to the isotope user community.

The Federal Government's Three Priorities for Allocating the Limited Supply of Helium-3 Exclude Domestic Radiation Detection Portal Monitors

In July 2009, the National Security Staff, under the National Security Advisor, established an interagency policy committee consisting of officials from DOD, DOE, DHS, the Department of Commerce, and the Department of State to address the helium-3 shortage. In doing so, the policy committee established the following three priorities for allocating the limited supply of helium-3:

- Priority 1: Applications for which there are no alternatives to helium-3, which includes, for example, research that requires ultra-low temperatures that can be achieved only with helium-3.
- Priority 2: Programs for detecting nuclear material at foreign ports and borders, which includes, for example, NNSA's Second Line of Defense program that deploys radiation detection portal monitors at key overseas ports and border crossings.
- Priority 3: Programs for which substantial costs have already been incurred, such as DOE's Spallation Neutron Source research facility that conducts physics research.

[11] Nuclear Science Advisory Committee, NSAC Isotopes Subcommittee, *Isotopes for the Nation's Future: A Long Range Plan. Final Report: Second of Two NSAC Charges on the Isotope Development and Production and Research for Applications Program* (August 27, 2009).

Furthermore, the committee eliminated further allocations of helium-3 for domestic radiation detection portal monitors beginning in fiscal year 2010 because, according to committee documents, it determined there are alternatives to using helium-3 to detect neutrons in these portal monitors. The policy committee also determined that it will not support allocating helium-3 for any new applications that would increase the demand for helium-3.

Following this approach, the policy committee has allocated helium-3 to federal agency and commercial customers from 2009 through 2011, as shown in table 2. These allocations have brought the supply and demand of helium-3 into closer balance and mark a significant decrease from the amount the Isotope Program previously sold or transferred from 2003 through 2009—an average of about 30,000 liters per year.

Table 2: Quantities of Helium-3 Allocated and Used, in Liters, from Fiscal Year 2009 to Fiscal Year 2011

	Quantities		
Customer	**FY 2009**	**FY 2010**	**FY 2011**
Low temperature research	N/A[a]	452[b]	700
DHS	N/A[a]	438[c]	1,218
DOD	N/A[a]	1,530	3,521
NNSA	6,367	5,098[d]	5,791
DOE's Office of Science	2,400	341	315
Intelligence Community	N/A[a]	N/A[a]	763
NIH	N/A[a]	260[e]	1,400
NIST	N/A[a]	607[f]	236
Oil and gas industry	N/A[a]	695[g]	1,000
Road construction industry	N/A[a]	N/A[a]	350
Total	**8,767**	**9,421**	**15,294**

Source: GAO analysis of information from the interagency policy committee and Linde.

[a]N/A refers to instances when a customer either did not receive an allocation or received its allocation through another customer.

[b]Low temperature research was allocated 1,800 liters but used only 452 liters.

[c]DHS was allocated 772 liters but used only 438 liters.

[d]NNSA was allocated 5,150 liters but used only 5,098 liters.

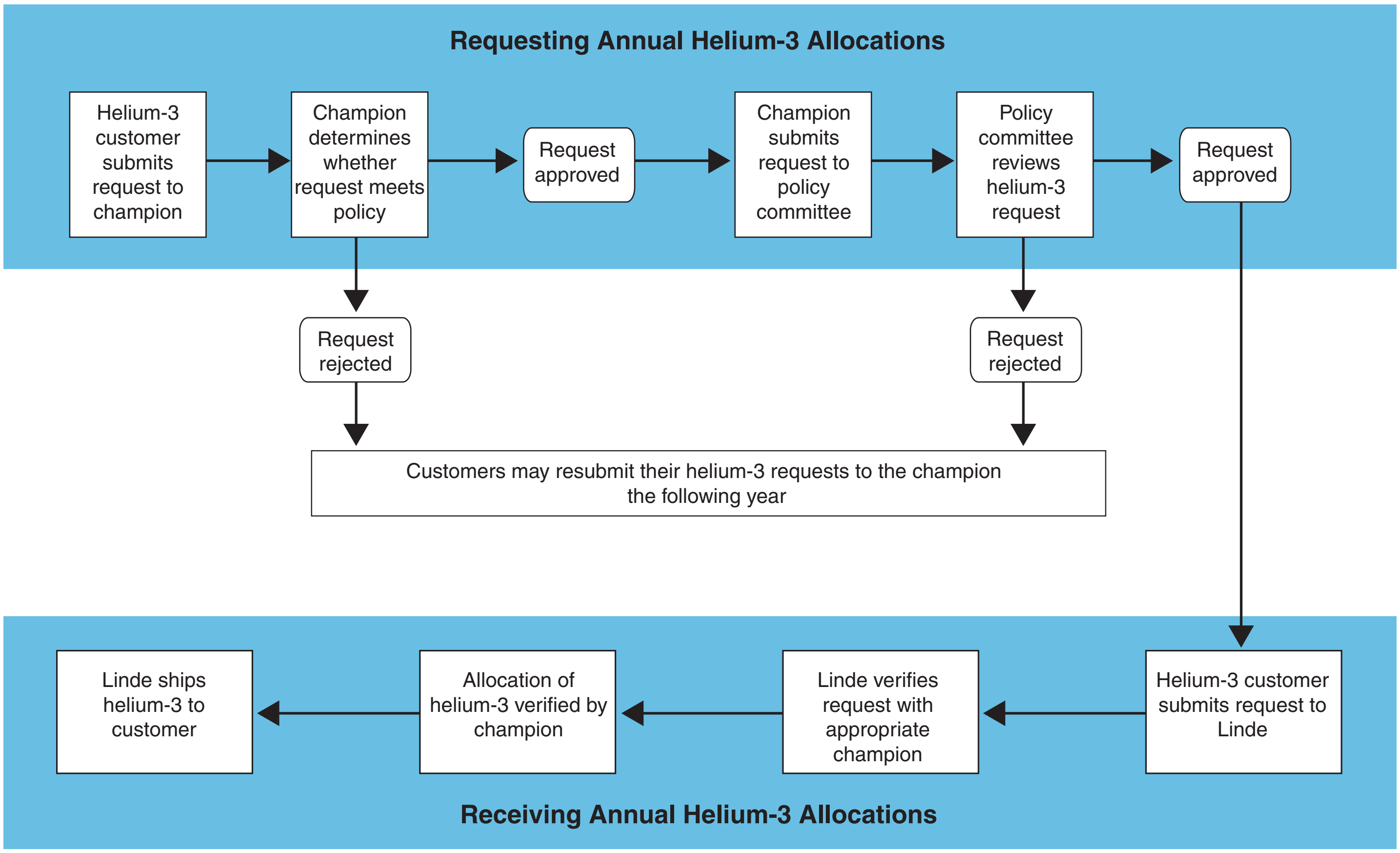
[e]NIH was allocated 1,800 liters but used only 260 liters.

[f]NIST was allocated 832 liters but used only 607 liters.

[g]The oil and gas industry was allocated 1,000 liters but used only 695 liters.

The policy committee developed a process for customers to request allocations of helium-3 using “champions,” which are agency officials who represent the federal agencies for which they work and its grantees; a champion is appointed by the Isotope Program for nonfederal customers, such as the oil and gas industry. The champion for a specific category of customer gathers all the helium-3 requests and determines whether the requests are consistent with the policy for allocating helium-3. If so, the champion submits the requests to the policy committee. The policy committee weighs the requests against the helium-3 priorities and the amount of helium-3 that is available to make allocation decisions. After allocation decisions are made, customers are notified and, if they received an allotment, they must submit a request for the helium-3 to Linde, which is contracted by the Isotope Program to purify and distribute the helium-3 allocations. When Linde receives a request for helium-3, according to Linde representatives, they verify the customer’s allocation with the appropriate champion. Once verification is received, Linde ships the allotted amount of helium-3 to the customer. This allocation and receipt process is the same for all customers—federal agencies, researchers, and private companies, as shown in figure 1.

Figure 1: Helium-3 Request and Receipt Process



Source: GAO analysis of information from DOE and Linde.

The helium-3 champions or the policy committee may reject a request for helium-3, as shown in figure 1. If rejected, customers may resubmit a request the following year. According to seven of the agency champions, customers are aware of the policy committee's priorities and have usually reduced the amount of their request to the absolute minimum amount of helium-3 that is needed. As a result, the committee has approved most requests.

When determining the annual allocations for helium-3, the policy committee also recommends to the Isotope Program a price at which helium-3 should be sold to different customers—including the federal, medical, and commercial entities. When the policy committee first began to allocate helium-3 in 2009, the Isotope Program, in consultation with the policy committee, established two different prices—one for medical applications and the other for all other applications. For use in the manufacture of drugs, medical devices, and other products, the Food and Drug Administration requires that helium-3 must be certified to meet specific requirements, called current good manufacturing practices (cGMP).[12] In 2009, the price for cGMP helium-3 was $600 per liter; helium-3 for all other applications was priced at $450 per liter.[13] Certifying helium-3 under cGMP requirements is more expensive, according to Linde representatives, because of the extra certification and purity testing that is required. This practice was continued for allocations in 2010. In 2011, however, the Isotope Program divided the price for helium-3 to be used for non-cGMP applications into two categories: one for federal agencies and their grantees and one for commercial and nonfederal agencies. Table 3 shows the different prices for helium-3, per liter, beginning with 2009.

Table 3: Allocated Helium-3 Prices per Liter

Customers	2009	2010	2011
Federal agencies and their grantees	$450	$365	$600
Commercial and nonfederal agencies	$450	$365	$1,000
cGMP	$600	$485	$720

Source: GAO analysis of information from DOE and Linde.

Key Federal Agencies Are Collaborating to Increase the Helium-3 Supply and Develop Alternatives

DOE and NNSA are taking actions to increase the supply of helium-3 by, among other things, pursuing other sources and recycling helium-3 from retired equipment. Specifically, NNSA officials said that NNSA is in discussions with Ontario Power Generation (OPG) to determine the feasibility of obtaining helium-3 from OPG's stores of tritium. OPG has accumulated this tritium as a by-product of producing electricity using heavy-water nuclear reactors.[14] According to OPG officials, it owns 16 heavy-water nuclear reactors that are currently operating that have produced enough tritium to initially yield approximately 100,000 liters of

[12]Current good manufacturing practices (cGMP) are regulations set by the Food and Drug Administration for the manufacture of drugs, medical devices, and other products to ensure that companies' products meet specific requirements for identity, strength, quality, and purity.

[13]From 2003 through 2009, before helium-3 allocations were managed by the policy committee, the price for helium-3 ranged from about $40 per liter to about $85 per liter.

[14]Heavy-water reactors are nuclear power reactors that use water containing deuterium oxide as a coolant and natural (not enriched) uranium as its fuel source.

helium-3. According to NNSA officials, once this initial amount is recovered, OPG estimates that its stores of tritium may yield about 10,000 liters of helium-3 annually. Combined with NNSA's current annual production of helium-3, obtaining helium-3 from OPG could boost the United States' supply to about 18,000 to 20,000 liters per year. In addition, DHS and DOE have expressed interest in exploring the option of extracting helium-3 from natural helium, or helium-4. Helium-3 is found in small quantities in natural helium and could possibly be extracted from the nation's helium reserve near Amarillo, Texas, that is managed by the Department of the Interior's Bureau of Land Management. The Bureau of Land Management estimates that approximately 125,000 liters of helium-3 may be present in the helium reserve, which could be extracted over the next 10 years. DOE officials estimate that a similar reserve of natural helium in Wyoming could yield another 200,000 liters of helium-3 that could be extracted over the life of the reserve. DHS officials note, however, that a feasibility study is needed to determine whether it would be cost-effective to extract helium-3 from natural helium.

Federal agencies and private sector companies have started to recycle helium-3 from unused equipment in order to boost the supply. For example, an analysis conducted by DOE shows that it can extract helium-3 from retired tritium storage beds at its tritium extraction facility at the Savannah River Site. DOE estimates that it could extract 8,000 to 10,000 liters from these storage beds every 8 to 10 years, beginning as early as 2012. Additionally, DOE surveyed its national laboratories and identified over 1,500 liters of helium-3 in unused equipment and storage cylinders that could be reused immediately. DHS has also identified retired equipment from which helium-3 can be extracted. Private companies have also started to recycle helium-3 from decommissioned radiation detection portal monitors. For example, according to a representative from a helium-3 tube manufacturing company, the company is buying retired radiation detection equipment to extract the helium-3.

In addition to increasing the supply of helium-3, federal agencies and private companies are researching alternatives to helium-3 for several applications in order to decrease demand. For example, the government is conducting research to develop alternatives for neutron detection applications, including radiation detection portal monitors and nuclear physics research, which together use more helium-3 than any other application. DHS, DOE, DOD, and NIST, for example, are supporting approximately 30 different programs, some of which may result in technologies available for use in radiation detectors that, according to agency documents, could be ready by 2012.[15] Similarly, DOE's Spallation Neutron Source research facility is coordinating with similar facilities internationally—including those in Germany, Japan, Russia, and Sweden—to develop alternative technologies for large-scale physics research applications. The private sector is also researching alternatives to helium-3 for radiation detection portal monitors and other applications, including MRIs for the lungs. For example, equipment using the isotopes lithium-6 and boron-10 may be able to replace helium-3 in radiation detection portal monitors, according to representatives from companies that are developing them. Like helium-3, lithium-6 is produced by NNSA and sold by the Isotope Program. According to one program official, this official contacted NNSA to inquire about the inventory and production rate of lithium-6 because of the potential for increased demand if lithium-6-related technologies are chosen to replace helium-3 in radiation detection portal monitors. NNSA officials told the Isotope Program official, however, that such information is classified and cannot be shared, but assured the official that NNSA has enough lithium-6 to meet any future increase in demand. In March 2011, the Director of the Facilities and Project Management Division, which manages the Isotope Program, said that, although classified, program officials do have access to this information through NNSA's Office of Nuclear Materials Integration. DOE officials said that they have evaluated the potential demand for lithium-6 and have taken steps to ensure there is an adequate supply. According to its director, the Office of Nuclear Materials Integration is responsible for, among other things, coordinating management of certain isotopes produced by NNSA, including tracking the inventory of these isotopes, and coordinating communication within DOE and NNSA. The director stated that it is the responsibility of the Isotope Program, however, to manage the activities under its control for these isotopes, such as selling them outside DOE and NNSA and conducting 5-year supply and demand forecasts. This raises concerns that without stewardship responsibility for the overall management of the supply and demand of lithium-6, or the other isotopes produced by NNSA, neither the Isotope Program nor any other DOE or NNSA entity may detect an imbalance, resulting in the shortage of another isotope.

[15] We are currently conducting a technology assessment of alternatives for detecting neutrons. This technology assessment will examine the potential and maturity of various technologies that could lower demand for helium-3. We expect to issue a report on this assessment later in 2011.

Conclusions

Facing a critical shortage of helium-3 since 2008, DOE and other federal agencies are collaborating to bring supply and demand into balance, while supporting essential applications for which there are no alternatives. This shortage occurred because the demand for helium-3 rose sharply in response to the increased deployment of radiation detection portal monitors, in addition to the increased use of helium-3 in research and other applications. The amount of helium-3 sold by the Isotope Program quickly outpaced the annual production, and this imbalance went undetected until the supply of helium-3 reached a critical shortage. The overall federal awareness of and response to the helium-3 shortage was delayed because no entity within DOE had stewardship responsibility for coordinating the production and sale of helium-3. Furthermore, there was a lack of communication between NNSA and Isotope Program officials over the size of the helium-3 inventory, how much was added to the inventory annually, and how quickly the Isotope Program's sales were depleting the inventory. While the Isotope Program's mission is to manage the production and sale of isotopes, including developing strategic plans and assessing risks for these isotopes, it has not taken a similar stewardship role in managing the 17 isotopes, including helium-3, whose supply it does not control. A key risk to managing the sale of all these isotopes is the lack of control over, and knowledge of, their supply. Under the federal standards for internal control, federal managers are to assess the risks faced entity-wide, and at the activity level, from external and internal sources and decide what actions to take to mitigate such risks. Because Isotope Program officials do not believe that they have a stewardship role for helium-3, they did not take steps to mitigate the risk of selling helium-3 without information on the size of the inventory or its rate of replenishment. Similarly, without a stewardship role, the program did not take sufficient steps to accurately forecast the increased demand for helium-3. Such forecasting is important in order to align demand with current inventory levels. In this regard, the subcommittee report of the Nuclear Science Advisory Committee stated that for the Isotope Program to be efficient and effective, it needs accurate forecasts for the demand for isotopes. A lack of communication and failure to identify risks and forecast demand ultimately delayed the Isotope Program's awareness of, and the federal government's response to, the helium-3 shortage. In conclusion, we believe that all isotopes without clear stewardship responsibilities may face the same risks that led to the helium-3 shortage.

Recommendations for Executive Action

We are making four recommendations to the Secretary of Energy designed to avoid future shortages associated with managing all isotopes that the Isotope Program sells but whose supply it does not control, including helium-3. First, we recommend that the Secretary of Energy clarify whether the stewardship for all these isotopes belongs with the Isotope Program or elsewhere within the Department of Energy. Once the stewardship for these isotopes has been assigned, we further recommend that the Secretary of Energy direct the head of the responsible office(s) to take the following three actions:

- develop and implement a communication process that provides complete information to the assigned entity on the production and inventory of isotopes that are produced outside the Isotope Program;
- develop strategic plans that, among other things, systematically assess and document risks to managing the isotopes and supporting activities, such as not having control over the supply of these isotopes, and implement actions needed to mitigate them; and
- develop and implement a method for forecasting the demand of isotopes that is more accurate than the one that is currently used. In this regard, the actions taken should be consistent with the forecasting recommendation from the subcommittee report of the Nuclear Science Advisory Committee.

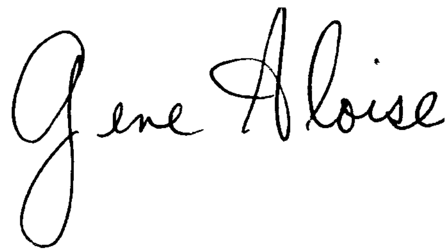
Agency Comments and Our Evaluation

We provided a draft of this report to the Secretaries of Energy and Homeland Security for their review and comment. DHS had no comments on the findings of the draft report or our recommendations. In a written response for DOE, the National Nuclear Security Administration's Associate Administrator for Management and Budget stated that he understands our recommendations and can implement them but took exception to our characterization of the Isotope Program's mission. In the report, we state that the Isotope Program's mission is to produce and sell isotopes and related isotope services, maintain the infrastructure required to do so, and conduct research and development on new and improved isotope production and processing techniques, which was its mission from 2003 through 2008—the time during which the Isotope Program was selling helium-3 by auction and the helium-3 shortage occurred. In its response, NNSA explained that the Isotope Program has been working to clarify its responsibilities for isotopes since 2009. In this regard, the DOE fiscal year 2012 Congressional Budget request describes the Isotope Program's mission as that of producing and distributing isotopes that are not commercially available and distributing other materials as a service to DOE. However, according to NNSA's comments, the Isotope Program does not have the mission to be the steward of stockpiles of other materials and their byproducts, including helium-3. Neither DOE's fiscal year 2012 Congressional Budget request, nor NNSA's comments explain what entity does have stewardship responsibility for helium-3 and several other isotopes that are sold by the Isotope Program, but produced elsewhere. Regardless of how the Isotope Program defines its mission today, at the most crucial time when helium-3 should have been carefully managed in order to avoid the sudden awareness of the shortage, no one entity believed it had the responsibility to do so. As a result, the shortage of an isotope that is critical to national security, research, industrial, and medical applications went undetected until the supply reached a critical level. Our recommendations are intended to assist in avoiding such a problem with helium-3 and other isotopes in the future.

DOE also provided technical comments that we incorporated as appropriate throughout the report. DOE's comments on our draft report are included in appendix I.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the appropriate congressional committees, Secretaries of Energy and Homeland Security, Administrator of NNSA, National Security Staff, and other interested parties. The report will also be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staffs have any questions about this report, please contact Gene Aloise at (202) 512-3841 or aloisee@gao.gov or Timothy M. Persons at (202) 512-6412 or personst@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix II.



Gene Aloise
Director
Natural Resources and Environment

Timothy M. Persons, Ph.D.
Chief Scientist
Director, Center for Science, Technology, and Engineering

Appendix I: Comments from the Department of Energy

NNSA National Nuclear Security Administration

Department of Energy
National Nuclear Security Administration
Washington, DC 20585

May 4, 2011

Mr. Gene Aloise
Director
Natural Resources and Environment
Government Accountability Office
Washington, DC 20458

Dear Mr. Aloise:

The Department of Energy (Department) and National Nuclear Security Administration (NNSA) appreciates the opportunity to review the Government Accountability Office's (GAO) report, *Managing Critical Isotopes: Weaknesses in DOE's Management of Helium-3 Delayed the Federal Response to a Critical Supply Shortage,* GAO-11-472. In response to a request made by the Subcommittee on Investigations and Oversight, Committee on Science and Technology, House of Representatives, GAO was asked to review the Department of Energy's (DOE) management of He-3 (He-3) to: (1) determine the extent to which the federal government's response to the He-3 shortage was affected by DOE's management of He-3; (2) determine the federal government's priorities for allocating the limited supply of He-3; and (3) describe the steps that the federal government is taking to increase the He-3 supply and develop alternatives to He-3. NNSA is responding on behalf of the Department.

The Department recognizes the need for improvements in managing He-3 and began to address this issue in 2008 via the Integrated Product Team (Team). As described in this report, He-3 allocation priorities have been established that have brought the supply and demand into a better balance. The result has been to defer the total exhaustion of US-origin He-3 from 2011 until the 2017-2018 timeframe, allowing the Team to develop alternative technologies to reduce the need for He-3, as well as secure additional supply.

We understand the GAO recommendations and can implement them. We are concerned, however, that the report does not accurately reflect the mission of the Isotope Program (IP), which in important aspects is determined by Congressional direction to both the Office of Science (SC) and the NNSA, and is not open to interpretation. To clarify the roles of both SC and NNSA regarding isotope production, in 2009, Deputy Secretary of Energy Dan Poneman directed SC and NNSA to develop a joint statement, describing the Department's approach to isotope research, development, and production to minimize risk or misuse. As a result, since the FY 2011 Congressional Budget request the Department has included a joint SC/NNSA statement on responsibility for isotopes in the SC budget Overview. A copy of the statement in the FY 2012 Budget Request is enclosed. While the IP has the mission to produce and distribute isotopes that are not commercially available and can distribute legacy materials as a service to the Department, it does not have the mission to be the steward of stockpiles of legacy materials and their byproducts. We believe the report, as written, may mislead the reader with an impression of the IP's mission and role as related to He-3.

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Below are a couple of points that we feel need some clarification:

- Throughout the report, the GAO says that NNSA "produces" He-3. NNSA does not produce He-3; rather He-3 is extracted. While this may seem an issue of semantics, we feel it is important to note that we never manufactured He-3 for the purpose of commercial sales. Rather, NNSA extracted He-3 as part of our mission to maintain the U.S. nuclear weapons stockpile. Additionally, on Page 5 of the report states that He-3 is rare because it is only produced through the radioactive decay of tritium. While He-3 is currently only extracted from the radioactive decay of tritium it exists in very low concentration in natural sources, for example natural gas.

- With respect to using Lithium 6 (Li-6) as an alternative technology, we are fully aware of the need to avoid incurring the same issues with the U.S. Li-6 supply. We have taken steps to evaluate the potential demand using the most conservative estimates for Li-6. Should the decision be made to use Li-6, we will take all necessary steps to ensure there is an adequate supply to meet demand.

Further, as a result of the Team's discussions, and a Workshop held in August 2008 on the Isotope Program's initiative, the supply of other isotopes which are sold by the Isotope Program, but produced elsewhere, such as Li-6 mentioned in the report, is being addressed. In the case of Li-6, for example, Portal Monitor users within the USG were asked to estimate their long term needs, assuming that all their monitors would use Li-6 rather than He-3. As a result of that discussion, a Li-6 stockpile has been established to ensure supply of Li-6 for Portal Monitor use. We would be happy to provide GAO with documents showing our work in this area.

Also enclosed are specific comments to help clarify and improve the report in areas that may be confusing or misleading.

If you have any questions concerning this response, please contact JoAnne Parker, Director, Office of Internal Controls, at 202-586-1913.

Sincerely,

Gerald L. Talbot, Jr.
Associate Administrator
for Management and Budget

Enclosures

Appendix II: GAO Contacts and Staff Acknowledgments

GAO Contacts

Gene Aloise, (202) 512-3841 or aloisee@gao.gov
Timothy M. Persons, (202) 512-6412 or personst@gao.gov

Staff Acknowledgment

In addition to the contact named above, Ned H. Woodward, Assistant Director; Eric Bachhuber; R. Scott Fletcher; and Wyatt R. Hundrup made key contributions to this report. Kendall Childers, Nancy Crothers, Cindy Gilbert, Jonathan Kucskar, and Mehrzad Nadji also made important contributions.

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