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DEPARTMENT OF ENERGY

Transactions Involving USEC Inc. Since 1998

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GAO Highlights

Highlights of GAO-15-730, a report to congressional requesters

September 2015

DEPARTMENT OF ENERGY

Transactions Involving USEC Inc. Since 1998

Why GAO Did This Study

DOE has had a long and complex relationship with USEC Inc. and its successor, Centrus Energy Corp. Until 2013, USEC, a government corporation that was privatized in 1998, was the only company enriching uranium that, according to DOE, could meet DOE's LEU needs for tritium production. However, USEC ceased enrichment operations in May 2013, and the future of its planned next-generation American Centrifuge enrichment facility is uncertain. GAO has previously reported on financial and other transactions involving DOE and USEC, including transactions that involved the transfer of uranium.

GAO was asked to report on the history of the financial relationship between DOE and USEC. This report (1) identifies transactions involving DOE and USEC since USEC was privatized and (2) describes the costs and benefits, if any, of these transactions to DOE, as identified by DOE. GAO defines a transaction as a contract or agreement providing for an exchange of monetary payments, uranium of any type, or services between or involving DOE and USEC occurring from USEC's privatization on July 28, 1998, through July 1, 2015. GAO analyzed key DOE and USEC documents and interviewed DOE and Centrus Energy Corp. officials.

What GAO Recommends

GAO is not making recommendations in this report. DOE reviewed a draft of this report and provided technical comments that GAO incorporated as appropriate.

View GAO-15-730. For more information, contact David C. Trimble at (202) 512-3841or trimbled@gao.gov.

What GAO Found

The Department of Energy (DOE) has engaged with USEC Inc. (USEC) in 23 transactions since USEC was privatized in 1998 through July 1, 2015. The 23 transactions fall into the following six categories:

- **Establishment of USEC**. DOE engaged with USEC in 3 transactions to help establish the company as a private company. For example, from 1998 to 2003, DOE transferred enriched uranium, as required by the USEC Privatization Act, to USEC to establish commercial value for USEC.
- **National security**. DOE engaged with USEC in 6 transactions for national security purposes. For example, DOE engaged in several transactions to secure domestic low-enriched uranium (LEU), used in nuclear reactors, for the production of tritium—a radioactive isotope of hydrogen used to enhance the power of nuclear weapons—and support the development of USEC's next-generation American Centrifuge uranium enrichment technology.
- **Facilities management**. DOE engaged with USEC in 5 transactions regarding the operation and management of various facilities. For example, after USEC ceased enrichment operations at the Portsmouth Gaseous Diffusion Plant (GDP)—which it leased from DOE—DOE contracted with USEC from 2001 to 2011 to maintain the facility in a dormant condition and prepare it for future decontamination and decommissioning.
- **Nuclear materials management and security.** DOE engaged with USEC in 3 transactions to support nuclear materials management. For instance, in a transaction beginning in 1999, DOE agreed to pay USEC to provide safeguards and security services for highly enriched uranium (HEU), which is used in nuclear weapons, that DOE stored at the Portsmouth GDP.
- **Issues from prior transactions**. DOE engaged with USEC in 3 transactions to address issues with previous transfers of uranium. For example, in 2003, DOE transferred HEU to USEC to replace previously transferred material that turned out to be contaminated and that did not conform to industry standards.
- **Other.** In 2 other transactions, USEC and its subsidiaries paid a fee for access to DOE restricted data related to the centrifuge technology. A third transaction involved a pilot project to determine the usability of certain uranium as nuclear fuel.

DOE identified various monetary and nonmonetary costs and benefits of the 23 transactions. DOE was able to identify the costs and benefits for most transactions that have occurred since 2005. For these transactions, DOE incurred costs through the transfer of appropriated funds and various types of uranium, as well as acceptance of responsibility for the future disposition of certain uranium. The benefits DOE received include monetary payments, LEU, and nonmonetary national security benefits. For transactions that occurred or began occurring prior to 2005, DOE was not always able to provide definitive information on its costs and benefits, in part because the agency's accounting system changed in 2004, and agency officials were not able to access information on certain transactions occurring prior to that time.

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Abbreviations

AVLIS	atomic vapor laser isotope separation
Centrus	Centrus Energy Corp.
CRADA	Cooperative Research and Development Agreement
DOE	Department of Energy
GDP	gaseous diffusion plant
HEU	highly enriched uranium
LEU	low-enriched uranium
MTU	metric tons of uranium
NAC	NAC International Inc.
NMMSS	Nuclear Materials Management and Safeguards System
NRC	Nuclear Regulatory Commission
SWU	separative work unit
USEC	USEC Inc.

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U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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September 10, 2015

The Honorable Edward J. Markey
United States Senate

The Honorable Michael C. Burgess
House of Representatives

The Department of Energy (DOE) has had a long and complex relationship with USEC Inc. (USEC) and its successor, Centrus Energy Corp. (Centrus), which has been the only company to enrich uranium with U.S. technology.[1] In the 1940s, the federal government began providing uranium enrichment services—first for national security purposes and later for the emerging commercial nuclear power industry—using government-owned gaseous diffusion plants (GDP).[2] In 1992, United States Enrichment Corporation was established as a government corporation to, among other things, provide these services and to take over operations of DOE's two operating GDPs in Portsmouth, Ohio, and Paducah, Kentucky. In 1998, the corporation was privatized under the USEC Privatization Act and became a subsidiary of the newly created USEC Inc.[3] From 1998 until 2013, DOE relied exclusively on USEC to obtain enrichment services for the production of low-enriched uranium (LEU) needed to produce tritium, a radioactive isotope of hydrogen used

[1]To be transformed into a form that can be used to fuel nuclear reactors, uranium ore goes through a number of steps including mining, conversion, and enrichment. Enrichment is the process of separating uranium-235—the form, or isotope, that undergoes fission to release energy in nuclear reactors and weapons—from uranium-238 to increase the concentration of uranium-235.

[2]To enrich uranium, DOE and its predecessors operated three GDPs in Tennessee, Ohio, and Kentucky. DOE ceased operating its GDP in Oak Ridge, Tennessee, in 1985 as a result of decreased demand for enrichment services. The gaseous diffusion process involves the passage of uranium hexafluoride in a gaseous form through a series of filters. Because uranium-235 is lighter, it passes through the filters more readily than uranium-238, resulting in gaseous uranium that is enriched in uranium-235—the fissionable isotope.

[3]USEC Privatization Act, 42 U.S.C. §§ 2297h-2297h-13 (2015). The privatization was accomplished by an initial public offering on July 28, 1998. With the creation of USEC Inc., United States Enrichment Corporation ceased to exist as a government corporation. In September 2014, USEC Inc. changed its name to Centrus Energy Corp.

to enhance the power of U.S. nuclear weapons, and DOE has contracted with USEC for a variety of related services.[4] However, USEC ceased enrichment operations at the Portsmouth and Paducah GDPs in 2001 and 2013, respectively, citing high production costs due to the use of energy-intensive enrichment technology.

Since 2002, USEC has been developing next-generation enrichment technology—called the American Centrifuge—which has been demonstrated by USEC to be significantly less energy intensive than USEC's World War II-era gaseous diffusion technology.[5] If successfully commercially deployed, the American Centrifuge technology would again establish a commercial uranium enrichment capability based on U.S. technology, which, according to DOE, is necessary to obtain LEU to meet U.S. national security needs for tritium production. However, the future of the American Centrifuge is in question. USEC filed for Chapter 11 bankruptcy protection in March 2014, citing the need to restructure its convertible notes that were issued to finance the American Centrifuge plant and other corporate needs. In September 2014, it emerged from bankruptcy and changed its name to Centrus Energy Corp.[6] As of July 2015, the company was not enriching uranium either commercially or for national security purposes and, therefore, DOE no longer has an assured

[4]An assured source of tritium is necessary to maintain the U.S. nuclear weapons stockpile. However, tritium has a relatively short half-life of 12 years and decays at a rate of about 5.5 percent per year. As long as the United States relies on nuclear weapons, DOE requires a continuous supply of LEU to produce tritium. Tritium is produced as a by-product in nuclear reactors fueled by LEU, and DOE's National Nuclear Security Administration supports a program that produces tritium as a primary product to collect enough tritium to meet stockpile demands.

[5]For the potential commercialization of the American Centrifuge technology, USEC applied for a $2 billion loan guarantee for U.S. government guaranteed debt financing both in 2008 and 2010 under DOE's Loan Guarantee Program. DOE deferred USEC's applications in 2009 and 2011, citing financial and technical concerns.

[6]On September 5, 2014, the U.S. Bankruptcy Court for the District of Delaware approved USEC's plans for reorganization. At that time, USEC announced that it planned to emerge from Chapter 11 reorganization under the name Centrus Energy Corp. On September 30, 2014, Centrus Energy Corp. announced that it had satisfied all conditions set forth in its Plan for Reorganization and that it was emerging in a stronger position to support the energy and national security needs of the United States. For the purposes of this report, we will refer to the company as United States Enrichment Corporation when discussing events prior to privatization, USEC Inc. (USEC) when discussing events between privatization and September 2014, and we will refer to the company as Centrus Energy Corp. (Centrus) when discussing events after September 2014.

source of LEU enriched with U.S. technology for tritium production.[7] In April 2014, the Secretary of Energy tasked DOE's Oak Ridge National Laboratory with maintaining the operability of the American Centrifuge technology.[8] The following month, USEC signed a 17-month contract with UT-Battelle, which manages and operates Oak Ridge National Laboratory, to carry out this task. In the interim, DOE is assessing options for meeting national security needs for enriched uranium and is preserving the option of commercial deployment of the American Centrifuge technology.

We have previously reported on financial and other transactions involving DOE and USEC, which have continued to have a relationship since the company was privatized. For example, in June 2006, we found that USEC had invoiced DOE for about $152 million to decontaminate uranium under several separate agreements.[9] In September 2011, we found that DOE released natural uranium valued at about $194 million in return for cleanup work done by USEC at the Portsmouth GDP to prepare the facility for eventual decontamination and decommissioning.[10] In addition, in May 2014, we found that, from March 2012 to April 2014, DOE and USEC were involved in a dozen transfers of funding and uranium, which were largely intended to support USEC's research, development, and demonstration of the American Centrifuge technology.[11] For 10 of these 12 transfers, DOE provided about $280 million to USEC—including eight

[7]We found in October 2014 that DOE had interpreted certain international agreements to require the use of U.S.-developed enrichment technology for any uranium used for U.S. military purposes, including uranium ultimately used to produce tritium. LEU is considered unobligated when neither the uranium nor the technology used to enrich it carries an "obligation" to a foreign country, including an obligation requiring that the material only be used for peaceful purposes. See GAO, *Department of Energy: Interagency Review Needed to Update U.S. Position on Enriched Uranium That Can Be Used for Tritium Production*, GAO-15-123 (Washington, D.C.: Oct. 14, 2014).

[8]DOE has an irrevocable, nonexclusive, royalty-free license, for use by or on behalf of the United States, for all centrifuge intellectual property for government purposes.

[9]GAO, *U.S. Enrichment Corporation Privatization: USEC's Delays in Providing Data Hinder DOE's Oversight of the Uranium Decontamination Agreement*, GAO-06-723 (Washington, D.C.: June 16, 2006).

[10]GAO, *Excess Uranium Inventories: Clarifying DOE's Disposition Options Could Help Avoid Further Legal Violations*, GAO-11-846 (Washington, D.C.: Sept. 26, 2011).

[11]GAO, *Department of Energy: Enhanced Transparency Could Clarify Costs, Market Impact, Risk, and Legal Authority to Conduct Future Uranium Transactions*, GAO-14-291 (Washington, D.C.: May 9, 2014).

monetary payments of about $148 million and two transfers of uranium valued at $132 million.

In light of Centrus' emergence from bankruptcy and the potential for a continued relationship between DOE and Centrus, you asked us to report on the history of the financial relationship between the two entities.[12] This report (1) identifies transactions involving DOE and USEC since USEC was privatized in 1998 and (2) describes the costs and benefits, if any, of these transactions to DOE, as identified by DOE.

For the purpose of our review, we define a transaction as a contract or agreement providing for an exchange of monetary payments, uranium of any type, or services between or involving DOE and USEC. We included in our scope any transactions that occurred between USEC's privatization on July 28, 1998, and the present (July 1, 2015), as well as transactions that commenced before July 28, 1998, but that continued to be executed after USEC was privatized. We excluded interactions involving DOE and USEC if no exchange of monetary payment, uranium, or services occurred.

To conduct this work, we reviewed and analyzed documents to identify these transactions and to obtain information on the type, purpose, costs, and benefits of the transactions. These documents included DOE's annual budget justification materials, USEC's corporate filings with the U.S. Securities and Exchange Commission, contracts and agreements between DOE and USEC, and prior GAO reports. Once we identified a preliminary list of transactions, we asked DOE to review the list. DOE amended the list and provided documentation for additional transactions to be included. Based on our analysis of DOE documents, and through interviews with DOE officials, we then added and consolidated certain transactions and removed others that were inconsistent with our definition and ultimately developed a final list of 23 transactions.[13] We also interviewed Centrus officials and provided them an opportunity to review

[12]This request was originally made by the Ranking Member of the House Committee on Natural Resources, Representative Edward J. Markey, who is now a member of the Senate, and Representative Michael C. Burgess.

[13]Some transactions we reviewed involved multiple steps or were based on several agreements between DOE and USEC. The total number of transactions involving DOE and USEC could be added differently, depending on whether related contractual agreements between DOE and USEC are consolidated or separated.

and confirm the final list of transactions, and they concurred with the list. For the purpose of this review, we are reporting the costs and benefits that DOE provided us. To assess the reliability of the costs and benefits that DOE identified for each transaction, we requested and reviewed relevant documentation to corroborate DOE-reported costs and benefits, including contracts, memorandums of agreement, and lease agreements and found the information we are reporting on DOE-identified costs and benefits sufficiently reliable for the purposes of this review. Appendix I describes our objectives, scope, and methodology in more detail.

We conducted this performance audit from November 2014 to September 2015 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

This section describes nuclear fuel production and uranium enrichment, DOE's and USEC's involvement in uranium enrichment, and cleanup of uranium enrichment plants.

Nuclear Fuel Production and Uranium Enrichment

Uranium enrichment is the process of raising the concentration of uranium-235, which is the isotope of uranium that undergoes fission to release enormous amounts of energy. Uranium is categorized by its concentration of uranium-235, expressed as a percentage of weight or "assay" level. DOE categorizes uranium in five general types, each of which is characterized by a different assay level and has different uses (see table 1).

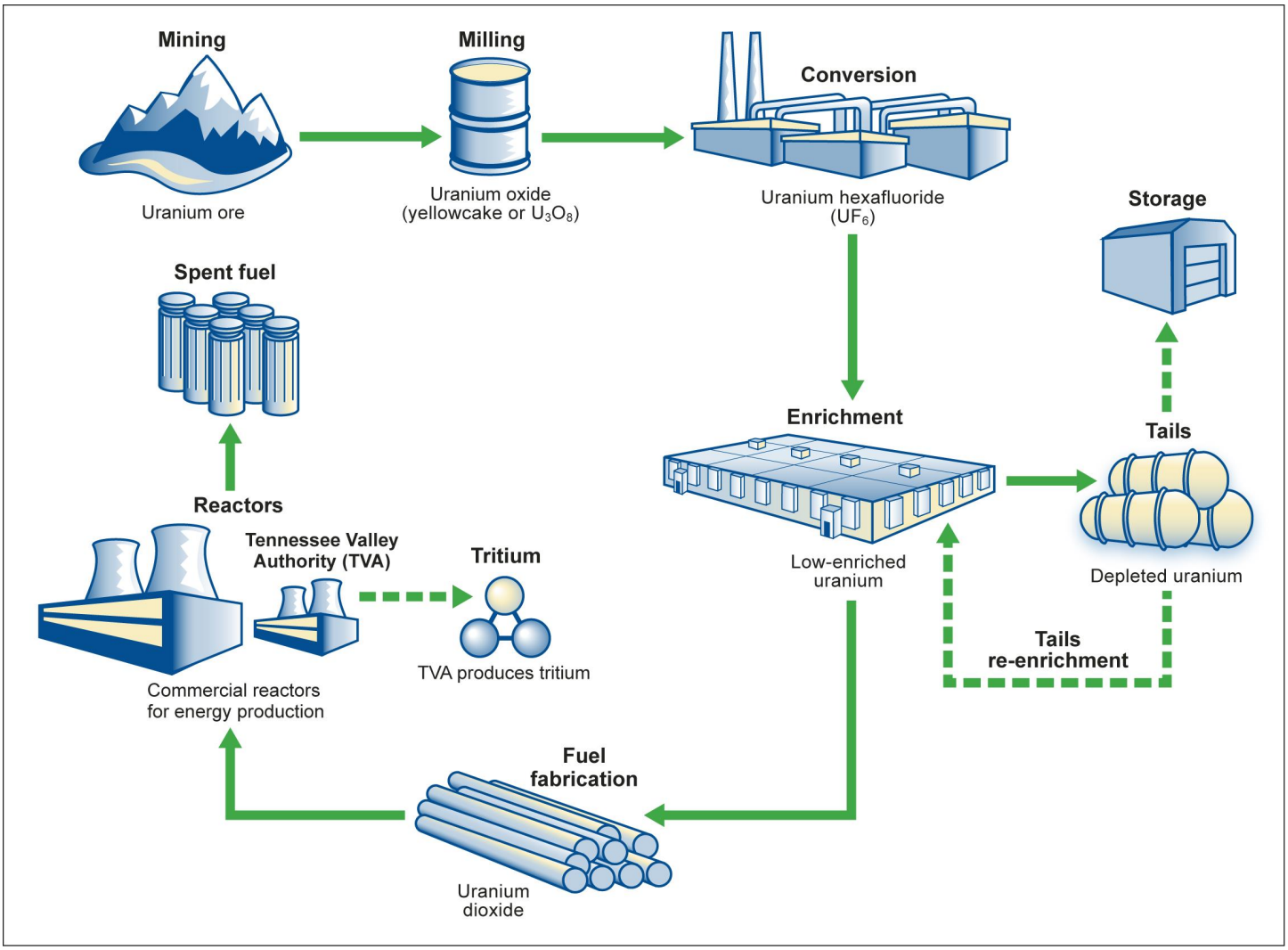
Table 1: Types of Uranium

Type	Assay level of uranium-235	Description
Low-assay depleted uranium tails	Less than 0.34%	Tails are a product of the enrichment process. Tails consist of uranium hexafluoride containing fewer isotopes of uranium-235 than occur in natural uranium. Some low-assay tails are not considered economical to re-enrich.
High-assay depleted uranium tails	0.34% - 0.7%	In some cases, it may be profitable to re-enrich “high-assay” tails with assays greater than 0.34%. All tails regardless of assay are radioactive and hazardous to human health and the environment. Tails may be safely stored for years but eventually require stabilization and disposal.
Natural uranium	0.7%	Natural uranium is mined from the earth and contains 0.7% of the uranium-235 isotope. The remaining 99.3% is mostly the uranium-238 isotope. Natural uranium may be used for fuel in certain foreign nuclear reactor designs; otherwise, it is enriched for the uses described for low-enriched uranium and highly enriched uranium.
Low-enriched uranium (LEU)	More than 0.7% - 20%	LEU is used in commercial reactors at assay levels generally between 3% and 5%. Research, isotope production, and test reactors may use low-enriched uranium at assay levels between 12% and 19.75%. DOE also needs LEU for the production of tritium.
Highly enriched uranium (HEU)	More than 20%	HEU is used in the construction of nuclear weapons, for naval reactors, and for some research reactors. Weapons grade HEU generally has an assay level of at least 90%. HEU can be downblended by mixing it with either depleted or natural uranium, or LEU, to convert it into a new product that is less than 20% uranium-235.

Sources: GAO analysis of documents from DOE, Nuclear Regulatory Commission, and USEC Inc. | GAO-15-730

Uranium undergoes a number of processing steps to produce LEU nuclear fuel, beginning with the mining of uranium ore and ending with the fabrication of LEU fuel for nuclear reactors (see fig. 1). The uranium enrichment stage falls approximately in the middle of the nuclear fuel cycle.

Figure 1: Nuclear Fuel Cycle



Sources: GAO analysis of International Atomic Energy Agency, Nuclear Regulatory Commission, Congressional Research Service, Department of Energy, and TVA documents. | GAO-15-730

Note: The Tennessee Valley Authority produces tritium through an interagency agreement with DOE.

As can be seen in figure 1, the enrichment process results in two principal products: (1) enriched uranium hexafluoride and (2) leftover "tails" of uranium hexafluoride. These tails are also known as depleted uranium because the material is depleted in uranium-235 compared with natural uranium. Tails are generally considered an environmental liability. The Nuclear Regulatory Commission (NRC) requires uranium enrichment facility operators to provide financial assurance that funds will be

available when needed for the disposition of depleted uranium.[14] To meet these NRC requirements, USEC has used surety bonds—which guarantee payment for the tails disposition costs by a third party, among other things, in the event that USEC defaults on such obligations—to guarantee the disposition of its depleted uranium and stored wastes.

LEU resulting from the enrichment process is valued based on two components: (1) the value of the feed component, which is generally natural uranium in the form of uranium hexafluoride, and (2) the value of the enrichment component, or separative work units (SWU), which is the industry standard for the measure of effort needed to transform a given amount of natural uranium into LEU.

DOE's and USEC's Involvement in Uranium Enrichment

According to DOE, the United States needs an assured source of tritium to maintain the U.S. nuclear weapons stockpile. In October 2014, we reported on DOE's practice of using only unobligated LEU to meet national security needs for tritium.[15] To produce tritium, DOE has stated that it can only use unobligated LEU. LEU is considered to be unobligated when neither the uranium nor the technology used to enrich it carries an "obligation" from a foreign country regarding its use, such as a requirement that the material only be used for peaceful purposes. These obligations are contained in international agreements to which the United States is a party.

In the 1940s, DOE and its predecessor agencies began operating government-owned uranium enrichment plants first to meet national security needs for enriched uranium and later for use as fuel in commercial nuclear reactors. In 1992, United States Enrichment Corporation was established as a government corporation to, among other things, provide uranium enrichment services for the U.S. government and utilities that operate nuclear power plants and to take over operations of DOE's two GDPs in Portsmouth, Ohio, and Paducah,

[14]NRC is the federal agency that regulates, among other things, the civilian uses of nuclear materials in the United States.

[15]See GAO-15-123.

Kentucky.[16] Then, in 1996, the USEC Privatization Act authorized the government corporation's sale to the private sector.[17] Two years later, the government corporation was privatized through an initial public offering on July 28, 1998, which resulted in proceeds to the U.S. government of nearly $1.9 billion.[18] Through privatization, United States Enrichment Corporation became a subsidiary of the new private company USEC Inc. USEC Inc. then changed its name to Centrus Energy Corp after it emerged from bankruptcy in September 2014.[19] Today, United States Enrichment Corporation continues to be a subsidiary of Centrus.

The Energy Policy Act of 1992 required the President to transfer to United States Enrichment Corporation, at its request, any intellectual and physical property related to a type of next-generation uranium enrichment technology called atomic vapor laser isotope separation (AVLIS). In 1973, Lawrence Livermore National Laboratory began conducting research on AVLIS—a technology that uses laser light to separate from natural uranium the specific uranium atoms needed to sustain nuclear reactions. Prior to transferring the technology to United States Enrichment Corporation in 1995 for further research and development and for eventual commercialization, DOE spent more than $1.7 billion developing the technology, which, according to USEC, was expected to use significantly less electricity than gaseous diffusion technology. In June 1999, USEC announced that it was suspending further development on AVLIS technology—on which it had spent over $100 million since the company was privatized—and would instead focus on developing other

[16]Pursuant to the Energy Policy Act of 1992, DOE and United States Enrichment Corporation signed a 6-year lease for the use of these two GDPs with an open-ended renewal option. The lease was transferred to USEC Inc. in 1998 at the time of privatization, as required by the USEC Privatization Act.

[17]USEC Privatization Act, 42 U.S.C. §§ 2297h-2297h-13 (2015).

[18]The proceeds consisted of nearly $1.4 billion from the sale of USEC stock, and $500 million borrowed by USEC and paid to the government. In addition, the United States retained about $1.2 billion in cash from the government corporation's account at the U.S. Treasury, known as the U.S. Enrichment Corporation Fund.

[19]USEC filed for Chapter 11 bankruptcy protection in March 2014 in order to strengthen its balance sheet and replace notes maturing in October 2014 with equity and new notes maturing in 5 years and extendable to 10 years. On September 5, 2014, the U.S. Bankruptcy Court for the District of Delaware approved USEC's Plan for Reorganization. On September 30, 2014, Centrus announced that it had satisfied all conditions set forth in its Plan for Reorganization.

commercially viable enrichment technologies. According to USEC's 1999 Annual Report, USEC determined that the returns from AVLIS would not be sufficient to outweigh the risks and costs of further development, and centrifuge technology was a well-established enrichment process. [20]

In 2002, DOE and USEC signed an agreement that committed USEC to pursue the development of gas centrifuge technology. This technology, which is now known as American Centrifuge, is based on gas centrifuge technology originally developed by DOE from the 1960s to the 1980s, after which DOE suspended development, in part due to budget constraints. According to USEC documents, the American Centrifuge technology would be significantly less energy intensive and more cost-efficient than the gaseous diffusion process used in the Portsmouth and Paducah GDPs. Subsequently, in 2004, USEC announced its selection of the Portsmouth plant as the future home of the American Centrifuge Plant—the facility where the American Centrifuge technology would be deployed—and received a license to operate the plant from NRC in 2007. DOE and USEC signed a cooperative agreement in 2012 to share the cost of supporting a research, development, and demonstration program for the American Centrifuge technology. According to USEC, the program ended in April 2014 and achieved all of its technical milestones on time and within budget. In May 2014, USEC and UT-Battelle—the management and operating contractor of DOE's Oak Ridge National Laboratory—signed an agreement to maintain the capability of the American Centrifuge technology.

Cleanup of Uranium Enrichment Plants

In accordance with the USEC Privatization Act, the government is responsible for all costs incurred by the uranium enrichment program before July 1, 1993, when United States Enrichment Corporation began operating the two GDPs. Due to decreased demand for enrichment services and high costs of operating the GDPs, USEC ceased enrichment operations at the Portsmouth GDP in 2001 and at the Paducah GDP in 2013. These plants, as well as the Oak Ridge GDP (now known as the

[20]Gas centrifuge technology employs rapidly spinning cylinders containing uranium hexafluoride to separate the fissionable uranium-235 from the nonfissionable uranium-238. The centrifuge is significantly less power intensive than the gaseous diffusion process, and centrifuge technologies have already been commercialized by USEC's competitors, all of whom are foreign owned and use foreign-developed technology. For more information, see GAO-15-123.

East Tennessee Technology Park), which was never operated by USEC, are contaminated with hazardous industrial, chemical, nuclear, and radiological materials. Cleanup activities, known as decontamination and decommissioning, include assessing and treating groundwater or soil contamination, disposing of contaminated materials, and making general repairs to keep the plants in a safe condition until they can be fully demolished.[21] According to DOE's 2010 *Uranium Enrichment Decontamination and Decommissioning Report*, the decontamination and decommissioning of the GDPs will cost billions of dollars and span several decades. DOE is decontaminating and decommissioning the three GDPs in the following phased approach:

- **Oak Ridge GDP**: DOE began decontaminating and decommissioning its Oak Ridge GDP in 1994 and estimates that it will be completed in 2024.

- **Portsmouth GDP**: DOE began decontaminating and decommissioning its Portsmouth GDP in 2009, announcing that it had contracted with USEC for accelerated environmental cleanup work to prepare the facility for decontamination and decommissioning. In August 2010, DOE entered into a new contract with another contractor (Fluor-B&W Portsmouth LLC) to decontaminate and decommission the former facilities at Portsmouth. According to a March 2014 DOE Office of Inspector General report, the decontamination and decommissioning work at the Portsmouth GDP is currently estimated to extend until 2044.

- **Paducah GDP**: DOE has not yet started decontaminating and decommissioning its Paducah GDP. After ceasing enrichment activities in May 2013, Centrus returned full control of the Paducah GDP to DOE in late October 2014. In July 2014, DOE contracted with Fluor Federal Services, Inc., to conduct activities to prepare the facility for eventual decontamination and decommissioning. According to a March 2014 DOE Office of Inspector General report, the decontamination and decommissioning work at the Paducah GDP is currently estimated to extend until 2044. However, according to DOE

[21]For more information, see GAO, *Uranium Enrichment: Decontamination and Decommissioning Fund Is Insufficient to Cover Cleanup Costs*, GAO-04-692 (Washington, D.C.: July 2, 2004), and *Uranium Enrichment: Extension of Decontamination and Decommissioning Fund May Be Needed to Cover Project Cleanup Costs,* GAO-08-277T (Washington, D.C.: Nov. 15, 2007).

officials, the department is currently evaluating the projected lifecycle cost and schedule estimates for the Paducah cleanup completion.

Since 1998, DOE and USEC Have Been Involved in 23 Transactions

Since USEC was privatized in 1998 through June 1, 2015, DOE and USEC have engaged in 23 transactions (see app. II for a detailed description of the 23 transactions).[22] Based on our analysis of documents and interviews with DOE officials, we grouped these transactions into the following six broad categories:

- **Establishment of USEC**. DOE and USEC engaged in 3 transactions to help establish the company as a private company. For example, DOE transferred enriched uranium to USEC, as required by the USEC Privatization Act, from 1998 to 2003. These transfers established value for USEC in the marketplace. In addition, beginning in 1998, DOE agreed to provide employment transition services to USEC for employees affected by restructuring activities that occurred at the Portsmouth and Paducah GDPs as a result of USEC's privatization.

- **National security**. DOE and USEC engaged in 6 transactions for national security purposes. Specifically, DOE engaged in one transaction in 2012 to secure unobligated LEU from USEC to meet national security needs for the production of tritium for up to 18 months, and DOE engaged in a second transaction later in 2012 to secure unobligated LEU from USEC to meet national security needs for the production of tritium for up to 15 years. The other 4 transactions in this category supported the research and development of the American Centrifuge technology to meet long-term national security needs for unobligated LEU, such as for tritium production. For example, in 2010, DOE and USEC signed a cooperative agreement to share the cost of USEC's development and demonstration of the American Centrifuge technology for a year. To provide its share of the cost, DOE took title to and financial responsibility for the disposal of depleted uranium tails from USEC.

- **Facilities management**. DOE and USEC engaged in 5 transactions regarding the operation and management of various facilities,

[22]In 2008 and 2010, USEC applied for a loan guarantee from DOE for development of the American Centrifuge technology, but DOE deferred USEC's application on both occasions. We did not include this interaction in our list of transactions because it was attempted, but it was not completed.

including the Portsmouth and Paducah GDPs, as well as other facilities associated with the development of the American Centrifuge technology.[23] For example, in one transaction, DOE signed a lease agreement with United States Enrichment Corporation in 1993—when it became a government corporation—and the lease was transferred to the private corporation when the company was privatized. The agreement included USEC's lease of the Portsmouth and Paducah GDPs, as well as an electric power agreement and an agreement between DOE and USEC to provide certain services for each other related to the use of the GDPs. In another transaction, after USEC ceased enrichment activities at the Portsmouth GDP, DOE contracted with USEC from 2001 through 2011 for several activities associated with maintaining the facility in a dormant condition and preparing the facility for decontamination and decommissioning.

- **Nuclear materials management and security**. DOE and USEC engaged in 3 transactions to support the management and security of nuclear materials. In one transaction beginning in 1999, DOE agreed to pay USEC to provide safeguards and security services for HEU that DOE stored at the Portsmouth GDP. In another transaction beginning in 1999, USEC contracted with DOE for the storage of enriched uranium that exceeded the amount of material USEC could possess in its facilities under NRC limits. In the third transaction, from 2005 through 2008, DOE contracted with a USEC subsidiary to manage the U.S. government's nuclear materials tracking system, called the Nuclear Materials Management and Safeguards System.[24]

- **Issues from prior transactions**. DOE and USEC engaged in 3 transactions to address issues with previous transfers of uranium when DOE had inadvertently provided USEC with uranium that did not conform to industry standards or more uranium than originally agreed on by the parties. For example, in March 2000, USEC discovered that

[23]In May 2013, DOE and USEC were involved in negotiations about a possible transaction that would have involved USEC enriching off-specification uranium—that is, uranium with content that does not meet industry standards for commercial nuclear reactor fuel—to extend operations at the Paducah GDP, but negotiations ultimately were unsuccessful. We did not include this interaction in our list of transactions because it was not completed.

[24]In 2004, USEC acquired a company with which DOE had an existing contract to manage the Nuclear Materials Management and Safeguards System. According to DOE officials, DOE extended the contract with this USEC subsidiary from October 1, 2005, through September 30, 2008.

uranium that it had received from DOE prior to privatization was contaminated with technetium, a radioactive metal that is considered a contaminant by commercial specifications for nuclear fuel. In a 7-year transaction that began in 2002, DOE (1) contracted with USEC to clean up some of the contaminated uranium, (2) provided replacement uranium and monetary payment to USEC, and (3) took title to some of USEC's depleted uranium. In a second transaction, in 2003, DOE transferred HEU to USEC to replace other material that DOE transferred to USEC prior to privatization that did not conform to industry standards. In a third transaction, DOE and USEC addressed the fact that they had underestimated the amount of material stored in certain HEU cylinders that DOE had transferred to USEC prior to privatization. Specifically, DOE had transferred to USEC about 0.8 metric tons of HEU more than initially agreed on. To address this issue, in 1998, USEC agreed to pay DOE about $35 million more than originally agreed on by the parties.

- **Other**. DOE and USEC engaged in 3 other transactions since 1998. One transaction—which occurred from 2005 through 2006 and involved DOE, USEC, and a third party—was intended to determine the feasibility and benefits of re-enriching a portion of DOE's depleted uranium inventory for potential use as nuclear fuel in a commercial reactor. In the other two transactions, USEC and its subsidiaries paid a fee for access to DOE restricted data related to the centrifuge technology.[25] Access to this data allowed USEC to utilize DOE centrifuge technology in the development and design of the American Centrifuge technology.

See appendix III for a table of the 23 transactions organized by category.

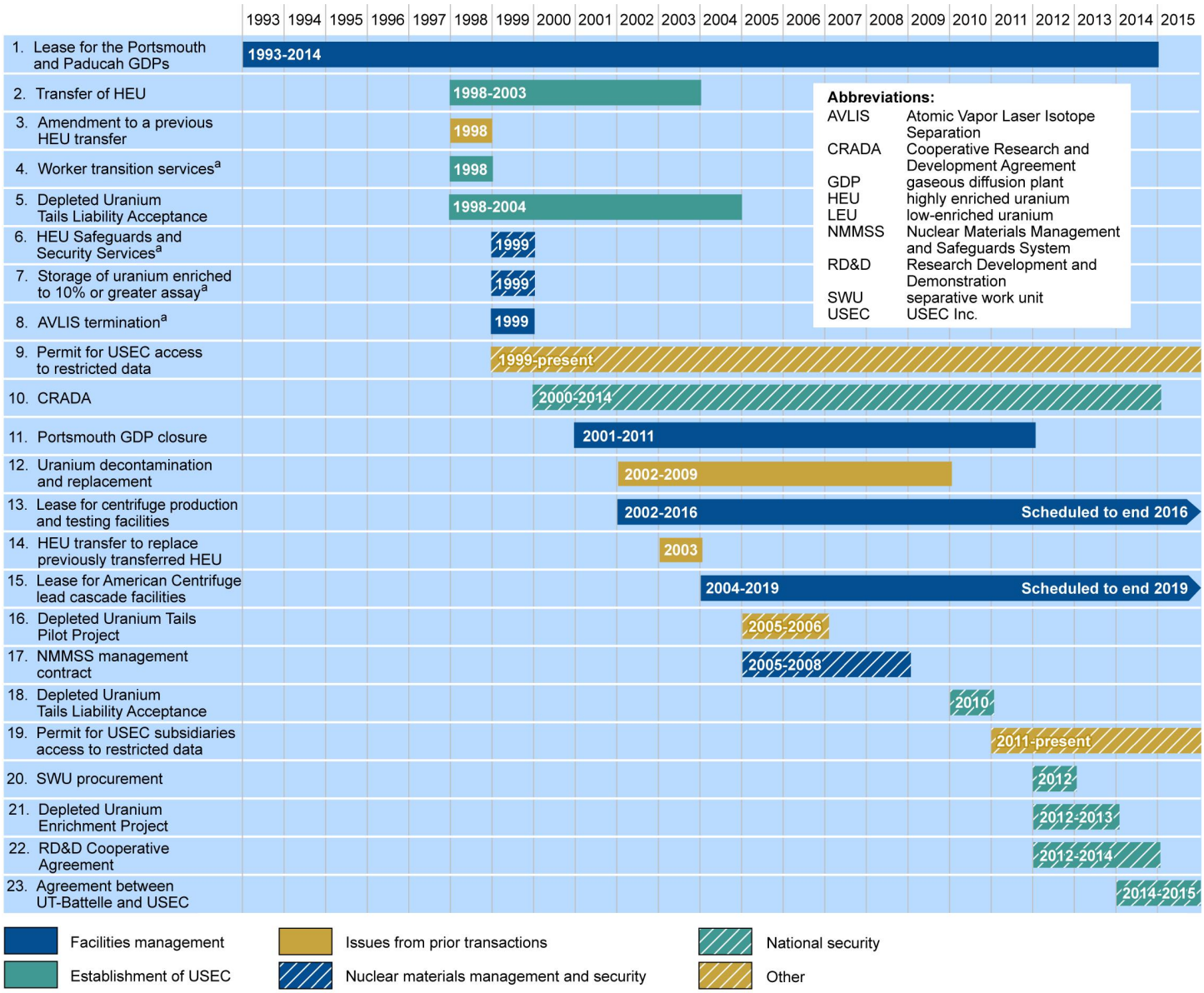
Figure 2 shows how the transactions were distributed over the 17-year period that we reviewed.[26] Our analysis shows that the general nature of the transactions evolved over time. Immediately following USEC's

[25]Restricted data is information concerning the design, manufacture, or utilization of atomic weapons; production of special nuclear material; or use of special nuclear material in the production of energy, not including data declassified or removed from the restricted data category (i.e., formerly restricted data).

[26]As described in the scope and methodology section of this report, for the purposes of our review, we examined the 17-year period from USEC's privatization on July 28, 1998, through July 1, 2015. However, as shown in figure 2, we also included the lease for the Portsmouth and Paducah GDPs, which was signed in 1993, because it commenced before July 28, 1998, and continued to be executed after USEC was privatized.

privatization, the majority of the transactions were of the establishment of USEC category. In the middle part of the 17-year period, most of the transactions were of the facilities management and nuclear materials management and security categories. In recent years, the majority of the transactions were of the national security category. DOE and USEC have been continuously involved in transactions since 1998. Of the 23 transactions, at least 6 have spanned a decade or longer, while the other transactions were of shorter duration.

Figure 2: Timeline of 23 Transactions in Which DOE and USEC Have Been Involved Since 1998



Sources: GAO analysis of Department of Energy (DOE) and USEC documents, and intrviews with DOE officials. | GAO-15-730

Note A: These transactions began on the year listed in the graphic. However, we do not have information on the extent of their duration because DOE officials told us that they do not know when these transactions were completed.

In addition to the transactions described above, there were at least three other significant arrangements involving DOE and USEC, which were noteworthy because, in each case, DOE or USEC received something of value as part of the arrangement, even though the arrangement did not meet our definition of a transaction. These arrangements were as follows:

- Before it was privatized, the U.S. government selected United States Enrichment Corporation as the U.S. government's executive agent for the HEU Purchase Agreement—a 1993 nuclear arms reduction agreement between the United States and Russia. USEC continued its role as sole executive agent after its privatization, and activities under the agreement continued through 2013. Under the agreement, United States Enrichment Corporation, and later USEC, purchased LEU from the Russian government's executive agent, which had produced it by downblending HEU taken from dismantled Soviet-era nuclear warheads.[27] Centrus officials told us that USEC used its large backlog of contracts with commercial utilities to place the LEU in the market. According to Centrus officials, this agreement provided a significant source of supply of LEU to USEC over a 20-year period and resulted in the destruction of the equivalent of 20,000 nuclear warheads. We did not identify any exchange of funds between DOE and USEC related to USEC's service as the executive agent.[28]

- In a December 2006 agreement, DOE granted USEC a nonexclusive patent license for the use or manufacture of the American Centrifuge technology. In this 2006 agreement, USEC agreed to pay DOE a royalty for the use of the American Centrifuge technology. According to DOE and Centrus officials, DOE has never received royalties from USEC or Centrus under this license. According to Centrus officials, the company has not made any payments because it has not yet commercialized the American Centrifuge Plant or sold any material produced by the centrifuge technology.

[27]Downblending is the process of mixing HEU with depleted uranium, natural uranium, or LEU to produce a new product that has a lower concentration of uranium-235.

[28]DOE and the broader U.S. government benefited from the arms reduction associated with implementing the agreement, and this benefit would have accrued to the government regardless of the entity selected to serve as the agent. The agreement was completed in 2013.

- In 2012, USEC granted to DOE (1) an irrevocable, nonexclusive, royalty-free license, for use by or on behalf of the United States, in all centrifuge intellectual property for government purposes and (2) an irrevocable, nonexclusive license in all centrifuge intellectual property, with the right to sublicense to other parties, for commercial purposes.[29] This arrangement was made at a time when there was uncertainty surrounding the future of the American Centrifuge technology. According to Centrus officials, USEC has transferred title to DOE for more than 30 existing centrifuges, built at USEC's expense, as well as all new machines built during the research, development, and demonstration program.

DOE Identified Various Costs and Benefits of Some of the Transactions

DOE identified various monetary and nonmonetary costs and benefits of the 23 transactions. For most transactions that occurred since 2005, DOE officials provided us with information through documents and interviews about the costs and benefits of each transaction. However, for transactions occurring prior to 2005, DOE officials were not always able to provide definitive information about the costs and benefits of the transactions independent of that which was stated in the transactional documents.

For transactions occurring after 2005—which mostly fell into the national security category—the costs DOE identified were incurred through the transfer of appropriated funds to USEC, transfer of various types of uranium, and acceptance of responsibility for the future disposition of depleted uranium tails. The benefits DOE identified were both monetary (*i.e.*, payments or a reduction in obligations for the disposal of depleted uranium) and nonmonetary (*e.g.*, LEU, national security benefits such as the development of the American Centrifuge technology).

For transactions prior to 2005, DOE officials were not always able to provide definitive information on the costs and benefits to DOE independent of that which was stated in the transactional documents. In some cases, for example, DOE officials told us that key officials familiar with the transactions had since retired or were deceased, and therefore information on the costs and benefits of these transactions was not

[29]DOE may exercise the commercial license only if USEC misses certain development milestones for the American Centrifuge technology or if it is no longer willing or able to proceed with or has determined to abandon or has constructively abandoned the commercial deployment of the American Centrifuge technology.

available. In addition, DOE officials told us that the department changed accounting systems in 2004, and therefore the officials could not always access definitive cost and benefit information prior to 2005.[30] For example, DOE officials provided us with information on USEC's payments to DOE for the lease of the Portsmouth and Paducah GDPs from 2005 to 2014, but they could not provide us with information on USEC's payments prior to 2005.

Agency Comments and Our Evaluation

We provided a draft of this report for comment to the Secretary of Energy on July 29, 2015. DOE provided technical comments that were incorporated, as appropriate. We also provided a technical statement of facts to Centrus Energy Corp. We received technical comments from Centrus and incorporated them, as appropriate.

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, the Secretary of Energy, and other interested parties. In addition, the report will be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or trimbled@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 V.

David C. Trimble
Director, Natural Resources and Environment

[30]In 2005, DOE replaced its legacy core financial systems with the Standard Accounting and Reporting System.

Appendix I: Objectives, Scope, and Methodology

The objectives of our review were to (1) identify transactions involving the Department of Energy (DOE) and USEC Inc. (USEC, now known as Centrus Energy Corp.) since USEC was privatized in 1998 and (2) describe the costs and benefits, if any, of these transactions to DOE, as identified by DOE.

For the purpose of our review, we define a transaction as a contract or agreement providing for an exchange of funds, uranium of any type, or services between or involving DOE and USEC. We included in our scope any transactions that occurred between USEC's privatization on July 28, 1998, and present (July 1, 2015), as well as transactions that commenced before July 28, 1998, but that continued to be executed after USEC was privatized. We excluded interactions involving DOE and USEC if no exchange of monetary payment, uranium, or services occurred.

To conduct this work, we reviewed and analyzed documents identifying these transactions and collected information regarding the type, purpose, costs, and benefits of the transactions. These documents include annual DOE budget justification materials for fiscal years 1999 through 2016, USEC/Centrus Energy Corp.'s annual reports and corporate filings with the U.S. Securities and Exchange Commission from 1998 through 2015, contracts and agreements between DOE and USEC, and prior GAO reports.[1] Once we identified a preliminary list of transactions involving DOE and USEC, we asked DOE to review the list. DOE officials amended the list and provided documentation for additional transactions to include. Based on our analysis of DOE documents, and through interviews with DOE officials, we added and consolidated certain transactions and removed others that were inconsistent with our definition of a transaction. We ultimately developed a final list of 23 transactions.[2] We also interviewed Centrus Energy Corp. officials and provided an opportunity to review and confirm the final list of transactions to ensure that the list was comprehensive and accurate, and they concurred with the list. We then provided DOE with a standard set of questions regarding the purpose, costs, and benefits of each of the transactions in the list. In two cases,

[1]See, for example: GAO-15-123, GAO-14-291, GAO-11-846, and GAO-06-723.

[2]Some transactions we reviewed involved multiple steps or were based on several agreements between DOE and USEC. The aggregate number of transactions involving DOE and USEC could be added differently, depending on whether related contractual agreements between DOE and USEC are consolidated or separated.

DOE was able to fully complete the standard set of questions. For the other transactions, DOE officials told us that documentation was not fully available to answer the standard question sets for reasons we discuss in the report. Instead, we conducted interviews with DOE officials to collect information that they did know about each transaction, and we reviewed available DOE and USEC documentation to obtain additional information on the costs and benefits of each transaction. See appendix IV for an example of the standard set of questions we provided to DOE officials on each transaction.[3]

For the purpose of this review, in cases where data were available, we are reporting DOE-identified costs and benefits of each transaction. To assess the reliability of the costs and benefits that DOE identified for each transaction, we reviewed documents to corroborate DOE-identified costs and benefits. Such documents included contracts, memorandums of agreement, lease agreements, and summary information from DOE/NRC Form 741.[4] Based on these steps, we determined that the information we are reporting on DOE-identified costs and benefits is sufficiently reliable for the purposes of this review.

We conducted this performance audit from November 2014 to September 2015 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.

[3]We slightly modified each question set to be specific to each transaction.

[4]Nuclear Regulatory Commission regulations require licensees who transfer, receive, or adjust their inventory of source or special nuclear material to report such activities. These reports are submitted using the DOE/NRC Form 741.

Appendix II: Information from Department of Energy on Its Transactions Involving USEC Inc. or Centrus Energy Corp. since 1998

Since 1998, the Department of Energy (DOE) and USEC Inc. (USEC) or Centrus Energy Corp. (Centrus) have been involved in 23 transactions that we grouped into six categories: (1) establishment of USEC, (2) national security, (3) facilities management, (4) nuclear materials management and security, (5) issues from prior transactions, and (6) other. DOE identified a variety of monetary and nonmonetary costs and benefits for most transactions occurring since 2005, but DOE was not always able to provide definitive information on the costs and benefits to DOE independent of that which was stated in the transactional documents.[1] The following 23 profiles provide a description of each transaction and information about the costs and benefits of each transaction, to the extent that DOE was able to provide it.

[1]In cases where the costs or benefits are reported as "unknown," DOE officials told GAO that they did not know what the costs or benefits were to the agency. In cases where the costs or benefits are reported as "none identified," DOE officials did not identify any costs or benefits to the agency for that transaction. In cases where the costs or benefits are reported as $0, DOE officials told us that there were no costs or benefits for that transaction.

1. Lease of the Portsmouth and Paducah Gaseous Diffusion Plants, 1993–2014

Table 2: Summary of Department of Energy (DOE)-Identified Costs and Benefits for the Lease of the Portsmouth and Paducah Gaseous Diffusion Plants (GDP)

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Facilities management	$0 [Note A]	At least $17,296,275 [Note B]	Compliance with the Energy Policy Act of 1992

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:DOE officials stated that they did not incur any costs for executing the lease agreement or the electric power agreement component of the lease, and they were unable to identify the costs to DOE for the services agreement.

Note B:This is the cumulative total amount that USEC paid to DOE for rent of the GDPs from fiscal year 2005 through fiscal year 2014. DOE was unable to provide information about USEC's rent payments prior to 2005. DOE officials also did not know of any monetary benefits of the electric power agreement and services agreement components of the lease.

Transaction Details

The Energy Policy Act of 1992 directed the newly created United States Enrichment Corporation to lease DOE's two gaseous diffusion plants (GDP) in Ohio and Kentucky. On July 1, 1993, DOE and United States Enrichment Corporation entered into an initial 6-year lease for the GDPs. When USEC was privatized in 1998, the lease was transferred to the private corporation and eventually renewed through July 1, 2016. However, USEC returned both GDPs to DOE prior to 2016.

- **Portsmouth GDP**: On December 23, 2010, USEC notified DOE of its intent to return the leased areas of the Portsmouth GDP to DOE. After ceasing uranium enrichment operations in 2001, USEC maintained the Portsmouth plant in cold standby at DOE's request and subsequently cold shutdown status until 2011.[2]

- **Paducah GDP**: On August 1, 2013, USEC notified DOE of its intent to return the leased areas of the Paducah GDP to DOE on October 21, 2014.

[2]USEC's American Centrifuge Plant is located on the site of the Portsmouth GDP and was unaffected by the return of the GDP facilities because associated facilities are leased to USEC beginning in 2004 under a separate agreement with DOE, which continues through June 2019 (see transaction number 15).

The lease contained three key components: (1) the lease of the two GDPs; (2) an electric power agreement for the GDPs; and (3) a services agreement, which enabled DOE and USEC to provide certain services for each other at the GDPs.[3]

- **Lease property at the GDPs**: USEC agreed to pay DOE annual rent at the two GDPs. The base rent represented DOE's costs of administering the lease (including the electric power agreement) and additional rent representing DOE's costs in providing regulatory oversight of the GDPs.[4] USEC's annual rent was to be increased or decreased each year to reflect DOE's actual costs for lease administration. According to DOE officials, from fiscal year 2005 through 2014, DOE received from USEC $17,296,275 in rent payments for the GDPs.[5]

- **Electric power agreement**: When USEC assumed operation of the GDPs, there were long-standing power purchase contracts in place between DOE and two electric power utilities—the Ohio Valley Electric Corporation and Electric Energy, Inc. These two utilities were formed in the early 1950s to provide power to one of DOE's predecessor agencies (the Atomic Energy Commission) for uranium enrichment. The Energy Policy Act of 1992 required that these power purchase contracts be transferred to USEC, or, if the Secretary determined that they could not be transferred, the act required the Secretary to continue to receive power under the contracts and resell the power to the government corporation at cost. In 1993, the Secretary of Energy determined that it was not possible to transfer these power contracts from DOE to USEC. Accordingly, DOE maintained the contracts and sold the power at cost to the government corporation. The USEC Privatization Act directed the government corporation to transfer to the private corporation the right to purchase power from the Secretary under the contracts and

[3]For the purpose of this review, we consider the lease and the two related components to be one transaction associated with facilities management.

[4]This cost structure was required by the Energy Policy Act of 1992.

[5]DOE was unable to provide information about USEC's rent payments prior to 2005 because of a change in DOE's accounting system in 2004.

directed the Secretary to continue selling power to the private corporation at cost.[6]

- **Services agreement**: DOE and USEC entered into this agreement to provide services to one another in support of each other's activities at the Portsmouth and Paducah GDPs. Under this agreement, DOE and USEC were to provide services in accordance with work authorizations, which included specific details such as scope of work, cost estimates, and schedule requirements applicable to the service requested. For example, according to the agreement, USEC agreed to perform certain services for DOE facilities, such as fire protection and janitorial services.

[6]According to Centrus officials, the power purchase agreement for the Portsmouth plant was terminated by DOE effective April 30, 2003. Since September 2000, USEC had been purchasing its power for the Paducah plant under an independent agreement with the Tennessee Valley Authority.

2. Transfer of Highly Enriched Uranium, 1998–2003

Table 3: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Transfer of Highly Enriched Uranium (HEU)

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Establishment of USEC	Up to 50 metric tons of HEU [Note A] and costs associated with safeguards and security [Note B]	None identified	• Compliance with the USEC Privatization Act • Reduced stockpile of HEU

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:DOE officials did not provide GAO with information about the actual amount of HEU that DOE transferred to USEC. According to the agreement between the two parties, DOE had agreed to transfer 50 metric tons of HEU on separate occasions between September 1998 and September 2003.

Note B:According to the agreement, DOE was responsible for paying the safeguards and security costs for the HEU until the HEU was made available or delivered to USEC, whichever was sooner. The agreement did not provide the actual amount DOE was to pay, and DOE officials did not provide us with this information.

Transaction Details

The USEC Privatization Act required DOE to transfer to USEC without charge up to 50 metric tons of enriched uranium and up to 7,000 metric tons of natural uranium from DOE's stockpile.[7] A Senate report accompanying an early version of the act stated that witnesses providing testimony on the bill sought such transfers to enhance the value of USEC in the marketplace and reduce DOE's costs of safeguarding surplus highly enriched uranium (HEU).[8] On April 21, 1998, DOE and USEC entered into an agreement for the transfer of the natural uranium and HEU. According to the agreement, DOE was to transfer the natural uranium to USEC by April 21, 1998—prior to privatization. In addition, DOE was to transfer the HEU to USEC in several allotments over subsequent years. According to DOE officials, the HEU transfers to USEC were completed in fiscal year 2006. The average assay of the HEU that DOE transferred to USEC was 43.7 percent. Because commercial nuclear reactors require an assay level of low-enriched uranium (LEU) between 3 percent and 5 percent, USEC needed to have the HEU downblended. USEC contracted with Babcock & Wilcox to downblend the HEU.

[7]USEC Privatization Act, 42 U.S.C. §§ 2297h-2297h-13 (2015).

[8]S. Rep. No. 104-173, at 14 (1995).

3. Amendment to a Previous HEU Transfer, 1998

Table 4: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Amendment to a Previous Highly Enriched Uranium (HEU) Transfer

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Issues from prior transactions	Unknown [Note A]	$34.7 million	None identified

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:DOE officials told us that they do not know what costs, if any, DOE incurred through this transaction.

Transaction Details

DOE and USEC underestimated the amount of material stored in certain HEU cylinders that DOE had transferred to United States Enrichment Corporation prior to privatization as part of a 1994 agreement. According to the 1998 amendment to the 1994 agreement, DOE and USEC determined that, “through a mutual mistake,” DOE transferred to USEC about 0.8 metric tons of HEU more than initially agreed upon. To address this issue, according to the 1998 amendment to the agreement, USEC agreed to pay DOE $34.7 million to cover the costs of the additional material. This $34.7 million was credited against amounts owed by DOE for services performed by USEC at the GDPs under the 1993 lease agreement.

4. Worker Transition Services, Beginning in 1998[9]

Table 5: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Worker Transition Services

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Establishment of USEC	None identified	$20 million [Note A]	None identified

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:According to the memorandum of agreement, USEC agreed to transfer $20 million to an account in the U.S. Treasury to be administered by DOE to provide the worker transition services.

Transaction Details

DOE agreed to provide services to and in coordination with USEC for the benefit of employees affected by workforce restructuring activities at the Portsmouth and Paducah GDPs as a result of USEC's privatization. USEC agreed to provide $20 million to be administered by DOE to carry out these services. These services were to include, among other things, DOE assistance to USEC in the formulation and implementation of a plan to achieve any necessary reductions in employment at the GDPs during fiscal years 1999 and 2000, and the administration of enhanced adjustment benefits, such as post-separation education assistance, to employees affected by restructuring. In addition, the parties estimated that $5 million would be allocated to economic development projects to create employment opportunities for the affected employees.

[9]DOE officials told us that they do not know when DOE stopped providing these transition services because key DOE officials knowledgeable about this transaction had retired from DOE.

5. Depleted Uranium Tails Liability Acceptance, 1998–2004

Table 6: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Depleted Uranium Tails Liability Acceptance

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Establishment of USEC	$50 million [Note A]	$50 million [Note B]	Unknown

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:This is the estimated dollar value of the liability associated with the depleted uranium tails that DOE accepted from USEC in this transaction.

Note B:USEC paid DOE about $50 million for the storage, management, and disposition of the transferred tails.

Transaction Details

DOE and USEC signed an agreement on June 30, 1998, under which DOE agreed to accept title to and possession of approximately 16,673,980 kilograms of uranium of depleted uranium tails—a product that is generated by the uranium enrichment process that is generally considered to be waste—from USEC. USEC agreed to transfer this material to DOE from fiscal years 1999 to 2004. In exchange, before it was privatized on July 28, 1998, USEC paid DOE about $50 million for the storage, management, and disposition of the transferred tails.

6. HEU Safeguards and Security Services, Beginning in 1999[10]

Table 7: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Highly Enriched Uranium (HEU) Safeguards and Security Services

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Nuclear materials management and security	Unknown [Note A]	Unknown	Unknown

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:DOE officials were unable to provide us with the actual costs to DOE; however, according to the letter agreement, DOE agreed to pay USEC $6.18 million for the safeguards and security costs of certain facilities storing HEU at the Portsmouth GDP from October 1, 1998, to September 30, 1999. The agreement provided that USEC would invoice DOE for costs subsequent to September 30, 1999, but did not detail those costs.

Transaction Details

DOE agreed to pay USEC to provide safeguards and security services for HEU that DOE stored at the Portsmouth GDP. Specifically, DOE agreed to pay USEC $6.18 million during fiscal year 1999 to safeguard and secure DOE HEU stored at the X-326 and X-345 buildings located at the Portsmouth GDP. While the agreement indicated that USEC would invoice DOE for subsequent safeguards and security services, DOE did not provide us with any details about subsequent payments.

[10]DOE officials told us that they do not know when this transaction was completed.

7. Storage of Uranium Enriched to 10 Percent or Greater Assay, Beginning in 1999[11]

Table 8: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Storage of Uranium Enriched to 10% or Greater Assay

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Nuclear materials management and security	Unknown [Note A]	Unknown [Note B]	None identified

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:DOE officials told us that they do not know what costs, if any, DOE incurred through this transaction.

Note B:DOE officials told us that they do not know what benefits, if any, DOE received through this transaction or how much USEC compensated DOE to store the enriched uranium.

Transaction Details

USEC contracted with DOE for the storage of enriched uranium that exceeded the amount of material that, according to a January 1999 agreement between DOE and USEC, USEC could possess in its facilities under Nuclear Regulatory Commission (NRC) limits. DOE agreed to store and manage some of USEC's equipment, containers, and uranium material enriched to 10 percent or greater assay level. USEC agreed to reimburse DOE for the costs associated with the storage of USEC's equipment, containers, and uranium.[12]

[11]DOE officials told us that they do not know how long the department stored enriched uranium for USEC.

[12]The agreement between DOE and USEC did not specify how much USEC would reimburse DOE, and DOE officials told us that they do not known how much USEC compensated the department to store the enriched uranium.

8. Atomic Vapor Laser Isotope Separation Termination, Beginning in 1999[13]

Table 9: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Atomic Vapor Laser Isotope Separation (AVLIS) Termination

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Facilities management	Unknown	Unknown [Note A]	Unknown

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:DOE officials told us that they do not know what benefits, if any, DOE received through this transaction. However, the agreement required USEC to pay DOE $27.1 million, minus $13.4 million for work already performed by USEC for DOE and another unspecified amount representing what USEC had paid or owed to a third-party contractor for work performed from July 1999 to August 1999.

Transaction Details

In the 1970s, DOE began researching a uranium enrichment technology called atomic vapor laser isotope separation (AVLIS) at the Lawrence Livermore National Laboratory in California.[14] The Energy Policy Act of 1992 required the President, if requested, to transfer DOE's intellectual and physical property pertaining to the AVLIS technology to United States Enrichment Corporation without charge. The transfer was made in April 1995. According to USEC, it invested over $100 million dollars to further develop and demonstrate this next-generation technology.[15] However, after determining that the benefits of continuing AVLIS research would not outweigh the potential risks, in June 1999, USEC suspended further development of the technology and decided that instead, it would focus on other enrichment technologies. Following that decision, USEC and DOE entered into an August 1999 agreement to terminate USEC's work on the AVLIS technology. This agreement required USEC to pay DOE to terminate certain of its obligations related to the original agreement, including obligations related to decontamination and decommissioning,

[13]DOE officials told us that they do not know when the activities or the contract terms ended for this transaction. According to DOE officials, the individual most familiar with this transaction is deceased.

[14]The AVLIS technology involves processing uranium metal—rather than uranium hexafluoride gas, which is the feedstock used in the gaseous diffusion and centrifuge enrichment processes—through lasers to separate uranium-235 from uranium-238.

[15]The AVLIS enrichment technology was considered next generation, because according to USEC, it was expected to significantly reduce operating costs and use 90 percent less electricity and 20 to 30 percent less uranium than the gaseous diffusion process.

disposal of waste, and access to records. USEC agreed to pay $27.1 million, minus $13.4 million for work already performed by USEC for DOE and another unspecified amount representing what USEC had paid or owed to a third-party contractor for work performed from July 1999 to August 1999.

9. Permit for USEC Access to Restricted Data, 1999–Present

Table 10: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Permit for USEC Access to Restricted Data

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Other	$0	Unknown [Note A]	None identified

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:Permittees must agree to pay $25,000 for a two-year access permit authorizing access to certain restricted data. However, DOE officials told us that they do not know how much USEC paid for the access permits, as the amount was included in USEC's ongoing rent payments, and the costs included in USEC's rent payments were not broken down.

Transaction Details

USEC paid a fee for access to DOE restricted data, and the permit had to be renewed every 2 years. According to DOE regulations, permittees must agree to pay $25,000 to DOE to authorize access to certain restricted data; however, the actual amount that USEC paid to DOE is unknown because, according to DOE officials, the amount was included in USEC's ongoing rent payments, and the costs included in USEC's rent payments were not broken down.

10. Cooperative Research and Development Agreement, 2000–2014

Table 11: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Cooperative Research and Development Agreement (CRADA)

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
National security [Note A]	$0 [Note B]	None identified	None identified

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:According to Oak Ridge officials, this transaction is also related to the development of a commercial enrichment capability.

Note B:According to the CRADA, the government's estimated contribution was $0.

Transaction Details

On June 30, 2000, DOE approved a Cooperative Research and Development Agreement (CRADA) between USEC and UT-Battelle, LLC—the management and operating contractor for DOE's Oak Ridge National Laboratory. The purpose of the CRADA was for the parties to develop an economically attractive gas centrifuge machine and enrichment process.[16] Initial extensions to the CRADA were approved by DOE in July 2002 and September 2002. According to Oak Ridge officials, the CRADA was renewed in 2012 and extended through 2017. Under the CRADA, USEC employees and technical personnel from Oak Ridge National Laboratory work to deploy USEC's "lead cascade" test facility.[17] The total estimated value of the CRADA was $435 million, funded entirely by USEC, which, according to Oak Ridge officials, was the single largest CRADA in the history of the laboratory. According to DOE officials, the CRADA was terminated in 2014 after UT-Battelle, LLC, signed the "Domestic Uranium Enrichment – Centrifuge Information and Analysis" agreement with USEC in May 2014 (see transaction number 23).

[16]While the CRADA is a transaction between USEC and UT-Battelle, we included it in the scope of our review because it was entered into under UT-Battelle's contract with DOE to manage and operate the Oak Ridge National Laboratory and therefore represented an indirect exchange of services between DOE and USEC.

[17]According to Centrus, a "lead cascade" is a configuration of full-size centrifuge machines operating in a closed-loop formation, whereby samples are withdrawn for testing purposes and the enriched and depleted uranium streams are recombined into feed material.

11. Portsmouth GDP Closure, 2001–2011

Table 12: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Portsmouth Gaseous Diffusion Plant (GDP) Closure

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Facilities management	$895 million [Note A]	Reduction of long-term decontamination and decommissioning costs	Maintenance of the GDP in a condition allowing enrichment to be resumed if needed

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:According to DOE officials, DOE paid USEC approximately $895 million for activities related to the Portsmouth closure from 2001 through 2011. About $700 million of this amount was in monetary payments from appropriated funding. DOE used natural uranium valued at about $195 million (about 1,473 metric tons of uranium) to pay for the remaining amount.

Transaction Details

DOE and USEC were involved in a 10-year transaction related to the closure of the Portsmouth GDP. Activities related to the closure were performed under one contract and represented two phases at the Portsmouth GDP: (1) cold standby and (2) cold shutdown.

- **Cold standby**: In June 2000, USEC announced its decision to cease uranium enrichment operations at the Portsmouth GDP in June 2001.[18] On March 1, 2001, the Secretary of Energy announced that DOE would place the Portsmouth GDP in cold standby mode—a dormant condition that would allow operations to be resumed within 18 to 24 months if needed. In August 2001, DOE and USEC signed an agreement for USEC to provide certain services, including those necessary for maintaining the GDP in cold standby mode. Specifically, beginning in 2001, USEC provided a number of services for DOE related to cold standby, including winterization and removal of deposits of uranium hexafluoride from equipment.

- **Cold shutdown**: In 2006, DOE and USEC modified the Portsmouth GDP cold standby contract to begin transitioning the GDP to cold shutdown mode. Cold shutdown mode involved work to maintain and prepare the GDP for eventual decontamination and decommissioning.

[18]According to Centrus officials, USEC decided to cease enrichment operations at the Portsmouth GDP as a result of increased supply of LEU from Russia under the HEU Purchase Agreement—a 1993 nuclear arms reduction agreement between the United States and Russia—and the high costs of operating the GDP.

According to DOE officials, the department let the contract expire on March 28, 2011.

12. Uranium Decontamination and Replacement, 2002–2009

Table 13: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Uranium Decontamination and Replacement

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Issues from prior transactions	Unknown [Note A]	None identified	• DOE was released of all liability associated with the contaminated uranium that it had transferred to USEC before privatization • DOE's contaminated uranium was also decontaminated, allowing DOE to use it to meet program needs

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:DOE officials told us that they do not know the costs DOE incurred through this transaction for the period 2002–2006. However, DOE officials stated that under 2004 and 2006 agreements, DOE compensated USEC with about $220 million, of which about $140 million was in monetary payments and about $85 million was in 1,104 metric tons of uranium (MTU) of natural uranium. In addition, according to a 2002 agreement, DOE agreed to accept title to up to 23,300 MTU of depleted uranium from USEC, as well as title to 4,080 MTU of depleted uranium under a November 2003 letter agreement, and title to an undefined amount of depleted uranium under a September 2003 letter agreement.

Transaction Details

Under this transaction, which spanned 7 years, DOE and USEC contracted for USEC to clean up contaminated uranium; in exchange, DOE provided replacement uranium and payments to USEC and also took title to some of USEC's depleted uranium. Specifically, in early 2001, USEC notified DOE that up to 9,550 metric tons of about 45,000 metric tons of natural uranium that it had received from DOE prior to privatization was contaminated with technetium—a radioactive metal that is produced as a by-product of fission in a nuclear reactor—at levels exceeding the commercial specification for nuclear fuel.[19] After USEC notified DOE of its contaminated uranium, DOE determined that about 5,517 metric tons of uranium in DOE's inventory was also contaminated with technetium.

According to USEC, replacing the 9,550 metric tons of contaminated uranium would have cost USEC approximately $238 million in 2001. USEC requested that DOE replace USEC's contaminated uranium with clean uranium from DOE's inventory. DOE did not admit legal liability for compensating USEC for the contaminated uranium. In addition, according

[19]Between United States Enrichment Corporation's creation in 1992 and its privatization in 1998, DOE transferred about 45,000 metric tons of natural uranium to the corporation for, among other things, fulfilling enrichment contracts with USEC's customers.

to DOE officials, DOE did not have enough available clean uranium in its excess uranium inventory to replace all of USEC's contaminated uranium.

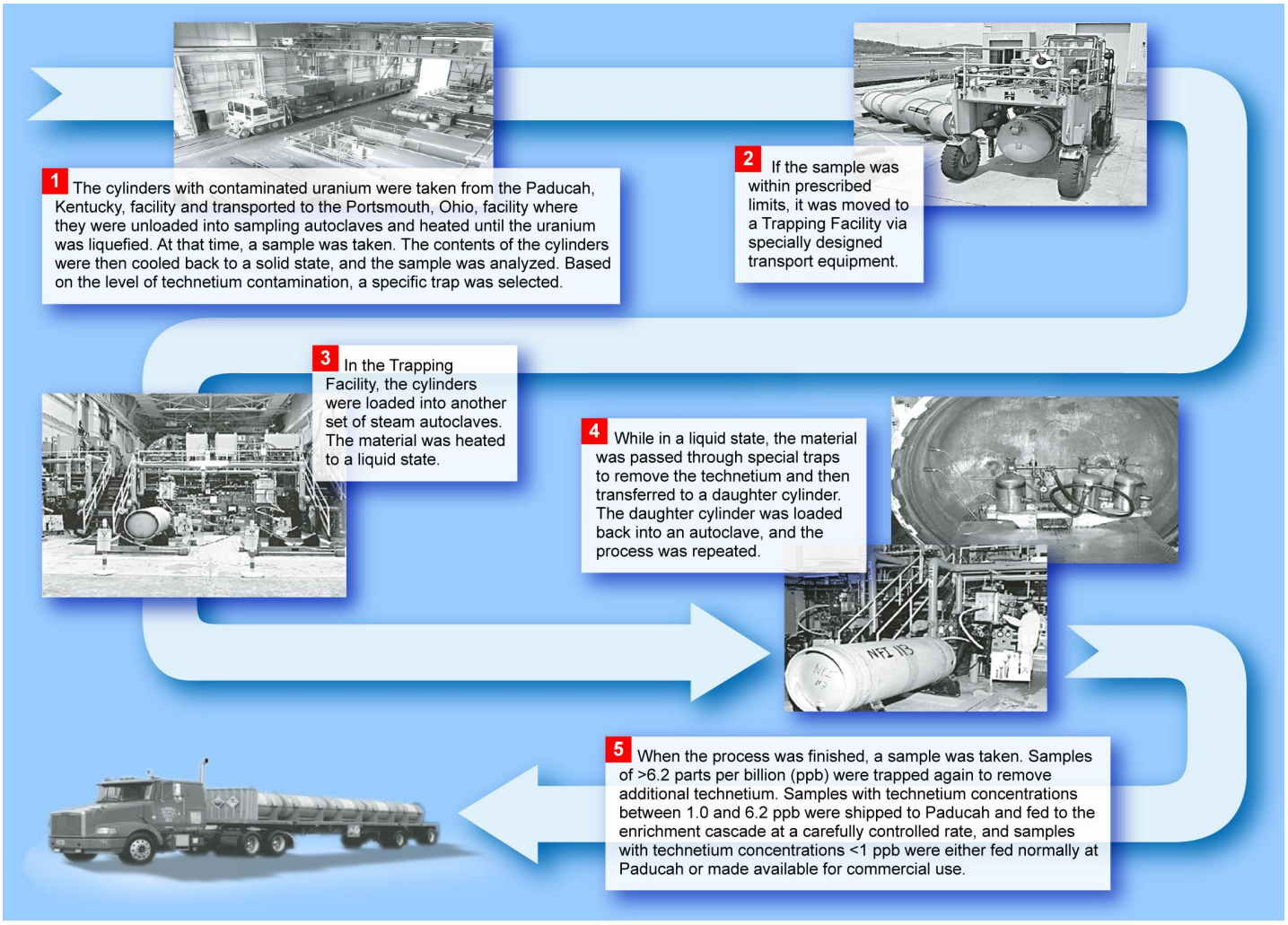
However, starting in 2002, DOE and USEC signed a series of agreements to decontaminate or replace USEC's contaminated inventory (see fig. 3 for a summary of the uranium decontamination process). In June 2002, DOE and USEC agreed that, among other things, USEC would process some of the contaminated uranium at the Portsmouth plant for 15 months to remove the technetium. USEC would initially pay about half of the costs associated with decontamination, and DOE would compensate USEC by taking title to some of USEC's depleted uranium, reducing USEC's costs for eventual disposal of this material. As part of the June 2002 agreement, USEC agreed to formally release DOE from any potential claims of liability as USEC decontaminated the uranium. USEC decontaminated about 2,900 metric tons of uranium under this agreement. DOE and USEC signed two subsequent agreements in September and November 2003 that extended USEC's decontamination work through December 2003.

In 2004, DOE and USEC signed additional agreements for USEC to decontaminate uranium. Specifically, under an April 2004 work authorization, DOE paid USEC using appropriated funds for decontamination work conducted from December 2003 to December 2004. USEC decontaminated about 2,050 metric tons during this time. In October 2004, DOE replaced 2,116 metric tons of USEC's contaminated uranium with the same amount of uncontaminated uranium. Two months later, in December 2004, USEC agreed to decontaminate an additional amount of contaminated uranium. In June 2006, we reported that DOE had provided USEC about 1,100 metric tons of uncontaminated uranium, which USEC sold on the commercial market for $84.4 million. In addition, in April 2006, DOE sold uranium to obtain funding to compensate USEC for decontamination services that were expected to last from July 2006 through November 2006. According to DOE officials, uranium cleanup activities continued through 2009.

In addition, DOE had a total of about 7,633 metric tons of contaminated uranium in its own inventory—including the 2,116 metric tons it took from USEC and the 5,517 metric tons of uranium in its own inventory that DOE had previously identified as being contaminated. USEC agreed to decontaminate some of DOE's inventory under the December 2004 agreement, which DOE agreed to pay for by transferring some uncontaminated uranium to USEC. All of the contaminated uranium would eventually need to be decontaminated before DOE could make it

commercially available because the presence of the contaminant significantly reduced the value of the uranium in the commercial marketplace.

Figure 3: Process Used to Decontaminate Uranium at the Portsmouth Gaseous Diffusion Plant



Source: GAO analysis of USEC data; USEC (photos). | GAO-15-730

13. Lease for Centrifuge Production and Testing Facilities, 2002–2016

Table 14: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Lease for Centrifuge Production and Testing Facilities

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Facilities management	$0	At least $8,188,799 [Note A]	None identified

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:This is the cumulative total amount that USEC paid to DOE for rent of the Oak Ridge facilities from fiscal year 2005 through fiscal year 2014. DOE was unable to provide information on USEC's rent payments prior to 2005.

Transaction Details

On December 20, 2002, DOE and USEC entered into a lease agreement for two buildings in Oak Ridge, Tennessee, for the purpose of developing American Centrifuge technology. The two leased buildings (K-1600 and K-101 in DOE's East Tennessee Technology Park) provided USEC with manufacturing and testing facilities. The term of the lease was initially through January 2006 but, according to DOE officials, the lease was eventually renewed through January 2016. Unlike the lease for the GDPs (see transaction number 1), for this lease USEC contracted directly with a third-party provider to procure electricity for the facilities, and therefore, electricity costs are not included in USEC's rent payments.

14. HEU Transfer to Replace Previously Transferred HEU, 2003

Table 15: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Highly Enriched Uranium (HEU) Transfer to Replace Previously Transferred HEU

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Issues from prior transactions	Unknown [Note A]	Unknown [Note A]	Unknown [Note A]

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:DOE officials told us that they do not know the costs and benefits of this transaction because key DOE officials knowledgeable about the transaction have retired from DOE.

Transaction Details

In February 2001, USEC notified DOE that it intended to reject some of the HEU delivered under a prior transaction in which DOE transferred HEU to USEC. Specifically, in a letter to DOE, USEC noted that the intent of the arrangement was for DOE to provide USEC with material that could be downblended into commercially acceptable LEU; however, “the quality of some of the HEU ha[d] been so poor” that it was not practical to make into LEU. Therefore, USEC requested that DOE take back the rejected material and provide an equivalent amount of HEU to replace the rejected material. In 2003, DOE agreed to transfer replacement HEU to USEC. According to the 2003 memorandum of agreement between DOE and USEC, DOE also agreed to compensate USEC for the costs of sampling, drying, repackaging, and shipping the rejected HEU to DOE.

15. Lease for American Centrifuge Lead Cascade Facilities, 2004–2019

Table 16: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Lease for American Centrifuge Lead Cascade Facilities

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Facilities management	$0	At least $13,109,756 [Note A]	None identified

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:This is the cumulative total amount that USEC paid to DOE for rent of the American Centrifuge lead cascade facilities from fiscal year 2007 through fiscal year 2014. DOE did not provide GAO with the amount USEC paid to DOE under the temporary lease from 2004 through 2006.

Transaction Details

In 2002, USEC announced that it had selected the Portsmouth GDP facilities in Piketon, Ohio, as the site of its future lead cascade for the American Centrifuge Plant. The purpose of USEC's lead cascade was to refurbish, test, evaluate, and demonstrate gas centrifuges. In addition, the lead cascade was expected to yield performance data for USEC on the design, cost, operation, and reliability of the centrifuge technology. In 2004, DOE entered into a temporary lease agreement with USEC at the Portsmouth GDP to facilitate preparation of the site—such as moving certain DOE material and equipment—for a longer-term lease of facilities related to the development of its lead cascade. Later, in 2006, USEC and DOE signed a second lease for the purposes of developing the lead cascade and for the construction and operation of a gas centrifuge enrichment plant. The lease agreement is still in place with Centrus Energy Corp.

16. Depleted Uranium Tails Pilot Project, 2005–2006

Table 17: Summary of Department of Energy (DOE)-Identified Costs and Benefits for the Depleted Uranium Tails Pilot Project

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Other	Unknown [Note A]	• $10,450 per cylinder successfully enriched • Avoidance of approximately $40 million in disposal costs	Demonstration that there is a viable path for reutilization of DOE's inventory of depleted uranium tails

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:DOE officials stated that they do not have an estimate of costs to DOE for this transaction.

Transaction Details

In 2005, DOE's Office of Environmental Management, the Bonneville Power Administration, Energy Northwest,[20] and USEC executed a series of agreements to carry out a pilot project to determine whether a portion of DOE's depleted uranium inventory could be used to produce nuclear fuel for Energy Northwest's Columbia Generating Station, a nuclear power reactor near Richland, Washington, the generating capacity of which Bonneville Power Administration had purchased.[21] The depleted uranium tails would be re-enriched and used instead of natural uranium-based feed to produce LEU for the Columbia Generating Station.

Accordingly, in spring 2005, DOE's Office of Environmental Management and the Bonneville Power Administration agreed that the Office of Environmental Management would transfer about 5,720 MTU of high-assay depleted uranium to Energy Northwest, and the Bonneville Power Administration and Energy Northwest agreed that Energy Northwest would accept the depleted uranium. Energy Northwest contracted with USEC to enrich the depleted uranium. At the time of the 2005 agreement,

[20]Energy Northwest is a membership organization of public utilities in the northwestern United States that includes the Columbia Generating Station—a nuclear power plant that provides all of its output at cost to the Bonneville Power Administration, a federal nonprofit agency.

[21]In 2004, Energy Northwest approached the Bonneville Power Administration about the possibility of re-enriching some of DOE's depleted uranium for use as fuel at the Columbia Generating Station. DOE was interested in the proposal because, if successful, it would reduce the costs DOE would otherwise incur for disposing of the depleted uranium. Energy Northwest and the Bonneville Power Administration were interested in the proposal because, if successful, it would reduce electricity rates for the Bonneville Power Administration ratepayers.

the parties estimated that Energy Northwest would pay USEC approximately $88 million for enrichment services and fees. Energy Northwest agreed to pay the Office of Environmental Management $10,450 per cylinder successfully enriched. Energy Northwest also agreed to pay the Office of Environmental Management $2,200 per cylinder of depleted uranium transferred or returned to offset shipping costs—which were, according to DOE officials, about $1.5 million in total. Because the costs were offset by Energy Northwest, DOE officials said that there were likely no major costs to DOE for the transaction. At the time of the transaction, DOE expected the transaction would enable it to avoid as much as $40 million in disposal costs, according to a DOE letter to Energy Northwest.

17. Nuclear Materials Management and Safeguards System Management Contract, 2005–2008

Table 18: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Nuclear Materials Management and Safeguards System (NMMSS) Management Contract

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Nuclear materials management and security	$10,230,000 [Note A]	None identified	Nuclear material control and accountability

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:DOE officials told us that DOE shared the costs of this contract with the Nuclear Regulatory Commission, which contributed $6,740,000 during this time frame.

Transaction Details

The Nuclear Materials Management and Safeguards System (NMMSS) is the U.S. government's official database for tracking nuclear material inventories and shipments by government and commercial nuclear facilities within, as well as to and from, the United States. NMMSS is jointly funded by DOE and the NRC and is operated under a DOE/National Nuclear Security Administration contract. According to DOE officials, in 1995, the contract for operation of the NMMSS database was transferred from a DOE management and operating contractor to NAC International Inc. (NAC). In August 2004, NAC notified DOE and NRC that it was to be acquired by USEC. USEC completed its acquisition of NAC in November 2004, becoming a wholly owned subsidiary of USEC.[22] Based on this change in ownership, NRC evaluated whether use of NAC to operate the NMMSS gave rise to an organizational conflict of interest.[23] The NRC concluded that a conflict of interest did exist and determined that mitigation of this conflict would be necessary in order for NAC to continue its role as NMMSS operator. According to DOE officials, NRC subsequently approved administrative measures to be put in place to mitigate this conflict, and based on the acceptance and imposition of these measures, NRC determined that the conflict of interest was

[22]USEC eventually sold NAC in March 2013 to a subsidiary of Hitachi Zosen Corporation. By this time, NAC was no longer managing NMMSS.

[23]Because of its uranium enrichment operations, USEC was one of the most significant entities reporting information to NMMSS. According to an NRC document, because, as the parent company of NAC, USEC assumed the dual roles of both reporting and processing information in NMMSS, NRC determined that its use of NAC to operate the NMMSS system appeared to give rise to an organizational conflict of interest.

adequately addressed and allowed NAC to continue to operate NMMSS. DOE officials told us that, in September 2005, DOE exercised an option capped at $25 million to extend the performance period of the NAC contract for an additional 36 months covering the period from October 1, 2005, through September 30, 2008. In 2008, DOE informed NAC that it would not execute any further options for it to continue in its role as NMMSS contractor and make the operating contract a small business set aside. The contract with NAC for management of NMMSS ended on September 30, 2008.

18. Depleted Uranium Tails Liability Acceptance, 2010

Table 19: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Depleted Uranium Tails Liability Acceptance

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
National security	$45 million	None identified	Supported the development of the American Centrifuge technology as a long-term source of unobligated low-enriched uranium

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Transaction Details

In March 2010, DOE and USEC signed a cooperative agreement valued at $90 million to share equally the costs of the continued development and demonstration of specific aspects of the American Centrifuge technology from January 1, 2010, to December 31, 2010. Under this agreement, DOE and USEC agreed to jointly fund the manufacture of American Centrifuge machines for use in USEC's lead cascade. To execute this transaction, DOE agreed to accept title to up to 19,700,000 kilograms of depleted uranium tails from USEC along with the responsibility for their disposal, which allowed USEC to release $45 million in funds that had been committed to the future disposal of these tails.

19. Permit for USEC Subsidiaries Access to Restricted Data, 2011–Present

Table 20: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Permit for USEC Subsidiaries Access to Restricted Data

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
Other	$0	Unknown [Note A]	None identified

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:Permittees must agree to pay $25,000 for a two-year access permit authorizing access to certain restricted data. However, DOE officials told us that they do not know how much USEC paid for the access permits, as the amount was included in USEC's ongoing rent payments, and the costs included in USEC's rent payments were not broken down.

Transaction Details

USEC paid a fee for five of its subsidiaries to access DOE restricted data, and the permit had to be renewed every 2 years. According to DOE regulations, permittees must agree to pay $25,000 to DOE to authorize access to certain restricted data; however, the actual costs that USEC paid to DOE are unknown because, according to DOE officials, the amount was included in USEC's ongoing rent payments, and the costs included in USEC's rent payments were not broken down.

20. Separative Work Unit Procurement, 2012

Table 21: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Separative Work Unit Procurement

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
National security	$43.7 million	$44.4 million	Obtained unobligated low-enriched uranium (LEU) for 18 months of tritium production [Note A]

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note: Separative Work Unit is the industry standard for the measure of effort needed to transform a given amount of natural uranium into LEU.

Note A:DOE later returned this unobligated LEU to USEC as part of one of its uranium transfers under its 2012 Research, Development and Demonstration Cooperative Agreement with USEC.

Transaction Details

In March 2012, USEC's financial condition was weakening and, according to DOE officials, USEC was struggling to support the development of the American Centrifuge technology. DOE requested authority to transfer $150 million from existing funds in fiscal year 2012 to support USEC's development of the American Centrifuge technology, but Congress did not provide this authority. Subsequently, DOE entered into a transaction with USEC in March 2012, under which it accepted title to 13,073 MTU of low-assay tails, along with the responsibility for their disposal, from USEC. This enabled USEC to free up $44 million in previously encumbered funds that were being used as collateral for surety bonds to satisfy NRC's financial assurance requirements for the tails' future disposal.

According to DOE officials, in order to receive an asset in return for assuming USEC's liability, DOE received $44.4 million in separative work unit (SWU) services from USEC (SWU is the industry standard for the measure of effort needed to transform a given amount of natural uranium into LEU). To facilitate receipt of this SWU, DOE provided 409 MTU natural uranium as uranium hexafluoride for 48 MTU of unobligated LEU (equivalent to 409 MTU of natural uranium plus SWU).[24]

[24]See GAO-14-291 for additional details about this transaction.

21. Depleted Uranium Enrichment Project, 2012–2013[25]

Table 22: Summary of Department of Energy (DOE)-Identified Costs and Benefits for the Depleted Uranium Enrichment Project

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
National security	$0 [Note A]	$759 million [Note B]	• Assured source of unobligated low-enriched uranium (LEU) for up to 15 years of tritium production [Note C] • Kept the Paducah Gaseous Diffusion Plant (GDP) open for an additional year and delayed DOE's cleanup obligations

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:In May 2014, we found that, although DOE determined that tails they transferred as part of this transaction had no value, they could have been valued at up to $300 million. See GAO, *Department of Energy: Enhanced Transparency Could Clarify Costs, Market Impact, Risk, and Legal Authority to Conduct Future Uranium Transactions*, GAO-14-291 (Washington, D.C.: May 9, 2014).

Note B:DOE identified this amount in cost savings primarily from avoiding the costs of an alternative to using tails to obtain LEU and delaying the turnover of the Paducah GDP facility.

Note C: LEU is considered unobligated when neither the uranium nor the technology used to enrich it carries an "obligation" from a foreign country regarding its use, such as a requirement that the material only be used for peaceful purposes.

Transaction Details

In May 2012, DOE took steps to secure a supply of unobligated LEU for tritium production in anticipation of USEC's pending closure of the Paducah GDP. The transaction involved four parties—DOE, USEC, Energy Northwest, and the Tennessee Valley Authority—but there were no monetary payments or uranium transfers directly between DOE and USEC. The four parties engaged in a series of transfers, beginning with DOE's transfer of depleted uranium tails to Energy Northwest, which then contracted with USEC to re-enrich the tails. Ultimately, Energy Northwest agreed to sell the majority of the LEU that USEC enriched to the Tennessee Valley Authority in installments from 2015 through 2022 under a long-term contract. Tennessee Valley Authority is then to use the LEU in its nuclear reactors for energy production and for the production of tritium, which it will provide to DOE under a separate, pre-existing contract. Ultimately, DOE expects to benefit from this transaction by

[25]The Depleted Uranium Enrichment Project involves four main parties, including DOE and USEC. DOE transferred depleted uranium tails to a third party in 2012, and USEC completed re-enrichment of the tails in 2013. See GAO-14-291 for additional details about this transaction.

ensuring a source of unobligated LEU for Tennessee Valley Authority use for up to a 15-year supply of tritium production from a single reactor.

22. Research, Development, and Demonstration Cooperative Agreement, 2012–2014

Table 23: Summary of Department of Energy (DOE)-Identified Costs and Benefits for the Research, Development and Demonstration Cooperative Agreement

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
National security	$280 million	None identified	Supported the development of the American Centrifuge technology as a long-term source of unobligated low-enriched uranium

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Transaction Details

On June 12, 2012, DOE and USEC signed a cooperative agreement to financially support a research, development, and demonstration program for American Centrifuge technology in furtherance of national security purposes and potential future commercialization. The cooperative agreement required the completion of a number of milestones and performance indicators. According to Centrus officials, USEC achieved all of the milestones and performance indicators on time and under budget. The terms of the cooperative agreement—which covered work performed from June 1, 2012, through April 30, 2014—committed DOE to providing up to $280 million, or 80 percent, of the costs for the program, with USEC committing to fund the remaining 20 percent. Initially the agreement was through December 31, 2013; however, the agreement was extended until April 2014. DOE ultimately provided USEC $280 million in support of the agreement, which included $148 million in transfers of appropriated funds and $132 million in credited value associated with two uranium transfers.[26]

[26]See GAO-14-291 for additional details on the two uranium transfers.

23. Agreement between UT-Battelle and USEC, 2014–2015

Table 24: Summary of Department of Energy (DOE)-Identified Costs and Benefits for Agreement between UT-Battelle and USEC

		DOE-identified benefits	
Transaction category	**DOE-identified costs**	**Monetary benefits**	**Nonmonetary benefits**
National security	$64.5 million [Note A]	None identified	Maintaining operability of the American Centrifuge and associated technology while DOE assesses options for meeting DOE's needs for low-enriched uranium

Sources: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Note A:The contract is incrementally funded. As of January 23, 2015, UT-Battelle/DOE had funded a total of $64,453,224. According to DOE officials, the total value of the contract is $117,037,597.

Transaction Details

In the wake of USEC's bankruptcy filing in April 2014, the Secretary of Energy tasked its Oak Ridge National Laboratory with maintaining the operability of the American Centrifuge technology. As operator of Oak Ridge National Laboratory, UT-Battelle signed an agreement—called the "Domestic Uranium Enrichment – Centrifuge Information and Analysis" agreement[27]—with USEC on May 1, 2014, to maintain the capability of and, where possible, advance the American Centrifuge technology in furtherance of DOE's national security objectives. According to Oak Ridge officials, this agreement provides for the collection of data and provides reports related to the cascade operations and research and development activities. As of January 23, 2015, UT-Battelle had provided USEC $64.5 million in funding. These costs are funded by DOE through UT-Battelle's contract with DOE.

[27]USEC documents refer to this agreement as the "American Centrifuge Technology Demonstration and Operations agreement."

Appendix III: Department of Energy Transactions Involving USEC Inc. or Centrus Energy Corp. by Category

Category	Transactions date and name
Establishment of USEC Inc. (USEC)	• 1998 – 2003: Transfer of highly enriched uranium (HEU) • Beginning in 1998: Worker transition services • 1998 – 2004: Depleted Uranium Tails Liability Acceptance
National security	• 2000 – 2014: Cooperative Research and Development Agreement • 2010: Depleted Uranium Tails Liability Acceptance • 2012: Separative work unit procurement • 2012 – 2013: Depleted Uranium Enrichment Project • 2012 – 2014: Research, Development, and Demonstration Cooperative Agreement • 2014 – 2015: Agreement between UT-Battelle and USEC
Facilities management	• 1993 – 2014: Lease of the Portsmouth and Paducah Gaseous Diffusion Plants (GDP) • Beginning in 1999: atomic vapor laser isotope separation termination • 2001 – 2011: Portsmouth GDP closure • 2002 – 2016: Lease for centrifuge production and testing facilities • 2004 – 2019: Lease for American Centrifuge lead cascade facilities
Nuclear materials management and security	• Beginning in 1999: HEU Safeguards and Security Services • Beginning in 1999: Storage of uranium enriched to 10% or greater assay • 2005 – 2008: Nuclear Materials Management and Safeguards System Management Contract
Issues from prior transactions	• 1998: Amendment to a previous HEU transfer • 2002 – 2009: Uranium decontamination and replacement • 2003: HEU transfer to replace previously transferred HEU
Other	• 1999 – Present: Permit for USEC access to restricted data • 2005 – 2006: Depleted Uranium Tails Pilot Project • 2011 – Present: Permit for USEC subsidiaries access to restricted data

Source: GAO analysis of DOE documents and interviews with DOE officials. | GAO-15-730

Appendix IV: Example of Standard Question Set Provided to Department of Energy Officials on Each Transaction

Transaction:

DOE/NNSA Point(s) Of Contact:

Related documents:

1. Please provide copies of the following documents:
   [...]
2. Please provide a copy of any additional contract, agreement, DOE/NRC Form 741, or other document(s) that supports the information on the date, purpose, costs, and benefits listed below.

Overview:

Please confirm that the transaction was agreed upon on *Date*:

☐ Correct.

☐ Incorrect. Please provide an alternate date, if applicable.

3. Date transaction was completed *(e.g.* date contract terms ended):
4. Please describe the overall purpose of this transaction.

Costs DOE

5. What were the overall costs to DOE for this transaction?
6. What types of costs, if any, did DOE incur from this transaction? (*Check all that apply*)

☐ Provided monetary payment[a] to USEC.

Total amount of payment:

Date payment provided:

☐ Provided uranium (natural or enriched) to USEC.

Type(s) of uranium provided:

Date(s) uranium provided:

Market value of uranium:

Amount of uranium in MTU[b]:

☐ Accepted liability for depleted uranium from USEC.

Estimated dollar value of liability:

Date(s) uranium provided:

Amount in MTU:

☐ Other costs.

Please explain.

7. If DOE did not incur any costs associated with this set of transactions, why not?

Benefits to DOE

8. What were the overall financial benefits of this transition to DOE?
9. What were the overall non-financial benefits of this transaction to DOE?
10. What types of benefits, if any, did DOE receive from this transaction? (*Check all that apply*)

☐ Received monetary payment from USEC.

Total amount of payment:

Date payment provided:

☐ Received uranium (natural or enriched) from USEC.

Type(s) of uranium provided:

Date(s) uranium provided:

Market value of uranium:

Transaction:
DOE/NNSA Point(s) Of Contact:
Amount of uranium in MTU[b]:
☐ Received services[c] from USEC.
Please summarize services received:
☐ Other benefits.
Please explain.
11. If DOE did not receive any benefits associated with this set of transactions, why not?

[a]Monetary payment includes any amount of money transferred to USEC using appropriated or transferred funding.
[b]MTU = metric tons of uranium
[c]Services could include enrichment, clean-up, maintenance, among other things.

Source: GAO. | GAO-15-730

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

David C. Trimble, (202) 512-3841 or trimbled@gao.gov

Staff Acknowledgments

In addition to the individual named above, Allison B. Bawden (Assistant Director), Eric Bachhuber, Antoinette Capaccio, Amanda K. Kolling, and Karen Villafana made key contributions to this report. Also contributing to this report were Doreen Eng, Ellen Fried, Risto Laboski, Mehrzad Nadji, Alison O'Neill, Dan C. Royer, and Rebecca Shea.

Appendix VI: Accessible Data

Accessible Text and Data Tables

Accessible Text for Figure 1: Nuclear Fuel Cycle

1) **Mining:** Uranium ore;
2) **Milling:** Uranium oxide (yellowcake or U_3O_8);
3) **Conversion**: Uranium hexafluoride (UF_6);
4) **Enrichment:** Low-enriched uranium:
    a) **Tails:** Depleted uranium:
        i) **Storage**;
    b) **Tails re-enrichment**;
5) **Fuel fabrication:** Uranium dioxide;
6) **Reactors:** Commercial reactors for energy production:
    a) Tennessee Valley Authority (TVA):
        i) **Tritium:** TVA produces tritium;
7) **Spent fuel**;

Sources: GAO analysis of International Atomic Energy Agency, Nuclear Regulatory Commission, Congressional Research Service, Department of Energy, and TVA documents. | GAO-15-730

Note: The Tennessee Valley Authority produces tritium through an interagency agreement with DOE.

Data Table for Figure 2: Timeline of 23 Transactions in Which DOE and USEC Have Been Involved Since 1998

Number	Transaction	Transaction type	Year range
1	Lease for the Portsmouth and Paducah GDPs	Facilities management	1993-2014
2	Transfer of HEU	Establishment of USEC	1998-2003
3	Amendment to a previous HEU transfer	Issues from prior transactions	1998
4	Worker transition services [Note A]	Establishment of USEC	1998
5	Depleted Uranium Tails Liability Acceptance	Establishment of USEC	1998-2004
6	HEU Safeguards and Security Services [Note A]	Nuclear materials management and security	1999
7	Storage of uranium enriched to 10% or greater assay [Note A]	Nuclear materials management and security	1999
8	AVLIS termination [Note A]	Facilities management	1999
9	Permit for USEC access to restricted data	Other	1999-present
10	CRADA	National security	200-2014

Number	Transaction	Transaction type	Year range
11	Portsmouth GDP closure	Facilities management	2001-2011
12	Uranium decontamination and replacement	Issues from prior transactions	2002-2009
13	Lease for centrifuge production and testing facilities	Facilities management	2002-2016 (Scheduled to end 2016)
14	HEU transfer to replace previously transferred HEU	Issues from prior transactions	2003
15	Lease for American Centrifuge lead cascade facilities	Facilities management	2004-2019 (Scheduled to end 2019)
16	Depleted Uranium Tails Pilot Project	Other	2005-2006
17	NMMSS management contract	Nuclear materials management and security	2005-2008
18	Depleted Uranium Tails Liability Acceptance	National security	2010
19	Permit for USEC subsidiaries access to restricted data	Other	2011-present
20	SWU procurement	National security	2012
21	Depleted Uranium Enrichment Project	National security	2012-2013
22	RD&D Cooperative Agreement	National security	2012-2014
23	Agreement between UT-Battelle and USEC	National security	2014-2015

Sources: GAO analysis of Department of Energy (DOE) and USEC documents, and interviews with DOE officials. | GAO-15-730

Abbreviations: AVLIS = Atomic Vapor Laser Isotope Separation; CRADA = Cooperative Research and Development Agreement; GDP = gaseous diffusion plant; HEU = highly enriched uranium; LEU = low-enriched uranium; NMMSS = Nuclear Materials Management and Safeguards System; RD&D = Research Development and Demonstration; SWU = separative work unit; USEC = USEC Inc.

Note A: These transactions began on the year listed in the graphic. However, we do not have information on the extent of their duration because DOE officials told us that they do not know when these transactions were completed.

Accessible Text for Figure 3: Process Used to Decontaminate Uranium at the Portsmouth Gaseous Diffusion Plant

1. The cylinders with contaminated uranium were taken from the Paducah, Kentucky, facility and transported to the Portsmouth, Ohio, facility where they were unloaded into sampling autoclaves and heated until the uranium was liquefied. At that time, a sample was taken. The contents of the cylinders were then cooled back to a solid state, and the sample was analyzed. Based on the level of technetium contamination, a specific trap was selected.
2. If the sample was within prescribed limits, it was moved to a Trapping Facility via specially designed transport equipment.
3. In the Trapping Facility, the cylinders were loaded into another set of steam autoclaves. The material was heated to a liquid state.

4. While in a liquid state, the material was passed through special traps to remove the technetium and then transferred to a daughter cylinder. The daughter cylinder was loaded back into an autoclave, and the process was repeated.
5. When the process was finished, a sample was taken. Samples of [greater than] 6.2 parts per billion (ppb) were trapped again to remove additional technetium. Samples with technetium concentrations between 1.0 and 6.2 ppb were shipped to Paducah and fed to the enrichment cascade at a carefully controlled rate, and samples with technetium concentrations [less than] 1 ppb were either fed normally at Paducah or made available for commercial use.

Source: GAO analysis of USEC data; USEC (photos). | GAO-15-730

Example of Standard Question Set Provided to Department of Energy Officials on Each Transaction

Accessible Text for Appendix IV: Example of Standard Question Set Provided to Department of Energy Officials on Each Transaction

Transaction:

DOE/NNSA Point(s) Of Contact:

Related documents:

1) Please provide copies of the following documents:

2) Please provide a copy of any additional contract, agreement, DOE/NRC Form 741, or other document(s) that supports the information on the date, purpose, costs, and benefits listed below.

Overview:

Please confirm that the transaction was agreed upon on [Date]

- [Checkbox] Correct.
- [Checkbox] Incorrect. Please provide an alternate date, if applicable.

3) Date transaction was completed (e.g. date contract terms ended):

4) Please describe the overall purpose of this transaction

Costs DOE

5) What were the overall costs to DOE for this transaction?

6) What types of costs, if any, did DOE incur from this transaction? (Check all that apply)

a) [Checkbox] Provided monetary payment [Note A] to USEC.

i) Total amount of payment:

ii) Date payment provided:

b) [Checkbox] Provided uranium (natural or enriched) to USEC.

i) Type(s) of uranium provided:

ii) Date(s) uranium provided:

iii) Market value of uranium:

iv) Amount of uranium in MTU [Note B]:

c) [Checkbox] Accepted liability for depleted uranium from USEC.

i) Estimated dollar value of liability:

ii) Date(s) uranium provided:

iii) Amount in MTU:

d) [Checkbox] Other costs.

i) Please explain.

7) If DOE did not incur any costs associated with this set of transactions, why not?

Benefits to DOE

8) What were the overall financial benefits of this transition to DOE?

9) What were the overall non-financial benefits of this transaction to DOE?

10) What types of benefits, if any, did DOE receive from this transaction? (Check all that apply)

a) [Checkbox] Received monetary payment from USEC.

i) Total amount of payment:

ii) Date payment provided:

b) [Checkbox] Received uranium (natural or enriched) from USEC.

i) Type(s) of uranium provided:

ii) Date(s) uranium provided:

iii) Market value of uranium:

iv) Amount of uranium in MTU [Note B]:

c) [Checkbox] Received services [Note C] from USEC.

i) Please summarize services received:

d) [Checkbox] Other benefits.

i) Please explain.

11) If DOE did not receive any benefits associated with this set of transactions, why not?

Note A: Monetary payment includes any amount of money transferred to USEC using appropriated or transferred funding.

Note B: MTU = metric tons of uranium

Note C: Services could include enrichment, clean-up, maintenance, among other things.

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