Congressional Research Service

**MEMORANDUM** May 15, 2012

**To:** Honorable Edward J. Markey
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**Subject:** **Potential sources of nuclear fuel for tritium production**

As you requested, this memorandum provides background on potential sources of nuclear fuel for tritium production and related nonproliferation issues raised in the Department of Energy's fiscal year 2013 request. A forthcoming memo for your office will discuss whether legal restrictions on the use of nuclear fuel for U.S. tritium production limit potential suppliers to U.S.-owned firms such as USEC Inc.

Tritium, produced in nuclear reactors, is an essential ingredient in U.S. nuclear warheads and must be regularly replenished as it radioactively decays. The need for a domestic fuel supplier for tritium-production reactors has been cited as a justification for providing government assistance to USEC.

USEC Inc. was established in 1998 through the public sale of a government corporation, the U.S. Enrichment Corporation, pursuant to the USEC Privatization Act (P.L. 104-134). The company enriches uranium in the fissile isotope U-235 (increasing the proportion of U-235 from the level found in natural uranium) for use as fuel by nuclear power plants. USEC leases an enrichment plant in Paducah, KY, from the Department of Energy (DOE). Built in the late 1950s, the Paducah plant uses an enrichment technology known as gaseous diffusion, in which uranium hexafluoride gas is pumped through permeable barriers to separate the major isotopes of uranium. As the isotopes are separated, U-235 is concentrated in a product stream, while the non-fissile isotope U-238 becomes more concentrated in a waste stream (or tails). USEC plans to replace the Paducah plant with a new plant at a DOE site near Piketon, OH, that would use advanced centrifuges to separate the isotopes, called the American Centrifuge Plant. The $150 million requested in the FY2013 Department of Energy budget justification is to support R&D activities for the American Centrifuge Plant.

## Tritium Production

DOE currently produces tritium by irradiating lithium-6 in the Watts Bar 1 commercial reactor (in Tennessee) and may expand the program to the two-reactor Sequoyah nuclear plant (also in Tennessee) as well, both of which are owned and operated by the Tennessee Valley Authority (TVA). Because the tritium is to be used in nuclear weapons, the Watts Bar 1 and Sequoyah reactors may not be allowed to use fuel from foreign sources or even some domestic uranium. U-234 is necessary for the production of tritium. USEC Inc. is the current supplier of fuel for tritium production. Thus, if USEC were to cease

enrichment operations, it has been argued, U.S. tritium production could be jeopardized because of a lack of alternative fuel from a solely domestic source.

Watts Bar 1 is refueled every 18 months, when about a third of its fuel is replaced. A load of replacement fuel contains about 30 metric tons of low-enriched uranium (LEU). If the Sequoyah plant were also used for tritium production, fuel requirements would double or triple. The National Nuclear Security Administration (NNSA), the DOE agency that runs the tritium program, is currently evaluating options for providing fuel for the tritium-production reactors. According to NNSA's 2011 Stockpile Stewardship report, "There is a potential strategic shortage in LEU. Therefore, the DOE/NNSA is pursuing identification of a source of 940 metric tons of unrestricted LEU or 1,800 metric tons for two reactors, for the life of the Tennessee Valley Authority (2048) agreement." The Stockpile Stewardship report classifies the fuel supply issue as green, indicating that "existing and/or future capacity [is] estimated to be sufficient" under current assumptions.[1] Therefore, although NNSA has flagged nuclear fuel supply as a potential problem, it appears optimistic that a solution can be found.

## Potential Alternatives to USEC

Fuel supply for tritium production is now under debate, and has been the subject of past Department of Energy reviews. Possible alternatives to using USEC-enriched fuel are discussed below.

### Urenco Enrichment Plant in New Mexico

The European consortium Urenco is one of USEC's major competitors. Urenco recently began operating a centrifuge enrichment plant in New Mexico, which is expected to reach a capacity of 5.8 million separative work units (SWU) by 2015. The New Mexico plant is operated by Urenco subsidiary Louisiana Enrichment Service (LES), so named because the facility was originally planned for Louisiana.

Construction of Urenco's New Mexico plant was authorized by the 1992 Washington Agreement between the United States and the three members of the Urenco consortium: Germany, the Netherlands, and the United Kingdom.[2] Article III of the agreement, "Peaceful Use," states that the New Mexico plant "shall only be used for peaceful, non-explosive purposes." The "special nuclear material" produced by the plant, enriched uranium, as well as any special nuclear material produced in a reactor using the enriched uranium, such as plutonium, is also restricted to peaceful uses.

Urenco has signed a contract with TVA to supply enrichment services from its New Mexico plant to the Watts Bar and Sequoyah reactors. This arrangement raised questions about whether the TVA plants could be used to make tritium for nuclear warheads while being fueled by enriched uranium from Urenco. A 2008 legal memorandum to NNSA concluded that the Washington Agreement did not preclude such use of the Urenco-produced nuclear fuel, because tritium is not defined as special nuclear material, but rather

[1] DOE/NNSA, *FY 2012 Stockpile Stewardship and Management Plan*, Report to Congress, April 15, 2011, pp. 44, 46, and 151, http://www.ucsusa.org/assets/documents/nwgs/SSMP-FY12-041511.pdf.

[2] Agreement between the Three Governments of the United Kingdom of Great Britain and Northern Ireland, the Federal Republic of Germany and the Kingdom of the Netherlands and the Government of the United States of America regarding the Establishment, Construction and Operation of a Uranium Enrichment Installation in the United States, Washington, July 24, 1992.

as byproduct material. A Joint Committee of the Urenco consortium, after being briefed on the issue at a 2005 meeting, did not object to the TVA contract.[3]

A Urenco official said that although the company does not object to TVA tritium production with its enriched uranium, current DOE policy would not approve the transfer.[4] An NNSA official said U.S. treaty obligations prevent fuel enriched by Urenco from being used for tritium production: "The answer in general for Urenco is that its enrichment technology has peaceful use restrictions, consistent with section 123(a)(3) of the Atomic Energy Act and our treaty with Euratom [an association of European countries that use nuclear energy], that prevent its deployment in support of nuclear weapons programs or 'for any military purpose.'"[5]

## Surplus U.S. HEU

USEC currently down-blends Russian weapons-origin HEU to LEU for fuel for nuclear reactors. It is possible that in the future, surplus DOE highly enriched uranium (HEU) could be similarly blended down to LEU. Since the mid-1990s, the U.S. government has declared 209 metric tons of HEU to be surplus to U.S. defense needs and available for downblending into commercial reactor fuel.[6] If the HEU is assumed to consist of 90% U-235, such downblending could result in about 6,000 metric tons of LEU.[7] But NNSA says most of that HEU was declared surplus in 1994 under a policy that it not be used for weapons purposes, and is therefore unavailable to the tritium program. A later batch of surplus HEU may be available, however:

> Some additional HEU that was removed from weapons use in 2005 explicitly does not have those restrictions against use for tritium production, but most of the latter is reserved for use by Naval Reactors. To the extent feasible, we are making LEU derived from the 2005 declaration HEU available for obligation exchanges to increase the supply of unencumbered LEU available to the tritium program.[8]

Some U.S. officials have argued that a domestic enrichment capability is also necessary for production of naval reactor fuel. However, a 2009 DOE memo[9] says that the United States has set aside sufficient fuel for naval reactors and has "additional reserves of HEU that could be used to supplement this naval reserve if necessary."

## Reenrichment of High-Assay Depleted Uranium

DOE depleted uranium stocks may provide another avenue to produce fuel that is unencumbered by peaceful use restrictions. Depleted uranium is the byproduct of the enrichment process, containing the

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[3] Memo from Mary Anne Sullivan, Hogan & Hartson, to Richard Goorevich, Director, Office of International Regimes and Agreements, NNSA, "Follow-Up Information Pertaining to Louisiana Enrichment Services' ("LES") Part 810 Authorization," May 9, 2008.

[4] Telephone interview with Melissa Mann, Marketing and Sales Manager, Urenco Inc., November 1, 2011.

[5] Email message from Dean Tousley, NNSA Office of Fissile Materials Disposition, NA-26, November 4, 2011.

[6] NNSA, "Surplus U.S. Highly Enriched Uranium (HEU) Disposition," http://nnsa.energy.gov/aboutus/ourprograms/nonproliferation/programoffices/fissilematerialsdisposition/surplusheudispositio.

[7] World Information Service on Energy, Uranium Downblending Calculator, http://www.wise-uranium.org/nfcub.html.

[8] Tousley, op. cit.

[9] Document posted on the Nonproliferation Policy and Education Center website, http://www.npolicy.org/article.php?aid=1133&tid=5

non-fissile isotope U-238 that was removed from the enriched product. Some DOE stockpiles of depleted uranium contain enough residual U-235 to possibly be worth enriching to LEU. Bills have been introduced in the House and Senate to carry out a reenrichment program (H.R. 2054, S. 1135).

### Mixed Oxide (MOX) Fuel Made from Surplus Weapons Plutonium

Additionally, MOX fuel could be considered as a fuel option for tritium production. NNSA is constructing facilities at its Savannah River Site in South Carolina to convert surplus weapons plutonium into MOX fuel for nuclear power plants. At least 34 metric tons of plutonium is involved in the program.[10] If MOX fuel contains 5% plutonium, the program could produce about 700 tons of reactor fuel. However, the surplus plutonium may have restrictions on its use. No U.S. reactors currently use MOX fuel, although TVA is considering using MOX fuel from DOE surplus plutonium in its reactors.[11]

### Non-USEC Operation of Paducah Plant

Concerns have been raised over the long-term commercial viability of USEC, Inc. USEC currently leases the Paducah enrichment plant from DOE. If USEC were to go out of business, DOE could attempt to find another operator or take over operations itself, as it did before USEC was initially established as a government corporation. However, those options might require significant government subsidies or expenditures.

## Nonproliferation Issues

In its FY2013 budget justification, the Department of Energy asserted that a domestic uranium enrichment R&D program "has important national security and nonproliferation implications, including discouraging the unnecessary spread of enrichment technology by contributing directly to sustained confidence in the international commercial enrichment market, improving the ability to detect proliferant programs, and producing tritium."

It is not clear that a U.S. enrichment capability would contribute to confidence in the international commercial enrichment market. Currently, market needs are being met by existing commercial enrichment suppliers and with a stalled expansion of nuclear power plants worldwide, enrichment markets (combined with planned enrichment plants using proven technology) are expected to meet demand into the future.

Since USEC's American Centrifuge Project is not similar to the enrichment technology designs proliferated by the A. Q. Khan network, the value for detection and safeguards development could be minimal. Those centrifuge designs are the basis of programs in Iran and North Korea. The United States retains valuable expertise on proliferation-relevant enrichment technology at its national laboratories. While expertise attrition from these laboratories may be a concern in the future, it is unclear whether the existence of a U.S-based commercial plant would assist with this challenge. For example, CRS has

[10] NNSA, "Plutonium Disposition," http://nnsa.energy.gov/aboutus/ourprograms/nonproliferation/programoffices/fissilematerialsdisposition/plutoniumdisposition.

[11] Dan Yurman, "How Can NNSA Meet Demand?," *Fuel Cycle Week*, May 20, 2011, http://fuelcycleweek.com/insight/title_of_insight_post_number_2.

learned through interviews that the national laboratories have productive relationships with commercial enrichers in the United States for the purpose of safeguards technology development.