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LOOKING BACK

The U.S.-Russian Uranium Deal: Results and Lessons

In February 1993, Russia and the United States signed an agreement on the disposition of highly enriched uranium (HEU) extracted from Russian nuclear weapons.[1] Under the terms of the deal, Russia undertook to down-blend 500 tons[2] of HEU, enough to build 20,000 nuclear warheads, over a 20-year period. The two sides agreed that the resulting low-enriched uranium (LEU) would be used as fuel by nuclear power plants in the United States, hence the informal name of the program, "Megatons to Megawatts."

In January 1994, Russia's Techsnabexport (Tenex) and the United States Enrichment Corporation (USEC), the state-run companies authorized by their respective governments to implement the deal, signed the contract. In the U.S. case, that meant that USEC was a supplier of enriched uranium to private utilities. According to assessments made at the time, the value of the entire program was expected to reach about $12 billion.

Background

The idea of down-blending excess stockpiles of weapons HEU and using the resulting LEU as fuel for nuclear power plants was first proposed in 1991 by Thomas Neff, a senior researcher at the Massachusetts Institute of Technology's Center for International Studies.[3] The idea was received in the U.S. academic community with great enthusiasm and was supported by the Bush administration in view of the signing in July 1991 of the Soviet-U.S. Strategic Arms Reduction Treaty (START I), which mandated a reduction of the two countries' nuclear weapons stockpiles by approximately 5,000 warheads apiece.[4]

Given the difficult economic situation in the Soviet Union at the time, Moscow expressed interest in Neff's proposal, which opened up the prospect of billions of U.S. dollars in hard currency earnings being generated as a by-product of implementing START I. The idea looked attractive to the Russian government, which hoped that some of that money could be used to support the Russian nuclear industry, which, like all other state enterprises, was suffering from a sharp reduction in government funding.

The HEU-LEU agreement differed in an important way from the 1992 Agreement on the Safe and Secure Transportation, Storage and Destruction of Weapons and the Prevention of Weapons Proliferation, which provided the legal framework for the so-called Nunn-Lugar program. Under the terms of the latter agreement, the United States was the donor and Russia was the recipient of U.S. financial and technical assistance, including money provided to help Russia implement the reductions specified in START I. In contrast, the HEU-LEU agreement was essentially a mutually advantageous commercial deal.

An important element of Neff's concept was his proposal to down-blend HEU at Russian plants rather than in the United States. The goal of the proposal was to employ as many Russian facilities and people in the post-Soviet nuclear establishment as possible. The Russian side strongly supported this approach, as HEU down-blending on U.S. territory was unacceptable to Russia because the isotopic composition of this material was classified.

The main factor driving the U.S. side was the doubts by many Western experts about the safety and security of the huge Soviet nuclear arsenal after the collapse of the Soviet empire. In addition, a significant part of that arsenal was left on the territory of the newly independent republics of Belarus, Kazakhstan, and Ukraine. The economic and political situation in all three was even worse than in Russia.

Leading Russian scientists, including Yuri Osipov, president of the Russian Academy of Sciences, also gave their backing to the plan. Osipov discussed the proposal with the Russian minister of atomic energy, Viktor Mikhailov, who

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Representatives from the United States Enrichment Corporation and Russia's Techsnabexport sign the commercial contract implementing the U.S.-Russian agreement on highly enriched uranium at USEC's headquarters in Washington on January 14, 1994. Under the agreement, HEU from Russian nuclear weapons was down-blended and then shipped to the United States for use in nuclear power plants.

gave it his full support. After a series of meetings and informal exchanges between Russian and U.S. representatives, the two governments entered into formal negotiations in the summer of 1992. They also set up a joint working group to undertake a comparative analysis of the two sides' proposals regarding the technology of down-blending HEU.

The Choice of Technology

HEU is produced by increasing the content of the fissile isotope uranium-235 from 0.7 percent in natural uranium to levels of 20 percent or more. In modern enrichment plants, enrichment involves running uranium in the form of the gas uranium hexafluoride through a gas centrifuge. At the plant, many thousands of them are installed, forming enrichment cascades.

Fuel for nuclear power plants typically has an enrichment level of about 4-5 percent, which means that it is LEU. In the global market, the enrichment level of the uranium for nuclear power plants is strictly limited to 5 percent. For weapons use, an enrichment level of 90 percent is desirable.

Stockpiles of HEU were accumulated in the Soviet Union and the United States during the Cold War era. The HEU-LEU agreement contemplated the reduction of the Russian HEU stockpile by 500 tons by down-blending it to LEU that could be used for nuclear power plant fuel.

However simple this looks, the question of down-blending was not a trivial one. Technologically, this could be done in different ways, and the choice of the blendstock and its form was one of the key elements of the process because it determined the final isotopic composition of the product.

One of the issues associated with blending was the possibility of accumulation in the LEU of the U-234 isotope, which is a kind of a poison for nuclear fuel. After detailed elaborations, the working group agreed with a proposal by Russian experts to use gas-phase dilution by mixing HEU hexafluoride with hexafluoride of slightly enriched uranium. The blendstock of slightly enriched uranium came from depleted uranium produced by uranium enrichment plants and later enriched to 1.5 percent. In this case, the resulting product satisfied the ASTM[5] requirements for power plant fuel isotopic composition, and the whole process also allowed Russian enrichment plants to continue to be busy with producing slightly enriched uranium.

LEU Production in Russia

The first 186-ton batch of LEU was produced in 1995 at the Urals Electrochemical Combine in the Sverdlovsk region from about 6 tons of HEU.

Another three Russian enrichment plants, which were run by the Ministry of Atomic Energy (the precursor to Rosatom, the Russian state atomic energy corporation), joined the program at a later stage: the Siberian Chemical Combine in the Tomsk region, the

Electrochemical Plant in the Krasnoyarsk territory, and the Angarsk Electrolysis Chemical Combine in the Irkutsk region. As a result, Russia was down-blending 30 tons of HEU every year by 2000 and producing 900 tons of LEU in the process, charging the United States for about 9,000 tons of natural-uranium component and 5.5 million separative work units (SWUs)—the enrichment services needed to make LEU out of natural uranium—per year. By the time the work under the agreement is completed later this year, Russia will have down-blended 500 tons of HEU and produced a total of 15,200 tons of LEU.

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Under the terms of the HEU-LEU agreement, the United States has the right to monitor the HEU down-blending process. In practice, that translates into quantitative monitoring of the flow of uranium hexafluoride in three pipes: two pipes for the HEU and the blendstock inflows and one pipe for the outflow of the LEU produced. U.S. personnel also recorded the U-235 enrichment level in each of these pipes.

In the early years of the agreement, the monitoring was conducted by U.S. inspectors who visited the Russian facilities involved in the program. Later on, however, the United States developed and installed a remote monitoring system at the down-blending facilities, thus eliminating the need for regular visits.

The Problem of Natural Uranium

The natural-uranium component of LEU was an important part of the deal. Essentially, it represents the amount of natural uranium (with 0.7 percent U-235 content) that would have been required to produce a given amount of LEU through natural enrichment rather than by down-blending HEU.

When LEU arrives in the United States under the HEU deal, two market products are delivered for payment: the SWUs and natural uranium feed, the raw material from which LEU was produced. In transactions on the uranium market, these two commodities are usually traded separately and have their individual prices.

According to the terms of the deal, there were two separate lines in the Tenex-USEC contract for the price of the natural component and the price of SWUs. These were based on the market prices at the time and later were periodically reviewed and adjusted by the parties.

Initially, under the terms of the deal, the United States agreed to pay in full for the SWUs and the uranium component required for the production of the down-blended material. This situation remained until April 1996, when the U.S. Congress passed a bill privatizing USEC. The bill introduced strict quotas on sales of the natural-uranium component on the U.S. market. Essentially, it made it impossible for USEC to pay for that natural-uranium component under the HEU-LEU agreement.

The problem was exacerbated by the fact that Russia and the United States had not signed an agreement for peaceful nuclear cooperation. The absence of that document complicated the return to Russia of the natural-uranium component, which no longer could be sold in the United States.

Moscow and Washington were forced to begin lengthy negotiations to find a mutually acceptable solution. The complications were such that LEU deliveries were interrupted for more than six months and the whole program was on the brink of complete collapse.

The two sides finally found a way out of the deadlock in March 1999. The Russian Ministry of Atomic Energy and the U.S. Department of Energy signed an agreement in Washington on the transfer of the natural-uranium component to Russia. They agreed that USEC would return to Russia an equivalent of the natural-uranium component and pay only for the SWU content. In the same agreement, Washington made an exception to its nuclear export law by allowing the natural uranium associated with the HEU deal to return to Russia even though the United States did not have a nuclear cooperation agreement with that country.

At the same time, Tenex and a group of Western companies (Areva, Cameco, and Nukem) signed an option for the purchase between 2002 and 2013 of the Russian natural-uranium component that was being accumulated on U.S. territory.

This arrangement allowed the deal to proceed, and LEU deliveries restarted in August 1999.

Prospects for Post-2013 Sales

In the United States, some politicians and independent observers had been arguing for proposals to induce Russia to continue the HEU-LEU operation after 2013, citing arms control and nonproliferation benefits. Until recently, there also were economic reasons because of a shortage of domestic enrichment capacity in the United States.

Russia, however, has no intention of extending the HEU-LEU agreement. Senior Rosatom executives have made that clear on more than one occasion, insisting that the remaining Russian excess HEU stockpiles would be needed for Russia's nuclear energy industry.

Considerable uncertainty existed over continued Russian supplies of uranium products to the United States after the HEU deal was finished, taking into account the restrictions imposed in conjunction with the suspension of the anti-dumping investigation agreement

signed by the Russian Ministry of Atomic Energy and the U.S. Department of Commerce in October 1992.

After the breakup of the Soviet Union, Russia and several other former Soviet republics sold many uranium products in the U.S. market at artificially low prices, a practice known as dumping. In response, Washington imposed a high anti-dumping tariff, essentially closing the door to the U.S. market for Russian nuclear suppliers. That door was partially reopened by the 1992 agreement, which created an exemption for the LEU shipments supplied under the HEU-LEU agreement via USEC. It was all but impossible, however, for Russia to provide natural uranium or enriched uranium that was not part of the HEU-LEU agreement, as those exports were not covered by the exemption.

In an effort to resolve that problem, which would have become much more serious for the United States after the supplies under the HEU-LEU had ended, Rosatom and the Commerce Department in February 2008 signed an amendment to the 1992 agreement, allowing the Russian nuclear industry to supply up to 20 percent of the U.S. market demand for uranium products between 2014 and 2020. Under the amendment, Tenex is to sign contracts directly with U.S. nuclear power plant operators, bypassing USEC. As of last January, the Russian portfolio of contracts signed under this arrangement was worth about $6 billion.

Criticisms of the Agreement

In the late 1990s, some Russian media outlets launched a campaign of sharp criticism against the HEU-LEU agreement. They quoted analysts as saying that the terms of the deal were daylight robbery because the price Russia was getting for the 500 tons of HEU being down-blended to LEU was an order of magnitude lower than it should have been. Critics also argued that the agreement undermined Russian national security because it reduced the country's strategic stockpiles of HEU.

That rhetoric culminated in 1999 during a special hearing launched by the Russian State Duma Committee on Geopolitics. The Duma members who presided over the hearing invited representatives of the atomic energy, foreign affairs, and defense ministries to testify. In his opening remarks, the committee's chairman, Alexey Mitrofanov, then a member of the nationalist political party LDPR, essentially repeated the arguments outlined above. He said that the Duma should discuss the question of Russian withdrawal from the agreement because the deal ran counter to Russian national interests.

One of the authors of this article, Vladimir Rybachenkov, was invited to the Duma meeting as the Foreign Ministry representative. He attended the hearing and rebutted criticisms by saying that selling 500 tons of weapons-grade

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Cylinders of low-enriched uranium produced under the U.S.-Russian HEU agreement arrive in Baltimore in 2002.

uranium down-blended to LEU would barely have any detrimental effects on Russian defense capabilities. He cited Western assessments that estimated Russia still would have another 700 tons of HEU left in reserve.[6]

U.S. HEU reserves were estimated at about 700 tons. In addition, Washington has declared 209 tons of that amount as being surplus to its national security requirements and stated that it was planning to eliminate that amount of HEU unilaterally over the next few years. Available reports suggest that the United States has already converted about 119 tons of HEU to LEU.[7]

Another argument that Rybachenkov made at the 1999 hearing was that the hard currency revenues generated by the HEU-LEU deal were a vital source of additional funding for the Russian nuclear industry, which was facing a serious deficit of state financing. Finally, he said, the overall value of the agreement was set at $12 billion based on the global market prices at the time of the signing of the deal.

Moscow possibly could have tried to find a more generous buyer, such as Saddam Hussein, for its weapons-usable uranium. As a depository of the nuclear Nonproliferation Treaty, however, Russia has a commitment "not in any way to assist, encourage, or induce any non-nuclear-weapon State to manufacture or otherwise acquire nuclear weapons or other nuclear explosive devices, or control over such weapons or explosive devices." The Foreign Ministry arguments were echoed by the representatives of the defense and atomic energy ministries.

In the end, the Duma rejected the LDPR initiative to withdraw from the HEU-LEU agreement.

Conclusion

In its implementation, the HEU-LEU agreement has become an effective instrument of irreversible nuclear disarmament. Its historic significance becomes clear when one realizes that for the first time, the two nuclear weapons superpowers turned a part of a nuclear weapons arsenal into something the countries really needed: electric power for Americans and money for Russia. The two countries mutually benefited from the deal in terms of increased security, thanks to the reduction of their nuclear material stockpiles.

The economic importance of the HEU-LEU deal for the United States can be illustrated by the following figures: For almost 20 years, LEU supplies under the agreement have accounted for about 50 percent of the nuclear fuel consumed by U.S. nuclear power plants. About 10 percent of U.S. electricity is generated from enriched uranium supplied under the HEU-LEU program.

According to a preliminary assessment, the overall revenue the HEU-LEU deal has generated for Russia could be as high as $17 billion, with about $13 billion in hard currency going directly to the treasury.[8] The revenue generated by the program, especially in the 1990s, made a substantial contribution not only to the Russian nuclear industry's bottom line, but to the Russian treasury as well. In 1999, a year after the 1998 financial crisis, proceeds from the HEU-LEU agreement made up almost 3 percent of the Russian federal government's revenues.[9] The money was partly used to finance programs to improve safety at the Russian nuclear power plants, convert defense industry plants to peaceful uses, and clean up contaminated areas after nuclear activities in previous years, mostly in the area of the Ural Mountains.

The implementation of the HEU-LEU agreement has created a favorable climate for the United States to adopt a reciprocal decision to down-blend some of the U.S. HEU stockpile on a voluntary basis, thereby making its use in weapons impossible.

The agreement has been a useful platform to demonstrate the possibility of using commercial approaches in the implementation of disarmament initiatives. It has also enabled the Russian and U.S. nuclear industries to gain useful experience in working together to facilitate further cooperation in commercial uranium-enrichment services.

Nuclear disarmament by the two oldest and largest nuclear powers is still a challenge and needs to be accelerated before control over nonproliferation is lost and many nuclear newcomer countries become involved in a new spiral of the nuclear weapons race. Only cooperation and joint projects will be able to stop such a negative development.

The HEU-LEU deal can provide useful lessons in that regard. It proves that countries' differences, no matter how great, can be overcome if political interest is accompanied by economic benefit. Policymakers need to look for projects that combine those features. Finding such projects and implementing the experience gained in the HEU-LEU deal becomes a more urgent task every day.

ENDNOTES

1. Agreement Between the Government of the United States of America and the Government of the Russian Federation Concerning the Disposition of Highly Enriched Uranium Extracted from Nuclear Weapons, n.d., http://partnershipforglobalsecurity-archive.org/Documents/021893_agreement.pdf.

2. In this article, all tonnages are in metric tons.

3. Thomas L. Neff, "A Grand Uranium Bargain," *The New York Times*, October 24, 1991.

4. "U.S. Strategic Nuclear Forces, End of 1994," *The Bulletin of the Atomic Scientists*, January 1995, pp. 69-71.

5. The standards organization formerly known as the American Society for Testing and Materials is now known as ASTM International.

6. Because these figures are classified in Russia, no official data are available. Foreign scholars estimate that the Soviet Union had accumulated about 1,200 tons of weapons-usable uranium. For a recent estimate, see International Panel on Fissile Materials, *Global Fissile Material Report 2011: Nuclear Weapon and Fissile Material Stockpiles and Production*, 2011, p. 9, http://fissilematerials.org/library/2012/01/global_fissile_material_report_5.html.

7. Ibid., p. 8.

8. Techsnabexport, "2011 Annual Report: Fulfilling Obligations Under the HEU-LEU Agreement," n.d., http://ar2011.tenex.ru/results/operational_results/performance_obligations (in Russian).

9. Gennady Leonov and Albert Shishkin, *Techsnabexport: Years and People* (Moscow: Reform Publishing House, 2009), p. 80 (in Russian).