

Energy from Bombs: Problems and Solutions in the Implementation of a High-Priority Nonproliferation Project

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The U.S.-Russian cooperative project to convert highly enriched uranium from the Russian nuclear weapons program into reactor fuel and sell it for peaceful use in commercial power stations is a high-priority nonproliferation initiative. Implementation of this project, however, has encountered a wide variety of problems. This account examines the obstacles encountered and the practical solutions that have been developed to allow this project to realize its nonproliferation goals.

INTRODUCTION

Keeping nuclear materials out of the wrong hands commands the highest of priorities, but projects to realize this goal encounter many obstacles. The U.S.-Russian cooperative project to convert highly enriched uranium (HEU) from Russian nuclear weapons into reactor fuel and use it for peaceful purposes has largely achieved its objectives in the face of a wide range of problems, whose solutions have required reconciliation of nonproliferation goals with other interests.

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The concept is deceptively simple: dilute weapons-grade HEU (approximately 90 percent U^{235}) to reactor fuel (4–5 percent U^{235}) and sell it to operators of commercial power stations. In 1991 the proposition was put forward that large-scale conversion of HEU from the former Soviet weapons program to reactor fuel, and purchase of the resulting product from Russia, could have substantial nonproliferation and economic advantages for both Russia and the United States.¹ This process would ensure that substantial amounts of fissile material would never again be used for nuclear weapons, would no longer require elaborate protection and accounting, and would never fall into the wrong hands.

The actual execution of this idea has proved enormously complex. In recent years reactor fuel derived from Russian weapons has been introduced into the U.S. market on a massive scale, and the U.S. industry has been downsized. The nonproliferation benefits are substantial and enjoyed by all citizens; the costs are borne by a relatively small number of companies and workers, who have recourse through elected representatives and trade laws. Resolution of these conflicting interests has required continuous intervention by the U.S. and Russian governments and a complex web of agreements whose elaboration continues today.

A measure of success has been achieved: after a five-year ramp-up, the goal of conversion and sale of 30 tons of HEU per year has been met since 1999. Material derived from Russian weapons now fills 45 percent of the U.S. market for reactor fuel, and generates 10 percent of the U.S. electricity supply.

Implementation of the HEU Agreement, however, has been a constant struggle to overcome technical, political, and commercial problems, some of which have been solved and others continue to be managed. The observation that many of the issues raised seem narrow and parochial in comparison with the nonproliferation imperative of reducing stocks of fissile materials does not make them easier to resolve.

As proposals are put forward to accelerate dilution of Russian HEU and step up the pace of nonproliferation efforts generally,² it is timely to study the record of the problems and successes in the implementation of the HEU Agreement. This comprehensive look examines how this project interfaces with established U.S. and Russian political, legal, and commercial interests, including trade laws, uranium product industries, and energy security policies, and shows how practical solutions were found for problems identified in earlier assessments.³

THE HEU AGREEMENT

During 50 years of the Cold War, the Soviet Union produced more than 1000 tons of HEU for nuclear weapons.⁴ Much of this is now in excess of Russian security

needs as large numbers of nuclear warheads are dismantled. The principal security threats to the United States and Russia no longer come from each other but from weapons of mass destruction in the hands of hostile states and groups. One of our highest nonproliferation priorities is to convert HEU to a form that can no longer be used for nuclear weapons, and use it for peaceful purposes.

In the summer of 1992, the State Department and the Department of Energy (DOE) developed a proposal for purchasing weapons-origin HEU from Russia. It called for the Uranium Enrichment Enterprise, then part of DOE, to purchase 500 tons of HEU from the Russian nuclear weapons program, convert it to reactor fuel, and use it to service its existing customers for enrichment services. The HEU would be converted to low enriched uranium (LEU) either in Russia or the United States. DOE would reduce production of LEU at its enrichment plants in Ohio and Kentucky, and pay to Russia the avoided costs (mainly the reduction in the electricity bill at the enrichment plants).

The United States put forward a proposal for a government-to-government agreement along these lines in the summer of 1992 in talks led by Gen. William Burns that had begun earlier that year to put in place the Nunn-Lugar program to assist Russia in the safety, security, and dismantling of forces made obsolete by the end of the Cold War. Negotiations moved quickly, and a tentative agreement was initialed by U.S. and Russian negotiators in August 1992, for review and approval by both governments.⁵ The “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” (the HEU Agreement) was signed by Gen. Burns and Russian Minister of Atomic Energy Mikhailov on 18 February 1993.⁶

The brief (six-page) HEU Agreement committed the United States and Russia to the goal of converting 500 tons of Russian HEU to LEU for use as fuel in commercial nuclear reactors, and called for agents for each side to conclude an initial implementing contract with detailed terms for the purchase, including price and delivery schedule. HEU would be converted to LEU and delivered to the United States at a rate of 10 tons per year for the first five years, and 30 tons per year thereafter, with all 500 tons converted and delivered within 20 years. The two governments would establish transparency measures designed to give each side confidence the objectives of the agreement were being met.

Negotiations on the initial implementing contract were undertaken by the United States Enrichment Corporation (USEC, a corporation established in July 1993 from assets of the DOE Uranium Enrichment Enterprise, and then owned by the U.S. government) and Techsnabexport (Tenex, a Russian company controlled by the Russian Ministry of Atomic Energy engaged in the export of Russian nuclear products). The two governments provided instructions

to USEC and Tenex on the terms of the contract, and senior U.S. and Russian government officials met in Vancouver in April 1993 to work out a set of principles to guide the implementation of the HEU Agreement. The terms of the HEU contract were completed at a meeting of the governments and the commercial parties at the State Department in May 1993; the last issue resolved was the price, \$82.10 per Separative Work Unit (SWU, a measure of effort expended to separate isotopes).

The U.S. government, however, did not authorize USEC to sign the initial implementing contract until a separate trilateral negotiation between the United States, Russia, and Ukraine resolved the question of the disposition of the nuclear warheads on the territory of Ukraine following the breakup of the Soviet Union. Ukraine sought compensation for the value of the nuclear materials in nuclear weapons transferred to Russia for dismantling. An elaborate solution was developed in which the United States advanced \$160 million to Russia to finance the shipment of reactor fuel from Russia to Ukraine for use in nuclear power stations, as compensation for the value of the HEU in 1900 strategic nuclear weapons transferred from Ukraine to Russia for dismantling.⁷ The \$160 million advance was repaid through deliveries of LEU derived from HEU to the United States under the HEU Agreement. This compensation financed by the HEU Agreement was crucial (along with security assurances and Nunn-Lugar assistance in dismantling nuclear forces) to securing Ukraine's agreement to become a nonnuclear state.

On 14 January 1994, the Presidents of the United States, Russia, and Ukraine signed in Moscow the Trilateral Statement committing Ukraine to join the Nonproliferation Treaty as a nonnuclear state and transfer the nuclear warheads on its territory to Russia for dismantling. That same day, USEC and Tenex officials signed the initial HEU implementing contract.

The HEU contract is a commercial contract nearly an inch thick, containing the agreed price for the first year; procedures for establishing the price, quantity, and delivery schedule for subsequent years; payment terms; allocation of costs; and numerous technical and commercial details to implement the transaction.⁸

THE SUSPENSION AGREEMENT

When negotiations on the HEU Agreement began in the summer of 1992, the import of Russian enriched uranium was effectively prohibited by a trade action initiated in 1991 by U.S. uranium producers and enrichment plant workers. This proved to be a major obstacle to implementation of the HEU Agreement that required seven years of continuous effort to overcome.

In the last months of the Soviet Union, the Ministry of Atomic Energy sold large amounts of uranium in the United States at very low prices. By 1991 Russia's share of the U.S. uranium market rose from zero to more than 15 percent, with Russian sales underselling the price of U.S.-produced uranium by as much as 70 percent.⁹

In response, a group of domestic uranium producers and the union representing workers at enrichment plants petitioned the Commerce Department and the International Trade Commission (ITC) in November 1991 to conduct an antidumping investigation. The petitioners argued that uranium was being sold by the Soviet Union at less than fair value, resulting in material injury to the U.S. industry.

Following procedures established in U.S. trade law, the ITC conducted a preliminary investigation, and determined on 23 December 1991 that there was a reasonable indication that the U.S. uranium industry was materially injured by imports of Soviet uranium.¹⁰ Two days later, the Soviet Union ceased to exist; the trade action against Russia and other newly independent states continued.

Following the preliminary determination of injury by the ITC, the Commerce Department took up the question of whether Russia and other former Soviet states were selling uranium in the United States at less than fair market value. Commerce provided Russia and the other states questionnaires requesting detailed information on production costs and sales. Deficiencies in the responses led Commerce to base its calculations largely on information provided by the U.S. industry. In June 1992 Commerce issued a preliminary determination that imports of both natural uranium and enriched uranium from Russia and five other former Soviet states were being sold in the United States at less than fair value. Commerce directed the Customs Service to require a deposit or bond equal to 116 percent of the value of all uranium imports from these countries prior to their entry into the United States. The practical effect was to prevent imports of uranium products from Russia.¹¹

During the summer of 1992, as negotiations commenced between State, DOE, and Russia on the HEU Agreement, Commerce engaged in parallel negotiations with Russia (and five other new states) to resolve the antidumping action in a manner that would allow the HEU Agreement to be implemented. As a result, in October 1992, Commerce and Russia signed an agreement with profound consequences for the HEU Agreement that, in amended form, remains in force today. It was called the Suspension Agreement because it suspended the antidumping investigation prior to the final determination of injury by the ITC and imposition of dumping duties by Commerce.¹²

The Suspension Agreement as signed in 1992 permitted imports of uranium products from Russia in three categories:

- ◆ Enriched uranium derived from HEU (more precisely, the enrichment services component of enriched uranium derived from HEU) and imported to the United States under the HEU Agreement (which was then being developed by U.S. and Russian negotiators) could come into the United States without restriction on quantity.
- ◆ Natural uranium could be imported into the United States subject to a quota tied to market price. The quota was zero when the U.S. market price of natural uranium was below \$13 per pound. For market prices above \$13 per pound, the size of the quota would depend on the market price; the higher the price, the bigger the quota. In this manner, the Suspension Agreement met a statutory requirement to prevent price suppression.
- ◆ Existing contracts for Russian sales of uranium products entered into before 5 March 1992 were grandfathered and allowed to go forward.

The U.S. and Russian governments and the petitioners who initiated the antidumping action all accepted the Suspension Agreement. Russia gained access to the U.S. market that would have been denied by 116 percent duties; the petitioners gained a ban on new Russian low-priced sales of natural uranium; and the United States gained a partial solution to the problem of reconciling our nonproliferation objectives with our trade laws to allow implementation of the HEU Agreement.

The Suspension Agreement with its exemption for import of enrichment services derived from dismantled Russian nuclear weapons under the HEU Agreement remains in force. It permits import of Russian enriched uranium on a massive scale, but only material derived from weapons, and only the enrichment services component. This solution for the enrichment component was created relatively quickly, in part because the only enrichment entity in the United States was controlled by the government and was deeply involved with and benefited from the HEU Agreement.

For natural uranium, the 1992 Suspension Agreement was the first of a series of attempts to balance our nonproliferation interests with the interests of the domestic uranium industry. The small U.S. uranium industry (fewer than 1200 workers producing less than 10 percent of U.S. consumption)¹³ perceived no benefits from the HEU Agreement, and could draw upon existing trade laws to resist Russian imports. The story of the HEU Agreement for the next seven years is largely the struggle to find a way to pay Russia fair value for the natural

uranium associated with the HEU Agreement within U.S. domestic commercial and political constraints.

THE NATURAL URANIUM PROBLEM

Utilities have traditionally entered into separate contracts to purchase natural uranium and enrichment services from separate suppliers. In a typical transaction, a utility would pay a uranium producer to deliver natural uranium to USEC, and pay USEC to enrich uranium and deliver the resulting LEU to a fuel fabricator.

In order to sell the Russian LEU derived from HEU into these established commercial markets, it was necessary to sell separately enrichment services (which represent about 2/3 of the value of the LEU) and the natural uranium (about 1/3 of the value of the LEU). In a typical transaction involving the Russian material, USEC would fulfill its enrichment obligation to a utility customer by delivering Russian LEU to a fuel fabricator. USEC would pay Russia the agreed price in the HEU contract for the enrichment component of the LEU delivered to the United States, and USEC would collect from the utility customer the payment for enrichment services specified in its contract with the utility. The utility would have a separate contract with a uranium producer to deliver natural uranium to USEC. That natural uranium would arrive at USEC but would not be used. (See Appendix for details of these transactions.)

When deliveries of LEU derived from HEU began in 1995, Russia received prompt payment for the enrichment value specified in the HEU contract. But Russia did not receive payment for the natural uranium value, which the HEU contract specified would be paid when this material was used or sold; sale of Russian natural uranium was precluded by the Suspension Agreement, and USEC had no use for it. So the displaced natural uranium piled up at USEC, and Russia received no compensation for one third of the value of the LEU it delivered to the United States.

Russia was not prepared to deliver LEU indefinitely to the United States and receive payment for two-thirds of its value. This position was expressed with increasing clarity by Russian officials, eventually including the Prime Minister. To preserve the long-term viability of the HEU Agreement, which in 1995 was just beginning to achieve real results with the first deliveries, the U.S. government undertook to find a way to promptly pay Russia fair value for the natural uranium associated with the HEU Agreement.

Revised Suspension Agreement (Matched Sales). As described previously, the agreement entered into by Russia and the Commerce Department in October 1992 to suspend the antidumping investigation against imports of Russian uranium provided a quota for sales of Russian natural uranium into the U.S. market tied to market prices. Russia could begin to make sales when the price of uranium exceeded \$13 per pound. Market prices remained well below \$13, however, so this provision prevented sales of Russian uranium in the United States, including the natural uranium component of the material delivered to the United States under the HEU Agreement.

Russia and the Commerce Department reopened discussion of the Suspension Agreement and developed a new approach to reconciling the nonproliferation benefits of importing Russian material with the interests of the domestic uranium industry. Signed in March 1994, this amendment to the Suspension Agreement established new annual quotas for sales of Russian uranium, and required that each sale “match” U.S. and Russian uranium.¹⁴ As envisaged in the agreement, Russia and U.S. uranium producers would jointly make sales to U.S. customers. In each transaction, Russia and the U.S. producer would each supply half the uranium to fulfill the contract, and divide the proceeds. Since uranium prices were low and the costs of U.S. producers were high, the division of the proceeds would be uneven, with the majority of the money going the U.S. producer. As a practical matter, few “matched sales” were made.

Domenici Quota. Having exhausted possibilities for flexibility under the Suspension Agreement, the effort to achieve a workable balance between nonproliferation goals and domestic interests turned to new legislation, and the vehicle chosen was legislation then being drafted to privatize USEC.

Administration officials worked with the staff of the Senate Committee on Energy and Natural Resources and its Chairman, Senator Domenici, to develop a mechanism to compensate Russia for the natural uranium component of the LEU delivered to the United States under the HEU agreement, and at the same time meet the interests of the domestic uranium industry. Maintaining the viability of the HEU project as USEC made the transition from government corporation to private company was a central issue in the legislation governing privatization, and a great deal of attention was therefore paid to the section dealing with natural uranium. All participants understood that the future of the HEU Agreement hinged on finding a way to compensate Russia for the value of the natural uranium.

In May 1995, Senator Domenici introduced the Senate version of the USEC Privatization Act. Congress had been preparing legislation for several years to govern the transfer of the U.S. uranium enrichment business to private ownership. The new element Senator Domenici introduced was a quota

schedule specifically for the sale of natural uranium associated with the HEU Agreement.¹⁵ Under this approach, the natural uranium displaced by LEU delivered to the United States under the HEU Agreement would be deemed to be of Russian origin and title would be given to Russia, and it could be sold into the U.S. market according to a quota schedule defined in the legislation. The quota would initially be small (about 4 percent of the U.S. market in 1998), and grow each year to reach 37 percent of the U.S. market in 2009 and beyond (enough to accommodate most of the natural uranium associated with the HEU Agreement). The legislation also called for DOE to purchase the natural uranium associated with the first two years of deliveries, 1995 and 1996, to keep this material off the market.

The graduated quota established a managed and predictable entry of Russian natural uranium into the U.S. market, provided a way to reimburse Russia for the value of the natural uranium component of the LEU delivered to the United States under the HEU Agreement, and eliminated a potential \$4 billion obligation that USEC had assumed in the HEU contract to pay Russia in 2013 for all the natural uranium delivered over the previous 20 years. This approach was broadly supported in Congress, the Administration, and the industry, and became law when the USEC Privatization Act was enacted in April 1996.

The legislation did not include a provision sought by the Administration to provide authority to waive the application of antidumping duties on imports of Russian uranium under the HEU Agreement. Proposed out of concern that extraneous events could unravel the Suspension Agreement, leading to prohibitive duties that would make implementation of the HEU Agreement impossible, this concept found no support in the Congressional committees responsible for trade and finance issues, who feared a precedent that might in the future be applied to other industries.

With legislation in place establishing a quota that would grow over time, a consortium of western uranium companies sought an agreement with Russia on the sale of the natural uranium associated with the HEU Agreement. The western companies would play a role in the disposition of the natural uranium comparable to the role USEC plays in the disposition of the enrichment services, managing the sale of the Russian material into U.S. and international markets and providing Russia with reliable revenues.

Following discussions that extended over four years, the consortium announced in August 1997 that agreement in principle had been reached.¹⁶ The three western companies—Cameco (the world's largest uranium producer based in Canada), Cogema (a large French producer) and Nukem (a trading company based in Germany)—would commit to purchase the majority of the natural

uranium associated with the HEU Agreement for 10 years. The balance would be sold by Russian companies—Tenex and Globe Nuclear Services and Supply (GNSS, a Russian-owned, U.S.-based marketing company). The western companies would pay Russia a price based on a discount from market prices, with a guaranteed minimum floor price.

The structure of this arrangement exposed the western companies to significant risks. They would pay Russia on delivery for material that in the early years was largely excluded from the U.S. market (the quota was zero for 1997, 4 percent of the market for 1998, 8 percent of the market for 1999, etc.). Proceeds from sales at the back end of the 10-year agreement could offset losses in the early years. The risks inherent in the front-loaded payments to Russia led the companies to seek commitments from the Russian government to provide confidence that the agreement would be fully implemented over its 10-year term. These proved unattainable, and negotiations broke down in December 1997.¹⁷ Russia briefly and unsuccessfully explored alternative ways to sell the natural uranium on its own without the western companies.

In the spring of 1998, the United States government encouraged Russia and the western companies to resume negotiations on a commercial solution to the disposition of the natural uranium component under the HEU Agreement. In June 1998, Russia and the companies signed a Protocol providing for the three western companies to purchase the majority of the natural uranium.

The June 1998 agreement collapsed within a month when new information on USEC's uranium holdings destabilized the uranium market. A few weeks before the July 1998 privatization of USEC, several companies considering bids to acquire USEC were provided information on USEC's assets and finances. This due diligence process revealed to the industry that substantial amounts of natural uranium had been transferred from DOE to USEC, along with plans for USEC to sell this inventory to raise cash to finance its business. The western companies, anticipating weak uranium prices, concluded that the floor price that they had agreed to with Russia in June was no longer viable, and they backed away from the tentative agreement. The unraveling of the June 1998 agreement was a major setback to the effort to find a commercial solution to the disposition of the natural uranium.

Twenty four tons of HEU were scheduled to be diluted and shipped to the United States in 1998, the fourth year of deliveries. But the failure to find a way to pay Russia for the value of the natural uranium component was undermining the stability of the agreement. Under a Russian law designed to prevent theft of state assets, export licenses cannot be issued without contracts for payment. Inability to meet this requirement, along with frustration at receiving two-thirds of the value of the LEU shipped to the United States, led to interruptions

of deliveries by Russia. At the end of 1998, shipments were 9 tons short of the agreed schedule.

March 1999 Natural Uranium Agreements. The collapse of the June 1998 tentative agreement between Russia and the western companies led the U.S. government to conclude that the commercial parties on their own would not be able to resolve the natural uranium problem; the solution would require intervention of the two governments. A DOE/State team conducted intensive negotiations with their Russian counterparts and the five commercial parties through the winter of 1998 and the spring of 1999.

The government brought three new assets to the table:

- ◆ DOE offered to withhold from the market a substantial portion of its uranium inventory for 10 years, to offset the negative market effect of the USEC inventory and sales. Commitments to maintain such U.S. and Russian “stockpiles” played a key role in the eventual agreement.
- ◆ State developed an innovative way to permit export of uranium from the United States to Russia. (Such exports had been believed to require a formal agreement for nuclear cooperation between the United States and Russia, and there was no prospect for such a broad U.S.-Russia nuclear cooperation agreement given Russia’s cooperation with Iran in the construction of a nuclear power plant.) A mechanism to return uranium to Russia opened the way to structure an agreement to give western companies an option to purchase the natural uranium, and return to Russia any uranium not purchased, resolving the front-loading and floor price problems that had derailed earlier efforts.
- ◆ Congress appropriated \$325 million to allow DOE to purchase from Russia the natural uranium associated with the 1997 and 1998 deliveries. This allowed the new agreement to take effect in 1999 without an overhang of uranium left from earlier years, and gave all parties a strong financial incentive to conclude an agreement.

Intense negotiations among the two governments and five commercial parties produced a complex set of agreements signed in Washington in March 1999:¹⁸

- ◆ *Government-to-government agreement.* The State Department and the Russian Ministry of Foreign Affairs brought into force an agreement establishing Russian commitments required by U.S. law for uranium returned to Russia (no use for military purposes, physical protection, prior consent for transfer or processing), and granting in advance U.S. consent to Russian

use of this material for dilution of HEU and for sales consistent with the Transfer Agreement and the commercial contract.

- ◆ *Transfer Agreement.* DOE and Minatom agreed that DOE would arrange to return to Russia uranium associated with the HEU Agreement not sold to the commercial companies. DOE purchased from Russia for \$325 million the 10,500 tons of natural uranium associated with the 1997 and 1998 deliveries, and agreed to combine this material with another 11,500 tons in DOE's inventory to create a stockpile which will be held off the market for 10 years until 2009. Russia agreed to use returned uranium for diluting HEU, for sales under the commercial contract, and for storage in a Russian stockpile which could grow to the same 22,000 ton size.
- ◆ *Commercial contract.* The three western companies (Cameco, Cogema, and Nukem) have the option to purchase the majority of the natural uranium associated with deliveries of LEU under the HEU Agreement. Tenex has the option to purchase the balance of the natural uranium, and there is an agreed allocation of the graduated quota among these four companies for sales into the U.S. market. There is an agreed algorithm for determining the price paid to Russia, based on published market prices and a floor price. Russia retains title to uranium that the four companies elect not to purchase, and may hold it in the United States or return it to Russia and place it in its stockpile.

The March 1999 package of agreements resolved the natural uranium problem that was put off as too hard in 1993 and 1994 when the HEU Agreement and HEU contract were drafted, and subsequently caused the biggest problems in the implementation of the HEU Agreement. The solution serves U.S. interests by removing the biggest obstacle to steady blending and shipping HEU from weapons, and by bringing natural uranium to the U.S. market according to the graduated quota. It serves Russian interests by establishing a mechanism for Russia to realize fair value for the natural uranium component of the material they ship to the United States, either in cash or in kind. And it serves the interests of the companies by managing the entry of this material into U.S. and international markets.

Recent Developments. Following the conclusion of the March 1999 agreements, at first the western companies purchased small amounts of natural uranium to demonstrate their commitment to the agreement, even though the price paid to Russia exceeded prevailing market prices. Substantial amounts were returned to Russia for diluting HEU and establishing the Russian stockpile. As market prices for uranium rose, the western companies increased their

purchases, and by 2002 they exercised options to commit to purchase most of their share of the natural uranium associated with deliveries through 2013. Tenex entered into a contract to sell its share of the natural uranium to GNSS, which in turn concluded contracts to sell this material to U.S. utilities. For a time, it appeared that the mechanism established by the March 1999 agreements was functioning as designed.

In October and November 2003, however, the Russian government and Tenex advised the U.S. government, the consortium of three western companies, and GNSS that Russia had decided to keep in Russia and use as an input into the HEU dilution process all of the natural uranium already returned to Russia or scheduled to return, and to terminate the contract between Tenex and GNSS. Tenex announced publicly it would cut off deliveries to GNSS as of January 1, 2004, causing GNSS to be unable to make deliveries of uranium to U.S. utilities scheduled for 2004. These abrupt actions by Russia called into question the reliability of Russia and the HEU Agreement as a supplier to U.S. utilities.

In November 2003, the State Department raised this issue with senior Russian officials, calling on the Russian government to work with the U.S. government and the commercial parties to resolve this problem, and to meet the supply commitments made by GNSS to U.S. utilities. The Russian government and Tenex responded that the uranium that the three western companies had elected not to purchase and returned to Russia, and the uranium which GNSS had not yet committed to U.S. utilities, were needed in Russia to implement the HEU Agreement through 2013; they said they would meet the supply commitments in the GNSS contracts with U.S. utilities, and were willing to enter into contractual arrangements with the western companies and the U.S. utilities to make this happen. Thus began yet another negotiation on the disposition of the natural uranium associated with the HEU Agreement.

There were two separate problems. The first was between Tenex and the consortium of three western companies. In the early years after March 1999, when uranium prices were low, the companies had declined some of their "first option" rights to purchase uranium, and therefore substantial amounts of uranium had been returned to Russia and placed in a stockpile. Under their March 1999 commercial contract with Tenex, the companies retained "second option" rights to this material even after it returned to Russia. The Russian decision to keep and use this material conflicted with these second option rights. Following a series of exchanges in the first half of 2004, the companies and Tenex reached agreement on a contract amendment providing for Russia to keep the uranium returned to Russia.

The second problem, meeting the supply commitments GNSS had made to U.S. utilities, was more complex. The U.S. government sought and received

commitments from both the Russian government and Tenex that Tenex would honor the prices and quantities in the contracts the utilities had made with GNSS. Months of careful exchanges between Tenex and the U.S. utilities resulted in contracts providing for supply of uranium.

Russia achieved its objectives. It will retain the uranium returned to Russia by the three western companies, and will return to Russia the uranium allocated to Tenex by the March 1999 agreements once the sales to meet the supply commitments to U.S. utilities are complete.

Another consequence of the new arrangements is that all of the natural uranium associated with the HEU Agreement is now fully committed through 2013 to the three western companies and the former GNSS customers, with the balance to return to Russia. The options that were central to the March 1999 agreements have now been exercised or relinquished.

TRANSPARENCY

For the United States government to permit Russia to supply half the market for commercial reactor fuel, make changes in its trade laws, purchase half a billion dollars worth of natural uranium, and invest the effort necessary to make this project work, it is important that the enriched uranium that the Russians deliver is actually diluted HEU. There would be no non-proliferation benefit to purchasing newly produced LEU not derived from HEU.

The Russians have a similar need to know that the material they deliver to the United States is used for peaceful purposes.

In addition to analysis of isotopic composition for consistency with commercial fuel specifications, the United States and Russia have established a number of cooperative transparency measures:¹⁹

- ◆ Agreements concluded in 1993 and 1996 permit U.S. experts to visit periodically each of the four Russian uranium processing facilities where HEU metal from weapons components is milled into chips, burned to form uranium oxide, purified, converted to uranium hexafluoride, diluted with blendstock to make LEU product suitable for use in power reactors, and loaded into cylinders for shipment to the United States. U.S. monitoring personnel observe each of these operations, monitor enrichment levels with portable devices, and review and retain nuclear material accounting records. In this way they observe the operation of the Russian industrial infrastructure that converts HEU to LEU.

- ◆ Russia has comparable rights to visit and monitor operations at the USEC facility which receives the LEU from Russia, and at the five U.S. fuel fabricators that manufacture commercial reactor fuel from Russian-origin LEU.
- ◆ At two of the Russian facilities where HEU in the form of uranium hexafluoride gas is mixed with blendstock to make LEU product, U.S. equipment has been installed to continuously monitor the conversion of HEU to LEU. Instruments developed at DOE national laboratories monitor the UF_6 gas flowing in pipes to and from a blend point where HEU and blendstock are combined to produce LEU product. U.S. equipment, installed on the outside of the pipes in order not to disrupt the Russian operations, exposes the UF_6 to neutrons and gamma radiation from radioactive sources supplied by Russia. Detectors measure the response of the UF_6 gas, allowing determination of enrichment levels, mass flows, and flow rates for the two inputs (HEU and blendstock) and the product (LEU). These measurements are recorded continuously, allowing the United States to confirm that Russia is downblending HEU to LEU consistent with shipments to the United States. Plans are underway for installation of continuous monitoring equipment at the third facility where HEU is diluted to make LEU.

The transparency measures in place to monitor implementation of the HEU Agreement represent a high degree of cooperation between the United States and Russia, permitting access to sensitive facilities to enhance confidence that the commitments with respect to origin and end use are being carried out.

INTERFACING WITH A COMPLEX WORLD

A nonproliferation initiative with major financial and energy dimensions, this project has encountered a wide range of problems.

Meeting Specifications for Reactor Fuel. If HEU (90 percent U^{235}) were diluted with natural uranium (.7 percent U^{235}) to produce LEU (4–5 percent U^{235}), the resulting product would not meet international specifications for reactor fuel. In particular, the amounts of U^{234} and U^{236} would exceed permissible limits. U^{234} is highly radioactive, creating problems for fuel fabrication and handling. U^{236} is a neutron absorber, raising reactor operation issues.

U^{234} is present in excess quantities because the gaseous diffusion and gas centrifuge enrichment processes that preferentially favor U^{235} over U^{238} because it is lighter, also favor the still lighter U^{234} . U^{236} does not occur in nature but is made in nuclear reactors, and its presence indicates that many years ago

the Soviets used uranium recovered from spent reactor fuel in the enrichment operations that produced HEU for weapons.

LEU that does not meet established international specifications for reactor fuel would have little value, and the two sides worked together to develop a technical solution that is reflected in the 1994 HEU contract. Russia makes blendstock by taking depleted uranium left over from decades of Cold War uranium enrichment operations, and enriching this material in gas centrifuges to an assay of 1.5 percent U^{235} (about twice the amount in natural uranium). HEU diluted with this blendstock yields LEU (with an assay of 4–5 percent U^{235}) which meets established international specifications for U^{234} and U^{236} .

Dilution of 30 tons of HEU per year requires the production of 885 tons per year of blendstock. Production of this quantity of blendstock from depleted uranium requires about 4 million SWU. The resulting 915 tons of LEU contains about 5.5 million SWU, so it is clear that diluting HEU is an inefficient way to make LEU, and only makes economic and thermodynamic sense as a nonproliferation program to eliminate weapons grade HEU made excess by the end of the Cold War.

Energy Security. The goal of converting and bringing to the United States 30 tons of HEU per year was established at the beginning of the project as an appropriate balance between the nonproliferation interest in converting as much HEU to LEU as quickly as possible, and the energy security interest in avoiding overdependence on a single foreign supplier for a significant portion of the U.S. electrical energy supply. LEU from 30 tons of HEU represents about 45 percent of the U.S. annual consumption of reactor fuel.

While Russia has until recently had a good record of performance in commercial uranium sales, the scale of U.S. dependence on Russian reactor fuel requires the government to prepare for potential interruptions in supply.

USEC inventories represent the first buffer against disruption in Russian deliveries. The interruptions that were experienced in 1997–1999 were offset by USEC inventories. Other potential sources of supply include additional production at the Kentucky gaseous diffusion plant (production of additional SWU would be possible but costly because the cost of additional power would be high), dilution of U.S. surplus HEU, resumption of enrichment operations at a portion of the Ohio gaseous diffusion plant maintained in a stand-by status, and additional imports from Europe. In addition, the U.S. and Russian governments have opened discussions on the purchase by DOE of additional LEU derived from HEU to be held in a stockpile as a hedge against future supply interruptions.

The natural uranium associated with the HEU Agreement raises similar security of supply considerations. Commercial stocks held by Russia and by

private companies represent an initial buffer against supply disruptions. The DOE and Russian stockpiles of natural uranium could be drawn upon if necessary.

Domestic Enrichment Capacity. A closely related question concerns the need to maintain some level of uranium enrichment capacity in the United States. The plant operated by USEC in Kentucky, the only enrichment plant in operation in the United States, was built for military purposes in the 1950s and uses inefficient gaseous diffusion technology that requires large amounts of electric power. The cost of enriched uranium produced in the Kentucky plant is not competitive with modern centrifuge systems. USEC closed another gaseous diffusion plant in Ohio in 2000 to bring U.S. enrichment capacity into line with the reduction in domestic enrichment needs due to the HEU Agreement.

The United States has an energy security interest in avoiding overdependence on imported reactor fuel. The United States also has a nonproliferation interest in remaining a reliable supplier of enriched uranium to the nuclear power industries of Japan, South Korea, and Taiwan, which encourages responsible nuclear policies in these countries. For both reasons, the U.S. government encourages the construction of modern competitive enrichment capacity in the United States to replace the Kentucky plant. In the spring of 2002 the U.S. government held up approval of a long-term pricing mechanism developed by USEC and Tenex for the HEU Agreement, as an inducement to agreement between USEC and DOE on the development and deployment of advanced enrichment technology. The DOE-USEC agreement, calling for construction of a modern facility with a 3.5 million SWU capacity by 2011, and a USEC commitment in the interim to produce at least 3.5 million SWU per year at the Kentucky plant, was concluded 18 June 2002.²⁰ The following day, the U.S. government approved the new pricing mechanism for the HEU Agreement.

USEC Privatization. When the negotiations on the HEU Agreement began in 1992, it was already established policy to privatize the Department of Energy's Uranium Enrichment Enterprise. The 1993 HEU Agreement itself mentions the intention of the U.S. government to designate such a corporation as its implementing agent.

The Energy Policy Act of 1992 called for the creation of a corporation wholly-owned by the government (the United States Enrichment Corporation) to market contracts for enrichment services, operate the gaseous diffusion plants, and pay dividends to the Treasury. The act called for a report on taking the further step of transfer to private ownership, and for the President to make recommendations to Congress.

The establishment of USEC as a government corporation in June 1993 did not affect the implementation of the HEU Agreement, as the actions of the

government corporation remained subject to the policies and direction of the government. But the prospect of a further transition to private ownership raised serious questions whether conflicts would arise between the nonproliferation interests of the government and the commercial interests of the company. The stewardship of the HEU Agreement became a major issue in the development of the USEC Privatization Act, and in the interagency process that followed to execute the transfer of USEC to private ownership.

The departments of State and Energy did not oppose the privatization of USEC, which proceeded along the path established by legislation, but instead took steps designed to ensure that the HEU project would continue to be implemented following the transition.

- ◆ In April 1997, State, DOE, and USEC signed a Memorandum of Agreement establishing a formal relationship between USEC and the government to assure continuation of the working arrangements that were developed when USEC was part of the government. The MOA established channels for providing guidance and direction from the government to USEC, and for providing reports and information from USEC to the government. It established a detailed procedure for the government to replace or supplement USEC with alternative entities to implement the HEU Agreement. If USEC as a private company should prove unable or unwilling to fully implement the HEU Agreement, the government has a mechanism in place for bringing in others to take on this task. If the government should replace USEC or if USEC should resign, USEC would retain an obligation to continue to purchase material from Russia for a 1–2 year transition period to allow new entities to make new marketing arrangements.²¹
- ◆ In November 1996, at the direction of the government, USEC concluded an agreement with Tenex establishing price and quantities for 1997–2001, in order to provide a five-year period of stability and predictability for implementation of the HEU Agreement while USEC transitioned from a government corporation to a private company.
- ◆ The April 1996 USEC Privatization Act transferred title of the natural uranium associated with the HEU Agreement to Russia, confining USEC's role to purchasing the enrichment component and removing USEC from the then-unsolved natural uranium problem.

Notwithstanding these preparations, the transfer of large amounts of natural uranium from DOE to USEC prior to privatization in July 1998, combined with USEC's business plan to sell this uranium to raise cash, led to the unraveling of an agreement long-advocated by the United States and painstakingly

put together over several years by Russia and western companies to resolve the problem of the natural uranium associated with the HEU Agreement. It took months of negotiations, an active role by the U.S. and Russian governments, and \$325 million to put together another agreement on natural uranium disposition in the weaker uranium market following the transfers to USEC.

In the fall of 1999, market prices for enrichment services declined, while the prices USEC paid to Russia were fixed by the September 1996 five-year agreement. USEC sought compensation from the U.S. government for its role in supporting nonproliferation, and thereby appeared to justify concerns expressed prior to privatization that USEC's commercial interests would conflict with its role as implementing agent for the HEU Agreement. The government's response was to interview candidates to replace USEC. USEC dropped its request for compensation and continued its role in the HEU agreement, and thereby appeared to justify the view that USEC's strategic interest in managing the introduction of Russian material into the U.S. market (rather than competing with someone else performing this role) would align USEC's commercial interest with the government's nonproliferation interest.

With the closure of the Ohio enrichment plant, USEC now relies on the HEU Agreement for half of its capacity to meet its commitments for enrichment services.

Noga. In 1991, Russia and a Swiss company, Compagnie Noga d'Importation et d'Exportation S.A., signed a \$1.5 billion agreement in which Noga agreed to provide Russia with consumer goods and agricultural products in exchange for oil. Noga claims Russia defaulted on this agreement, and won a judgement in a Swedish arbitration court in 1999. In January 2000 Noga filed lawsuits in New York and Kentucky seeking to enforce the Swedish arbitration award, apparently targeting payments to Russia under the HEU Agreement (which pass through banks in New York) and natural uranium Russia takes title to under the HEU Agreement (which is stored in Kentucky).

Fearing that payments and assets would be seized, Russia halted shipments in May 2000 and appealed to the U.S. government to resolve this problem. The U.S. government developed a creative solution. In June, the President issued an Executive Order under the authority of the International Emergency Economic Powers Act blocking all transfers of Russian assets in the United States related to implementation of the HEU Agreement, except for transactions specifically licensed by Treasury.²² Russia resumed deliveries shortly thereafter. To this day, sales of enrichment services and natural uranium connected with the HEU Agreement, and corresponding payments to Russia, receive licenses from Treasury following interagency review. Noga did not proceed against Russian HEU

assets in the United States (but was successful against less carefully protected Russian assets in France).

Market Pricing. The market prices of uranium and enrichment services have historically fluctuated over a wide range. The 1994 initial HEU contract envisioned that the price paid to Russia would be reset each year, through negotiations each October between USEC and Tenex on price, enrichment assay, and delivery schedule for the following year. If no agreement were reached on price, the price agreed for the previous year would carry over for one more year. If no agreement were reached for two years in a row, that would create an impasse.

The price paid to Russia set in the initial HEU contract (\$82.10 per SWU) applied to the first year of deliveries (1995). The five-year agreement worked out in September 1996 for 1997–2001 deliveries adjusted the price each year to U.S. inflation, resulting in a price of about \$90 per SWU by 2001. While the price paid to Russia escalated, the market prices USEC received for new sales declined, setting the stage for a serious problem in 2002. (USEC benefited temporarily through this period from deliveries under long-term contracts reflecting higher historic prices.)

An agreed algorithm for setting the price paid to Russia for the enrichment value based on market indices would have clear advantages for the long-term stability of the HEU Agreement, compared to the inherent uncertainties of periodic renegotiation. As noted above, such an algorithm is a central element of the March 1999 natural uranium agreement, tying the price paid to Russia for the natural uranium component to market prices.

In 1999, following consultations with the U.S. government, USEC initiated discussions with its Russian counterpart on a mechanism to tie the price paid to Russia for the enrichment component to market prices. The Russian side was not prepared to reopen the five-year price agreement in place for 1997–2001, but was open to discussion of market pricing for 2002 and beyond.

In May 2000, USEC and Tenex reached tentative agreement on an algorithm to be used each October to set the price for the following year, based on a discount from an index of published market prices averaged over recent years to dampen the effect of short-term price swings. USEC and Tenex submitted their tentative agreement to the two governments for approval, where it faced a protracted review in both capitals.

In Russia questions were raised because the new formula would likely result in a 2002 price lower than the \$90 per SWU expected in 2001, the last year of the five-year fixed price agreement.

In the U.S. the price formula was acceptable, but another element was controversial. The agreement called for USEC to purchase a small amount of commercial enriched uranium newly produced in Russian centrifuges, not

from diluted HEU. This provision had advantages for Tenex and Ministry of Atomic Energy (commercial revenues separate from the HEU Agreement revenue stream, which has been built into the Russian Federation budget) and for USEC (low-cost material). But for the U.S. government the HEU origin of the material from Russia is crucial to justify changing trade laws and displacing American workers to permit Russia half the U.S. market for reactor fuel. While the quantity was small (less than 5 percent of the much larger HEU Agreement purchases), the addition of commercial enriched uranium was difficult to justify.

This problem was greatly compounded a few weeks later when USEC announced a decision to close the Ohio gaseous diffusion enrichment plant, to bring U.S. domestic enrichment capacity into line with requirements that had been sharply reduced by imports from Russia under the HEU Agreement. As a practical matter, the U.S. government could not approve the USEC-Tenex market pricing agreement until it had a plan in place for the future of the Ohio plant and its workers. The future of the Ohio enrichment plant became an issue in the presidential election campaign, when candidate Bush wrote to the governor of Ohio criticizing the Administration for lack of a plan for the workers and equipment at the plant.²³

In October 2000, DOE announced plans to maintain a portion of the Ohio enrichment plant in a stand-by status, to permit restarting in the event of a disruption in the supply of enriched uranium, and to locate there a demonstration facility for advanced enrichment technology, creating employment opportunities for the workforce.²⁴

With the Ohio plant issues resolved, the U.S. government returned to the May 2000 market pricing agreement, and in January 2001 gave USEC guidance to work with Tenex to update the text and submit it for final approval prior to signature. In late January 2001 USEC and Tenex reached agreement on a revised text and submitted it to the two governments for approval. That same week the Bush Administration took office, and promptly informed Russia and Congress it would carefully review the draft agreement.²⁵

For the Bush Administration, construction of modern, competitive domestic enrichment capacity to replace the 50-year-old Kentucky plant was a key way the government could support nuclear power. After interagency consideration of a wide range of alternatives, the U.S. government decided in the summer of 2001 to use U.S. approval of the USEC-Tenex market pricing agreement (with modifications) and continuation of USEC's exclusive access to Russian LEU under the HEU Agreement as an inducement for USEC to commit to construct a modern enrichment facility according to an agreed schedule with milestones.

In October 2001, USEC was given guidance to pursue an interim arrangement for 2002, and a longer-term market-based solution for 2003 and beyond.

In February 2002, USEC and Tenex agreed to carry the \$90 per SWU 2001 price over to 2002, and agreed on an algorithm for computing the price paid to Russia for 2003 and beyond based on market prices. For the third time, USEC and Tenex submitted a market pricing agreement to the two governments for approval.

In parallel, USEC and DOE worked to develop a plan for a new U.S. domestic enrichment facility. On 18 June 2002, DOE and USEC announced the agreement described above to develop and deploy new enrichment technology. The following day, the State Department announced the approval of the market-based pricing agreement with Russia.²⁶

The new pricing agreement extends through 2013, when the HEU Agreement will terminate following dilution and delivery of 500 tons of HEU. It commits USEC to purchase at least 5.5 million SWU each year (equivalent to dilution of 30 tons of HEU), and to make up the 1.9 million SWU from the 1997–1999 shortfalls. Each year the price paid to Russia will be determined by an agreed algorithm using a discount from an index of published market prices, averaged over three years to dampen fluctuations.

While the price paid to Russia in 2003 was lower than the 2002 price, the multi-year averaging procedure indicates that over the next few years the price will likely rise. In addition, there is a provision to review the operation of the pricing mechanism and, if necessary, make adjustments to ensure that by 2013 Russia receives at least the \$7.5 billion envisioned when the initial HEU contract was signed in 1994 (\$82.10 per SWU \times 92 million SWU in 500 tons of HEU).

LOOKING TO THE FUTURE

Managing the HEU purchase has required continuous effort to overcome problems as they arise, and the future promises more challenges.

Follow-on Agreement. Structures and commitments to sell and to buy are largely in place through 2013, when the last of the 500 tons of HEU is converted to reactor fuel and shipped to the United States and the HEU Agreement will terminate. New arrangements will need to be put in place to continue the project beyond 500 tons.

The Soviet Union produced something over 1000 tons of HEU as part of its nuclear weapons program during 40 years of Cold War. In 1992, in the course of negotiations on the HEU Agreement, the Russian government decided that 500 tons were in excess of military needs. In the coming years, the Russian

government will consider how much additional HEU is in excess of military needs. This decision will depend in part on larger strategic issues, such as the course of reductions in the number of Russian strategic and tactical nuclear weapons, and judgements on requirements for reserves of nuclear weapons, weapons components, and fissile materials. An ambitious goal would be to aim to dilute and consume another 500 tons of Russia HEU in the years following 2013, recognizing that Russia has not yet decided to make such a quantity available.

In a follow-on agreement, structures substantially different than the current mechanisms can be considered. For example, after 2013 Russia might market LEU from HEU directly to U.S. utility customers. This could result in more favorable returns to Russia, which in turn could encourage making more HEU available for the next phase of the project.

Since most nuclear fuel is sold under long-term contracts, in order for new arrangements to be in place in 2013 for marketing 5.5 million SWU per year it will be necessary for the U.S. and Russian governments to agree upon those new arrangements several years in advance of 2013. Discussions on a follow-on agreement will need to begin within a few years.

Supplementary Projects. In the meantime, the two governments are discussing much smaller projects that would not bring additional material to the U.S. market and would not require Russia to make available large amounts of additional HEU. These include purchase of LEU from HEU by DOE for a stockpile to hedge against supply disruptions, purchase of HEU to be used as fuel for research reactors that use HEU fuel, and purchase of LEU from HEU for use in certain European reactors.²⁷ Another concept being examined would dilute HEU and hold the product for future sale (e.g., after 2013).²⁸

Suspension Agreement. The anti-dumping trade actions against imports of Russian uranium products, which in the early days were major obstacles to the HEU project, have evolved so that there is now more of a codependent relationship between the Suspension Agreement and the HEU purchase. The trade restrictions now permit massive imports under the HEU Agreement and restrict commercial imports of Russian uranium products not connected with the HEU Agreement. This serves the nonproliferation interest, but the future of the Suspension Agreement is difficult to predict, and remains a source of potential instability. The complaint and investigation underlying the Suspension Agreement have no termination date. Russia and the Commerce Department have joint responsibility for managing this issue.

The Future of Nuclear Power. Several trends are compatible with continuation of the HEU project well beyond 2013.

- ◆ The HEU Agreement has benefited from the substantially improved operating performance of the nuclear electric power industry in the United States over the last decade, stimulating demand for enriched uranium fuel.
- ◆ Global uranium production is about half of consumption, with the balance supplied by inventories from earlier overproduction and from former military stocks; as inventories are reduced, demand should grow for the natural uranium generated by the HEU Agreement (about 15 percent of world consumption).
- ◆ Large amounts of obsolete gaseous diffusion enrichment capacity in the United States and Europe need to be replaced with modern, competitive technology, allowing the global industry to be right-sized with a 15 percent share from Russian HEU.

The Future of USEC. USEC has met its commitments and performed its role, using Russian LEU from HEU to service its customers and paying Russia \$450 million per year. Looking forward, USEC faces financial and technological questions, as well as strong competition from Europe and Russia and potentially in the United States. The company faces a major challenge to demonstrate modern technology and finance a new enrichment plant necessary for a viable future. While other entities are probably capable of assuming the role of implementing the HEU Agreement, any transition would likely be disruptive to the project, as most near-term demand is already under long-term contract.

Linkage to Other Issues. The HEU purchase appears prominently on any short list of nonproliferation priorities. Nevertheless, this project has repeatedly been used to leverage other issues (e.g., denuclearization of Ukraine, development of transparency measures, and deployment of modern enrichment capacity in the United States). Despite the successful results of this tactic so far, tying the future of the HEU project to resolution of other issues is inherently risky.

Looking Ahead. Overall, the objectives the United States and Russia sought in 1993 are being realized. Excess Russian military HEU is being diluted and used to supply half the U.S. needs for reactor fuel, with substantial returns for Russia. With active management by the two governments, this project could continue well beyond 2013 to complete the task of putting to productive peaceful use HEU weapons components produced for the Cold War.

APPENDIX

Illustrative Transactions



Figure 1: Conventional transaction. A utility procures LEU by contracting with a mining company for uranium to be delivered to USEC, and contracting separately with USEC for enrichment services. The mine delivers the uranium to USEC, which processes it in an enrichment plant, and delivers the resulting LEU product to a fuel fabrication plant. The utility pays the mining company and pays USEC the prices specified in its contracts for uranium and enrichment services.

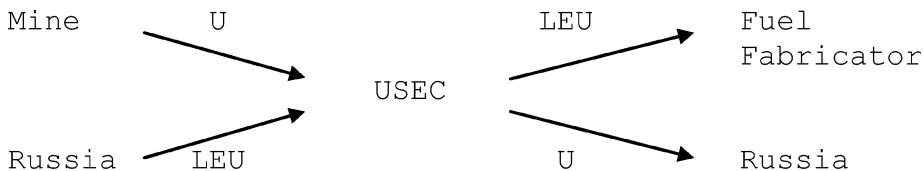


Figure 2: HEU Agreement transaction. As in a conventional transaction, the utility has a contract with a mining company to deliver uranium to USEC, and a contract with USEC to deliver LEU to a fuel fabrication plant. USEC receives LEU from Russia, and delivers it to the fuel fabricator with little or no processing. By law, Russia takes possession and title to the uranium. The utility pays the mining company and pays USEC the prices specified in its contracts for uranium and for enrichment services. USEC pays Russia the price specified in the HEU contract for the enrichment services component of the LEU. Russia realizes the value of the uranium by selling it or returning it to Russia.

Illustrative Numbers

Each year 30 tons of HEU (30,000 kgU, 90 percent U^{235})

are diluted with 885 tons of blendstock (885,000 kgU, 1.5 percent U^{235})

to produce 915 tons of LEU (915,000 kgU, 4.4 percent U^{235}), which represents:

5.5 million SWU, for which Russia receives approximately \$450 million, and

9100 tons of natural uranium, with a value of approximately \$250 million, which Russia receives part in cash and part in kind.

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