There has been a lot of discussion of late about a nuclear energy renaissance and the beginning of a «new era» of nuclear development. Though the use of the term «renaissance» is disputable, it is clear that many parts of the world are beginning to turn towards nuclear energy. According to the World Nuclear Association, there are 439 nuclear reactors in operation today while another 319 have been planned or proposed.

Under the circumstances, preventing the spread of sensitive technologies and knowledge associated with the military use of nuclear energy is taking on particular importance for the global community. For countries developing nuclear energy, questions of ensuring industry inputs are particularly critical: uranium, uranium enrichment, and qualified personnel. States beginning to develop the peaceful atom are most concerned with the uninterrupted supply of fuel cycle services, including uranium enrichment services.

In the 1970s, when nuclear energy was being actively developed, there were extraordinary plans for uranium enrichment to become a new, large-scale industry. In the United States alone, there were plans to build 16 new enrichment plants with a combined capacity of about 140 million SWU by the year 2000. In addition, there were expectations that in the 1980–1990s, besides the Soviet Union, United States, and the private consortiums Urenco and Eurodif, Australia, Brazil, Iran, South Africa, and Japan would obtain industrial enrichment capabilities. However, for a variety of reasons, with the exception of Japan none of these countries began operating new enrichment plants over the course of the past three decades. Over this period of time the United States stopped using two of its three enrichment plants, and by 2001 the production of low-enriched uranium (LEU) for domestic use had fallen to 12 percent of industrial needs.

Then, in 2005–2007, several states and groups of states presented a total of 12 proposals in the area of guaranteed supplies of uranium enrichment and nuclear fuel services. These proposals were meant, on the one hand, to remove fears related to the reliability of supplies to countries developing nuclear energy, and on the other hand to minimize the risks associated with the proliferation of dual-use enrichment technologies.

On January 25, 2006 at a session of the Eurasian Economic Community (EurAsEC), Russian President Vladimir Putin presented an initiative for the creation of international centers for the provision of nuclear fuel cycle services in Russia. The initiative envisioned the creation of international centers on Russian territory in four areas.
uranium enrichment;
spent nuclear fuel (SNF) handling;
training personnel in the nuclear sphere; and
developing innovative nuclear technologies, including the International Thermonuclear Experimental Reactor (ITER), the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), and the creation of fast breeder reactors.12

As a first step towards the practical realization of the initiative, the decision was made to create the International Uranium Enrichment Center (IUEC).

How will the Center operate? What are the criteria for participation in the project? What countries are potential IUEC participants? These and other questions related to Russia’s initiative for the formation of the IUEC are the subject of this article.

ENRICHMENT IN RUSSIA: CURRENT STATUS AND DEVELOPMENT PROSPECTS

Russia is the world leader in industrial uranium enrichment services with, according to various estimates, 40–45 percent of global capacity and a competitive enrichment industry.13 Domestic enterprises have employed centrifuge enrichment technologies on an industrial scale since 1964; this method is 30 times more energy efficient14 than its predecessor, gaseous diffusion.15

Centrifuge enrichment is an extremely complex technological process. The speed at which a modern gas centrifuge rotates reaches 1,000–2,000 revolutions per second, a world record for a mechanical device. Moreover, they can work nonstop for 25–30 years.16 Tolerances for the production of critical centrifuge components are just two-three microns;17 the series production of gas centrifuges requires extremely high skills and reminds of haute couture in engineering.18

This is how the work of an enrichment plant was described by Russian Academician and former Minister of Atomic Energy (2001–2005) Alexander Rumyantsev: «You enter, and there is complete silence on the shop floor, there are no people, although 500,000 centrifuges are spinning at over 1,500 revolutions per second.»19

The cost of gas centrifuges can be compared to the cost of an expensive automobile. Thus, when they were planning the production of new centrifuges, U.S. specialists were asked how they could reduce the cost of manufacturing from $100,000 to $50,000 per centrifuge.20 To be fair, it should be noted that the U.S. centrifuges are approximately 12 meters high, considerably exceeding the dimensions of Russian centrifuges, and thus their cost is higher as well.21

Aside from Russia, centrifuge technology is currently only used on an industrial scale by the German-Dutch-U.K. consortium Urenco,22 with a production capacity about 2.5 times smaller than Russia’s, and Japan, with a capacity some 20 times smaller than Russia’s. Other leaders in the field of nuclear energy—the United States and France—have to date not begun to employ industrial centrifuge enrichment plants and instead are using gaseous diffusion technology, which Russia stopped using over 15 years ago.

Retaining its leadership of the enrichment services market has special importance for Russia, given the reduction in the number of competitive industrial branches in the country and the displacement of high-technology exports by natural resource exports. From 1992 to 2002 Russian exports of hi-tech goods fell almost 50 percent,23 as a result of which the country’s share of global hi-tech exports is 0.13 percent, on a par with the Czech Republic, Norway, and Portugal.24 In 2005, Russia had almost three times fewer hi-tech exports than the Philippines, 4.5 times less than Thailand, 10 times less than Mexico, 13 times less than Malaysia and China, and 17.5 times less than South Korea.25

Russia has four uranium enrichment plants that were considered in the initial stage of project development as sites for the possible creation of the IUEP (see Table 1).
Table 1. Enrichment Plants in the Russian Federation

<table>
<thead>
<tr>
<th>Enterprise</th>
<th>Location</th>
<th>% of total Russian enrichment capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urals Electrochemical Combine (UEKhK)</td>
<td>Novouralsk, Sverdlovsk Region, Urals Federal District</td>
<td>48</td>
</tr>
<tr>
<td>Electrochemical Plant (EKhZ)</td>
<td>Zelenogorsk, Krasnoyarsk Territory, Siberian Federal District</td>
<td>28</td>
</tr>
<tr>
<td>Siberian Chemical Combine (SKhK)</td>
<td>Seversk, Tomsk Region, Siberian Federal District</td>
<td>14.4</td>
</tr>
<tr>
<td>Angarsk Electrochemical Combine (AEKhK)</td>
<td>Angarsk, Irkutsk Region, Siberian Federal District</td>
<td>9.6</td>
</tr>
</tbody>
</table>

Russia’s enrichment plants allow it to fulfill orders in four main areas (see Figure 1) (data as of 2000).

Figure 1. Utilization of Russia’s Enrichment Capacity

The realization of the branch’s targeted program Modernization of the Enrichment Complex through 2010 envisions the replacement of fifth-generation centrifuges that have exhausted their service lives with seventh and eighth generation centrifuges. They should increase Russia’s total enrichment capacity by 2010 by 34 percent over 2000. The program also provides for R&D on new, ninth-generation centrifuges. According to the plan, by 2010 the service lives of the first sixth-generation centrifuges that have been installed will have expired, and they will be replaced by ninth-generation centrifuges.

AEKhK PRODUCTION POTENTIAL

The Angarsk Electrochemical Combine (AEKhK), which has been selected to be the site for the creation of the IUEP, is equipped with sixth-generation gas centrifuges and is Russia’s youngest centrifuge enrichment plant: its first gas centrifuge cascades became operational in December 1990.

The Modernization of the Enrichment Complex through 2010 program foresees the expenditure of 36.7 billion rubles (over $1.5 billion), of which about 2 billion rubles (or nearly $85 million) are allocated for the modernization of AEKhK. Under the program, 100 percent of the resources for this modernization are to come from the enterprise’s own profits.

Thanks to measures taken in 2006, the productivity of the separation and conversion plants at AEKhK increased by 7 and 6.3 percent, respectively, and the total enrichment capacity of AEKhK in 2007 was 30 percent greater than in 2000, totaling 2.6 million SWU.
Protection in particular is aimed at the reconstruction of the enterprise’s control and accounting systems.

Thus, at the current time AEkhK enrichment capacity is about 5 percent of global capacity, with 50 percent of its capacity devoted to export contracts from China, the Czech Republic, Finland, South Korea, and Switzerland. Uranium for the fulfillment of domestic orders is supplied by the Priargunskiy Mining and Chemical Production Association (Krasnokamensk, Chita region), while for foreign orders the raw material comes from Central Asia, the Czech Republic, Ukraine, and so forth depending on the customer. AEkhK’s total annual separative capacity is equivalent to the production of fuel to load 22–26 VVER-1000 reactors (or its Western analogy, the PWR-1000).

On October 6, 2006 the Russian government approved the federal program Development of the Russian Nuclear Energy Complex in 2007–2010 and its Prospects through 2015, which added to and amended the nuclear branch plans for the modernization of enrichment production. According to the new federal program, the reconstruction of the enrichment plant at Angarsk should be completed by 2013, and in 2015 the combine’s separative capacity should total 4.2 million SWU. Over 10 billion rubles, or about $425 million, is envisioned to finance the modernization of the enrichment plant. Further, like the earlier program for the modernization of the enrichment industry, 100 percent of the funds are supposed to come from extra-budgetary sources.

In addition, under another project being undertaken with the use of AEkhK infrastructure—a Russo-Kazakhstani joint venture—plans call for an increase of plant enrichment capacity of 5 million SWU (of which the capacity to obtain the first million SWU should be ready by 2012). In all, by 2015 AEkhK’s separative capacity will be increased to 9.2 million SWU (see Figure 2).

Figure 2. Enrichment Capacity at the AEkhK site in 2000–2015, millions of SWU

Thus, two projects will be realized in the near future at the AEkhK site. The two projects—the IUEC and a Russian-Kazakh venture to create the closed joint stock company Center for Uranium Enrichment (CUE)—have been established by Techsnabexport (TENEX) and Kazakhstan’s national nuclear company Kazatomprom. The CUE project envisions large-scale investment, to the tune of $2.5 billion, and the construction of a new enrichment plant with a capacity of up to 5 million SWU on the basis of AEkhK infrastructure.

Besides this, AEkhK will continue to operate in the interests of domestic NPPs. That is, the plant’s capacities will be divided between orders for the IUEC, the Russian-Kazakh joint venture, and NPPs in operation both on Russian territory and abroad.
WHY ANGARSK?

In mid-September 2006, Russia officially informed the International Atomic Energy Agency (IAEA) that the IUEC would be created on the basis of AEKhK’s enrichment capabilities, 130 km from Lake Baikal in eastern Siberia.

The city of Angarsk, where the combine is located, has a population of just under 250,000, and is noted as the location of Russia’s largest city museum of clocks, with a collection of over 1,100, as well as for Russia’s largest oil refinery, with a capacity of almost 20 million tons per year (the tenth largest in the world), thanks to which it is considered Irkutsk’s petrocity. Angarsk’s Moscow Street is known for the fact that its asphalt lies over the old route to Moscow, over which the Decembrists were transported, in chains and shackles, in 1826.

But why was AEKhK chosen as the site for the IUEC?

The first reason is obvious – it is a relative simplicity of putting AEKhK under IAEA safeguards.

Three of Russia’s four enrichment plants (UEKhK, EKhZ and SKhK) are located on the territory of closed cities (ZATO), to which access is limited for both Russians and foreign citizens, and which have a special security regime. However, AEKhK is located in a city without such severe restrictions. In the 1980s the Angarsk combine was taken out of the «weapons» fuel cycle, stopped producing highly enriched uranium (HEU), and does not have any other defense production (unlike, for example, SKhK). This substantially facilitates the process of putting the facility under IAEA safeguards and makes it easier to allow foreign experts to visit the facility (the Soviet Union/Russia declared that it had ended production of HEU for weapons purposes in 1989).

Additionally, AEKhK specialists have experience in submitting a Russian-designed gas centrifuge plant to IAEA safeguards. In accordance with the intergovernmental agreement between Russia and China of December 18, 1992 on cooperation in the construction on Chinese territory of a gas centrifuge plant for uranium enrichment for nuclear energy, China was obligated to put the enterprise under Agency safeguards. AEKhK’s enrichment plant was used as a model for planning the Chinese plant. Since before that time the IAEA did not have any experience in safeguarding similar facilities (the safeguarding of Urenco’s gaseous centrifuge plant differs significantly from similar work at Russian facilities due to construction differences at these enterprises), a trilateral working group of experts from Russia, China, and the IAEA was created, which included experts from AEKhK.

The second reason is that the combine infrastructure exists and could be better utilized.

According to TENEX, 100 percent of the separative capacity at AEKhK is currently being used in an economically effective manner, including through the enterprise’s participation in the February 18, 1993 U.S.-Russian agreement on the conversion of HEU from nuclear warheads into LEU for use in NPPs (the HEU-LEU Purchase Agreement). The downblending of HEU, i.e. mixing it with a diluent (LEU with a U235 content of 1.5 percent) does not occur at AEKhK, but the diluent itself is produced at AEKhK, providing a considerable amount of work for the combine’s separative capacity.

At the same time, the plant has infrastructure that would permit the installation of additional separative capacities, since AEKhK was the last enrichment combine to be created in Russia (then the Soviet Union). Significant production space was also freed up after the replacement of gaseous diffusion equipment with centrifuges.

In its heyday, gaseous diffusion facilities occupied four shops, each about 900 meters long and 60 meters wide. The Irkutsk and Bratsk hydroelectric plants were built to supply power to the combine enrichment plants. Old hands at AEKhK tell the following story about this:

“Two months after the decree was issued by the Council of Ministers of the U.S.S.R on the beginning of the construction of the Angarsk combine, it became clear that an error had been made in the calculations: the capacity of the Irkutsk hydroelectric plant, then under construction, would not be enough for the combine to work at full capacity. The Bratsk hydroelectric plant could rescue the situation. In order to accelerate the beginning of its construction and get it on the list of facilities to be constructed in 1955, the signature of Nikita Khrushchev himself was needed. But
unfortunately he was not in Moscow at the time. He was traveling around the country. Minister of Medium Machine Building (the predecessor ministry to the Atomic Energy Agency) Yefim Slavsky managed to catch up with him in Volgograd, when he was leaving a hotel and getting into a car. After listening to the explanations, Khrushchev took the document and ordered his assistant: «Well, bend over!» Using his back as a table, he signed the document giving permission for the construction of the second hydroelectric plant of the Angarsk cascade.»

Today the energy requirements of the enrichment process at AEKhK (and at other Russian enrichment plants) are significantly lower. In 1983–1991 the modernization of the separative plant was undertaken via the replacement of gaseous diffusion equipment in the first two buildings with centrifuge equipment. This modernization program resulted in the freeing up of two industrial buildings with a remaining service life of about 50 years and a size that would make it possible to install centrifuge equipment of just about any reasonable capacity. Today, both buildings have been mothballed. All of the necessary infrastructure is in the buildings’ immediate proximity, including electric power lines of sufficient capacity, main pipelines for industrial water provision, etc.

The third reason is the presence of uranium conversion facilities at the combine.

Russia has uranium conversion facilities, i.e. plants for the production of the raw material for further enrichment, at AEKhK and SKhK. Moreover, about 15 percent of the world’s uranium hexafluoride conversion (U3O8–UF6) capacity is concentrated in Angarsk (about 8,000 tons per year). Russia’s other two enrichment plants (UEKhK and EKhZ) have to transport their material from the conversion plants in Angarsk and Seversk.

Finally, the fourth reason is the absence of centrifuge development and production divisions. AEKhK does not have any divisions for the development of new centrifuge types, including ninth-generation supercritical models, like those at UEKhK and EKhZ. This facilitates access by foreign specialists to the enterprise and decreases the potential risk of the proliferation of knowledge about centrifuge technologies to partners from foreign countries that might be looking for foreign assistance in the development of their own centrifuge uranium enrichment programs. This fact is of particular importance given the nonproliferation emphasis of the IUEC initiative.

**AEKhK FINANCIALS**

Assuming nonstop and trouble-free operations at AEKhK at full capacity and world prices for plant services, simple calculations (based on Table 2) indicate that yearly profits would total $380 million from the provision of enrichment services and $80 million from the sale of uranium conversion services at market prices. Thus, theoretically the enterprise’s annual profits should be about $460 million, given current capacities.

<table>
<thead>
<tr>
<th>Enterprise capacity (as of 2007)</th>
<th>Cost per unit of service (as of March 31, 2008)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrichment 2.6 million SWU</td>
<td>1 SWU=$146</td>
</tr>
<tr>
<td>Conversion 8,000 metric tons</td>
<td>$10/kg</td>
</tr>
</tbody>
</table>

After the 2013 and 2015 increases in the plant’s enrichment capacity to 5.2 million and 9.2 million SWU, the plant’s total income will increase to $840 million and $1.4 billion, respectively (in April 2008 prices for enrichment and uranium conversion services).

AEKhK’s real profits are considerably lower than those calculated, which can be explained by a combination of several factors. They include: the modernization of production; the fact that a substantial portion of plant production serves the domestic market, where prices are determined by Rosatom and are considerably lower than on the market (domestic contracts are
equally distributed between the four enrichment plants); and the production of diluent under the HEU-LEU deal at below-market prices.\textsuperscript{59}

**IUEC: GENERAL FEATURES**

In many ways, the IUEC project is a political initiative aimed at strengthening of the nonproliferation regime, and has been invoked to become a tool for the assured supply of enrichment services. At present, the project does not envision the installation of new separative capacity or large-scale investment, with the exception of investment in the creation of a guaranteed LEU fuel bank under IAEA control. The IUEC should become an AEKhK contractor, reserving a portion of its operational capacity through mutual obligations and chiefly taking orders for uranium enrichment services from the authorized organizations of states participating in the center. During the first stage of the initiative, plans call for IUEC orders to employ 300,000–500,000 SWU at AEKhK.\textsuperscript{60} Thus, the initiative does not involve the direct operation of enrichment facilities by the international center or access by specialists from IUEC participating states to enrichment technologies.

Currently, there are no plans for IUEC to acquire a controlling block of AEKhK shares or for the conclusion of a fiduciary agreement between IUEC and AEKhK.\textsuperscript{61} However, it is possible that in future the center might become the owner of a minority share of combine’s stocks.

The IUEC is primarily targeted at countries just beginning to develop nuclear energy, which have limited needs for enrichment services. The initiative is not aimed at the large-scale provision of enrichment services and the resale of their product on the world market with high value added. The IUEC is designed to be market-neutral, which means preferred access to uranium enrichment services through the center for end users, that is, energy companies from the countries developing their own nuclear energy. Kazakhstan, which has no nuclear power reactors on its territory to date,\textsuperscript{62} is the exception to this rule, but the leadership’s intention to construct NPPs is well known.

In August 2007, an agreement on the creation of the IUEC in the form of an open joint-stock company was signed, and in September the procedure for registering it as a legal entity was completed. According to the agreement between the parties, 90 percent of IUEC stocks belong to Russia, while 10 percent belong to Kazakhstan.\textsuperscript{63} Russia retained possession of the stocks that may in future be acquired by additional countries desiring to participate in the project. Moreover, Russia will retain a controlling block of IUEC shares (50 percent +1 voting share). In February 2008, Armenia completed the process of joining the center.

While the framework for the initiative was being worked out, a «leak» indicated that the possible provision of extraterritoriality to the center was under consideration. However, this would mean that the practical realization of the project would take at least five years. For this reason, the decision was made to provide additional assurances to participating states by other means: intergovernmental agreements that Russia will conclude with countries interested in participation in IUEC activities.

Another provision to ensure the reliable supply of IUEC enrichment services is the establishment of a guaranteed uranium reserve. The LEU (2–4.95) reserve, which will have about 120 metric tons in the form of hexafluoride (about 80 metric tons of fuel are needed for an initial load in a 1,000 MW reactor), will be held at the IUEC depot in Angarsk.

According to Article IX in the IAEA Statute, «members may make available to the Agency such quantities of special fissionable materials as they deem advisable and on such terms as shall be agreed with the Agency. The materials made available to the Agency may, at the discretion of the member making them available, be stored either by the member concerned or, with the agreement of the Agency, in the Agency’s depots.»\textsuperscript{64}

The uranium hexafluoride reserve created through the IUEC will remain the property of the Russian Federation, and can be supplied at commercial prices by IAEA decision when both a contractor and the market refuse to supply LEU for political reasons to a state developing the
peaceful use of nuclear energy that is in fulfillment of its nonproliferation obligations. The guar-anteed reserve is valued at $300 million. The establishment of the reserve may already begin before the end of 2008.

Figure 3. IUEC Organizational and Legal Structure (as of December 2008)

Source: TENEX

Since the operation of AEKhK enrichment equipment by IUEC members is not planned, the staff of the international center will consist of just a few dozen administrative personnel. In addition, depending upon the center’s needs, specialists may be hired in the area of nuclear materials control and accounting, the application of IAEA safeguards, and other activities. The IUEC head office will be located in Angarsk and a branch office in Moscow.

In fall 2007 the hiring of IUEC staff began: a board of directors has been formed, with TENEX Deputy Director General Alexey Lebedev selected as its chairman, while TENEX Director Alexey Grigoriev was appointed IUEC director general. During the same session, the board of directors approved the financial structure and resolved that work on a concrete business plan should proceed. Provision of uranium enrichment services by IUEC is expected to begin in late 2008/early 2009, after which time the IUEC will be included in the list of Russian legal entities permitted to possess nuclear materials and will receive a license to handle nuclear materials from the Federal Service for Environmental, Technological, and Nuclear Oversight (Rostekhnadzor).

WHAT DOES THE INTERNATIONAL CENTER BRING TO THE REGION?

Irkutsk region, the site of AEKhK, is the source of 85 percent of Russia’s mica, 53 percent of its synthetic resins and plastics, 50 percent of nitrogen fertilizers and caustic soda, 30 percent of aluminum, and about 10 percent of Russian gold. However, despite the existence of significant natural resources (coal, oil, gas, iron ore, and gold), important enterprises in the metallurgical, chemical, natural gas and lumber industries, and its location at the crossroads of important transcontinental highways, Irkutsk continues to be of limited attraction to investors.

The average level of investment per capita in the region is 1.7 times lower than the Russian average. In 2000–2004, the region was in the 20th percentile among Russian regions in terms of investment in fixed assets, along with the depressed regions of Ivanovo and Kurgan. While the region’s market potential is in the top two dozen of Russia’s 89 regions (17th place in 2006), it is 62nd in terms of investment risk.

Increasing the investment attractiveness of Irkutsk region is one of the regional administration’s main concerns. Among top-priority steps under consideration to achieve this goal are...
measures that could improve the region’s reputation as a reliable partner and expand its reputation beyond Russia’s borders. Irkutsk region’s leadership views achieving the rank of a key economic region within the Russian Federation, as well as the status of Siberia’s economic locomotive, as key strategic objectives.

In this regard, the IUEC project with the participation of the IAEA could have a positive effect on the successful positioning of the region and its economic prospects at the federal and international levels. High technology is particularly attractive for the Irkutsk region administration, since all of its other megaprojects involve raw materials (resource extraction or exports of gold, oil, gas, and lumber).

THE ROLE OF THE IAEA

One of the key conditions for the project is that IUEC activities be put under IAEA safeguards. Agency safeguards are carried out in Russia on the basis of the Agreement between the Union of Soviet Socialist Republics and the International Atomic Energy Agency for the Application of Safeguards in the Union of Soviet Socialist Republics (INFCIRC/327) of February 21, 1985. As a nuclear weapon state, Russia provides the IAEA with a list of nuclear fuel cycle facilities where it will accept the application of safeguards on a voluntary basis. From this list, the Agency determines where it will apply safeguards.75

In the Soviet Union, the Agency viewed examining the development of technical procedures and methods as its main safeguards task in the country.

For this reason, the U.S.S.R made up a list of facilities that could be subject to safeguards consisting of NPPs and research reactors. In accordance with the safeguards agreement, the Agency has the right to choose any installation on the list for the application of safeguards. In practice, IAEA safeguards at various periods of time were applied to just three facilities in Russia (U.S.S.R):

- The IR-8 research reactor, located at the Kurchatov Institute;
- The VVER-1000 reactor (Novovoronezhskaya NPP No. 5); and
- The nuclear fuel storage depot at the machine-building plant (Elektrostal, Moscow region).76

Even before the agreement was signed, the Agency’s international inspectors perfected technical procedures for safeguards on one of the VVER-440 reactors at Novovoronezhskaya NPP, which was analogous to one built in Eastern Europe.

In 1991, Russia initiated work to undertake IAEA safeguards at the BN-600 FBR at Beloyarskaya NPP, which was of interest to the Agency in view of the possible future growth of nuclear energy, and the development of procedures for the safeguarding of fast reactors. However, due to a shortage of IAEA resources safeguards were never applied to the reactor.77 For the same reason, as of the end of 2007 not one of the facilities Russia has put on the list of those open to the monitoring of international inspectors has been chosen for the application of Agency safeguards.

In order to put the IUEC under IAEA safeguards, Rosatom initiated the conclusion of an agreement on this question at the interagency level, after which the government decided to include the site on the list of facilities open to international inspection. In January 2008, the Ministry of Foreign Affairs sent a note informing the IAEA that the IUEC and AEKhK had been included on the list of facilities open for the application of Agency safeguards.78 Thus, for the first time enrichment plants located on Russian territory were included on the list of facilities open to IAEA inspections.

In accordance with the 1985 agreement, Russia (the Soviet Union) and the IAEA are each responsible for their own expenditures incurred in connection with the implementation of Agency monitoring in Russia; moreover, if Russia or persons under its jurisdiction incur extraordinary expenses as a result of specific IAEA requests, the Agency must reimburse such expenses provided that it has agreed in advance to do so. In any case, the Agency bears the
cost of any additional measuring or sampling which its inspectors request. However, there is an
understanding that the application of safeguards to nuclear material at the IUEC will be paid for
by Russia itself. IAEA safeguards will also be applied to the LEU reserve that will be created at
IUEC.

POTENTIAL PROJECT PARTICIPANTS, OR WHO SHOULD WE EXPECT IN ANGARSK?

The initiative to create the IUEC initially viewed a state’s renunciation of national enrichment
programs as a requirement for participation in the work of the international center. However,
in consultations with the IAEA on issues related to multilateral fuel cycle initiatives, several
countries, including Argentina, Australia, Canada, Kazakhstan, Ukraine, and South Africa,
made it clear that they were not prepared to renounce their right to enrich uranium in the future.
Furthermore, Brazil and Iran, which are actively undertaking research and development in the
area of centrifuge enrichment, as well as Japan, which has a small enrichment capacity, are
unlikely to give up their right to the development of this industry.

Therefore, the decision was made to adopt a more flexible approach towards this issue, in
accordance with which the renunciation of national enrichment programs is welcomed, but not
required. In the preamble to the Russian-Kazakh agreement on the creation of the IUEC, there
is a reference to the fact that at present Kazakhstan does not have enrichment capabilities.

Thus, according to the proposed arrangement, any country that would like to develop nuclear
energy and is a member of the Nuclear Non-Proliferation Treaty and the IAEA can become a
co-owner of the international center.

Current and potential IUEC participant states can be broken down into three main categories.

First, these are the countries just beginning to plan for the development of nuclear energy that
do not possess enough expertise, or economic and political motivation to create a national
enrichment capability. Algeria, Belarus, Egypt, Indonesia, Jordan, Kazakhstan, Libya, Lithuania,
Malaysia, Morocco, Thailand, Turkey, Uzbekistan, Vietnam and the countries of the
Persian Gulf can be included in this category.

Second, there are countries with significant experience in the operation of NPPs that currently
acquire enrichment services on the global market and have temporarily rejected the construc-
tion of their own enrichment plants. Armenia, Belgium, the Czech Republic, Finland, Hungary,
Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, South Korea, and Ukraine are in this
category.

The above groups are the targets of the initiative. At the same time, I would suggest that the ini-
tiative could interest the third group of countries as well. These are states that have their own
industrial-scale enrichment capabilities or are actively working on their creation, but have yet
to reach the capacity to satisfy national requirements. Brazil, Iran, and Japan belong to this
group.

The United States, which provides for just 12 percent of its own enrichment needs, could also
be considered in this group. At present the United States has 104 power reactors, for which
55 percent of its nuclear fuel is produced from LEU obtained from Russia under the HEU-LEU
Purchase Agreement. If by the time it expires (in 2013) the centrifuge enrichment plants being
built in the states of New Mexico and Ohio have yet to reach their design capacities, U.S. com-
panies will be faced with purchasing enrichment services abroad. However, in this case the
form of U.S.-Russian cooperation will most likely be different from the IUEC, since the latter
can not satisfy the needs of American NPPs.

One additional group of states interested in collaborating with Russia in the area of uranium
enrichment comprises the most important uranium producers, in particular Australia and
Canada. However, given the IUEC requirement of market neutrality, it is likely that the format for
such cooperation (if realized) would be different.

The prospects for the participation of some countries in the IUEC are examined in more detail
below.
**Kazakhstan**

About 21 percent of the world’s uranium reserves are concentrated in 129 deposits located in Kazakhstan. In 2006, uranium mined in the country amounted to about 5,000 metric tons, or 10 percent of the world total. Plans call for Kazatomprom, one of the three leading uranium mining companies in the world, to reach a yearly yield of 18,000 metric tons by 2010, and by 2015 to reach a maximum yield of 27,000 tons. In all, plans call for about 1.2 million metric tons of uranium to be mined by 2050.

Kazatomprom’s strategy sees leadership of the uranium ore market as the first stage in the construction of a vertically integrated holding company for the production of the complete nuclear fuel cycle. Kazakhstan produces nuclear fuel pellets at the Ulba Metallurgical Plant, which it inherited from the Soviet Union. Thus, Kazakhstan is interested in acquiring the intermediate production step between mining uranium and manufacturing nuclear fuel: uranium enrichment. Russia, for its part, is interested in ensuring supplies of uranium ore from Kazakhstan. These needs will be partially covered through the IUEC (mostly through the joint venture created at AEKhK).

On May 10, 2007, in the presence of President of the Russian Federation Vladimir Putin and President of Republic of Kazakhstan Nursultan Nazarbaev, the signing of the Russian-Kazakh agreement on the creation of the IUEC took place in Astana.

Plans call for the IUEC and Russian-Kazakh joint venture to coexist on the AEKhK site.

**Armenia**

On February 6, 2008, the heads of the Russian and Armenian governments, Victor Zubkov and Serzh Sarkisian, exchanged notes on the conclusion of an intergovernmental agreement on Armenian participation in the IUEC. In accordance with the agreement, the privately held company – Armenian Nuclear Power Plant is – currently preparing all of the necessary documentation to obtain possession of a 10 percent of shares in the international center.

**Ukraine**

Ukraine is considering the possibility of joining the center and the acquisition of 10 percent of its shares. The possibility of Ukrainian participation in the IUEC is documented in the protocol on cooperation between Ukraine and Russia in the nuclear sphere, signed on June 4, 2007, by Rosatom head Sergey Kiriyenko and Ukratomprom head Andriy Derkach. A draft agreement on joining the IUEC has been transmitted to Ukraine for study. Plans call for related legal questions to be resolved by mid-2008. However, the significant politicization of the question of Ukraine joining the IUEC should be noted, particularly given its plans to transfer several of its power reactors from the use of Russian fuel to fuel produced by Westinghouse.

**South Korea**

South Korea is actively seeking new sources of raw material for nuclear energy in the Central Asian region. On September 25, 2006, the prime ministers of Uzbekistan and South Korea signed a memorandum of understanding on the supply of Uzbek uranium. The agreement provides for yearly deliveries of 300 metric tons of uranium ore concentrate between 2010 and 2014.

In April 2006, the South Korean company Korea Resources Corporation and Uzbekistan’s State Committee for Geology and Mineral Resources (Goskomgeologii) agreed to create a joint venture for the industrial development of the large Dzhantuar uranium deposit in the middle of the Kyzylkum desert in Navoi region. According to preliminary data, the deposit’s proven reserves are about 7,000 metric tons of uranium.

Earlier, South Korea concluded an agreement on uranium supply with Kazakhstan. According to these plans, a Kazakh-Korean joint venture will begin production in 2008; its design capac-
ity is 1,000 metric tons of uranium per year. At present, 800 metric tons of Kazakh uranium is delivered to South Korea each year.\footnote{92}

Given Angarsk’s geographic proximity to the Central Asian region, placing orders for the enrichment of uranium of Uzbek and Kazakhstan origin at the IUEC could be economically more advantageous for South Korea than transporting the uranium to Urenco plants, whose services South Korea is using today.

**Iran**

The main reason why Iran might possibly be interested in participation in the project is that its enrichment capacity is not sufficient to meet the country’s nuclear energy needs. Iran’s current plans for the development of nuclear fuel cycle enterprises, if realized, will still not permit it to obtain self-sufficiency in the next few years in terms of uranium mining and enrichment and meet the annual needs of the first unit of the Bushehr NPP (a fuel supply agreement for a period of ten years has been signed by the relevant organizations in Russia and Iran).

It would seem that Iranian participation in the IUEC could be viewed by the country’s leadership as a project that could increase the country’s status in the international arena, and particularly in the Middle East, since it would allow the state to participate in a joint project in the area of high technology with countries that have very highly developed nuclear programs, such as Russia, Ukraine, and possibly South Korea and Japan. Additional Iranian interest in the project could be elicited by the present flexible approach of the IUEC initiative towards the presence of national capabilities and efforts to create them in states participating in the project.

In addition to this, participation in the IUEC leaves open the possibility that the country could make maximum use of its own fuel production capabilities – primarily, this relates to the possibility that Iran could employ its national uranium conversion plants and supply that material for enrichment to the IUEC.

**Japan**

Japan is actively seeking new sources of raw material for its NPPs in Central Asia and Russia. Japanese companies are interested in the development of uranium deposits in Kazakhstan and Uzbekistan, as well as the Elkon uranium deposit in Yakutia.

In late 2005 the Japanese company *Itochu* concluded an agreement on the purchase of 3,000 metric tons of uranium from Kazakhstan over the next ten years. On January 23, 2006, the Japanese companies *Sumitomo* and *Kansai Electric* signed an agreement on the creation together with *Kazatomprom* of a trilateral joint venture for the development of the Western Mynkuduk deposit in South Kazakhstan. The enterprise’s design capacity of 1,000 metric tons or uranium per year is expected to be reached in 2010. The mine’s service life is expected to last approximately 22 years, with a total volume of uranium production of about 18,000 metric tons.\footnote{93}

A number of other Japanese companies, including *Marubeni Corp.*, *Tokyo Electric Power Co.*, *Toshiba Corp.*, and *Chubu Electric Power Co.*, have obtained the right to joint development of the Kharasan-1 and Kharasan-2 uranium deposits with *Kazatomprom*. According to current plans, over the course of 40 years the output will be 2,000 metric tons of uranium per year.

During Japanese Prime Minister Junichiro Koizumi’s visit to Tashkent in August 2006, Japanese companies received proposals to participate in the development of Uzbek uranium deposits. The *Japan Bank for International Cooperation (JBIC)* and the government of Uzbekistan signed a memorandum of understanding according to which JBIC will provide credits in the uranium mining sector in Uzbekistan with the participation of Japanese companies and technologies.
Thus, there are plans to cover 30–40 percent of Japan’s yearly uranium needs from Central Asian mines. This number is currently 3 percent of the yearly requirement for Japanese energy, or about 8,000 metric tons of uranium.

Joint Russian-Japanese development of the Elkon uranium deposit in Yakutia is scheduled to begin in 2009. According to the contract, 100 percent of the ore is to be sent to enrichment plants in Russia.

Japan’s need for Russian enrichment services may soon grow, since it is cheaper to transport the uranium ore to Russian enterprises, located near the Central Asian region. At present, Japanese companies already buy 12–16 percent of the enrichment services they need in Russia; however, these bilateral relations could grow and this number could increase to 25–33 percent.

Japanese companies have shown an increased interest in the details of the IUEC on Russian territory. For instance, on September 1, 2006, a delegation from Kansai Electric visited AEKhK. On March 20, 2008, Atomenergoprom Director General Vladimir Travin and Toshiba Corporation President Atsutoshi Nishida signed a framework agreement on cooperation in the peaceful use of atomic energy, which among other things envisions cooperation in the area of uranium enrichment. On the basis of this agreement, the partners will begin to prepare the technical and economic substantiation for cooperation in various areas, including discussing the method for cooperation in the area of uranium enrichment.

According to TENEX Director General Alexey Grigoriev, negotiations are also being conducted with a number of countries in Western Europe and the Pacific that are interested in joining the project.

CONCLUSION

The creation of the IUEC could bring Russia substantial foreign and domestic political dividends – from the indirect expansion of Russia’s presence on the global uranium market to an increase in the investment attractiveness of Irkutsk region, where the enterprise will be located. No less important is the restoration of the position of Russia, one of the depositaries of the Nuclear Non-Proliferation Treaty, as one of the main players in the process of strengthening the nonproliferation regime.

The International Uranium Enrichment Center will not solve all of the existing nonproliferation problems, but could offer a new basis for solutions to current crises in this sphere and prevent the appearance of potential new threats by offering newcomers to the field of nuclear energy a (temporary) alternative to national uranium enrichment capabilities. In particular, one of the elements of a package solution to the crisis surrounding Iran’s enrichment program could be the participation of this state in the international center.

Given Russia’s limited number of economically competitive industries today, the high technology component of the proposed project is particularly valuable. Of late the assertion that «countries that predominantly export the product of human intellect will triumph, while the significance of those countries whose welfare and place in the world has depended on their role in the extraction of natural resources and the use of traditional energy sources is falling» has become axiomatic.

Among the numerous initiatives in the area of multilateral fuel cycle approaches, Russia’s is the most developed in terms of national legislation and the large amount of organizational work that has been done for the creation of the center, in addition to which the enterprise has been included in the list of facilities subject to IAEA safeguards. The time will come when the IUEC will have to prove its economic attractiveness on the market for enrichment services for states beginning to develop nuclear energy; here Rosatom still has a lot of work to do.

For Russia, though, creation of the IUEC is seen as a pilot project, where the ways to create international centers for the provision of fuel cycle services can be perfected in collaboration with the IAEA.
It is also likely that another byproduct of the creation of the IUEC will be the improvement of the environmental situation at AEKhK. Thanks to the organizational work undertaken for the international center, a solution to the problem of processing the stockpiles of depleted uranium hexafluoride stored at the combine has already been identified.

Notes

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5 If these plans had been realized, the financial volume of the U.S. part of the uranium enrichment market alone would have been about $25 million in March 2008 dollars. See «Enriched Uranium Is Next Big Industry in the United States,» Gallup Independent, August 20, 1973, p. 6.


7 «Urenco and the National Enrichment Facility (NEF),» http://www.urenco.com/fullArticle.aspx?m=1371 (last accessed on April 7, 2007); Yulia Kudrina, «What is Preventing a Russo-American ‘Nuclear Friendship’?» Atomprom Bulletin, No. 6, November 2007, p. 44.


10 The Eurasian Economic Community (EurAsEC) is an international economic organization designed to assist in the formulation of common external customs boundaries, foreign economic policies, tariffs, prices, and other elements of a common market among member states (Belarus, Kazakhstan, Kyrgyzstan, Russia, Tajikistan and Uzbekistan). EurAsEC is the legal successor to the CIS Customs Union.


12 «Kiriyenko: One Uranium Enrichment Center in Russia Is Enough,» RIA Novosti, February 8, 2006.


22 Urenco employs three plants in the United Kingdom, the Netherlands, and Germany with a total capacity of about 8 million SWU per year.
24 In recent years the absolute volume of hi-tech exports is about $2.5–3 billion; «Russia’s Share of Global Hi-Tech Exports Is 0.13 Percent: German Gref,» IA Regnum, October 10, 2006.
26 Data from Nuclear Power in Russia, Briefing Paper No. 62 (September 2006), http://www.uic.com.ua/nip62.htm (last accessed on October 1, 2007), which are in general agreement with the data found in V. D. Safutin, Yu. V. Verbin, and V. V. Tolstoy, «Status and Prospects for Enrichment,» Atomnaya Energiya, Vol. 89, No. 4 (October 2000), p. 339. According to the latter, the capacities of Russian enrichment plants are as follows: UEKhK – 49 percent, EKhZ – 29 percent, SKhK – 14 percent, AEKhK – 8 percent.
28 Ibid., p. 342.
30 «The Dollar is ‘Beating’ AEKhK,» Details (Angarsk), April 12, 2007.
34 Ibid.
35 According to the author’s calculations, based on AEKhK’s capacity and the fact that production of enriched uranium for a 1,000 MW reactor requires 100,000–120,000 SWU.
40 Transcript of meeting between Nikolay Spassky, Federal Atomic Energy Agency (Rosatom) deputy director and head of the commission to establish the International Uranium Enrichment Center, and rep-

41 Angarsk is a major industrial center with large enterprises in the chemical and petrochemical industries, petroleum refining, machine-building enterprises, as well as enterprises in the areas of metal working, light industry, food, and building materials. The main industrial branches that make up the economy of Angarsk municipality are: industry (54.2 percent of sales volume, according to data from the municipal administration), trade (12.8 percent), materials and machinery supply (7.9 percent), construction (6.5 percent), transport and communications (5.1 percent), housing and utilities (1.3 percent), and agriculture (1.1 percent). Official website of the administration of Angarsk, http://www.angarsk-adm.ru/info/adm/economic/ economic.html (last accessed on October 1, 2007).


46 V. Vandyshev, «AEXhK Meets All of the Conditions for the Creation of an International Uranium Enrichment Center,» Nuclear Branch Information and Exhibition Center, September 18, 2006.

47 TENEX comments on draft article by the author, entitled «Will Angarsk’s High Technology Enrich Siberia?» October 31, 2007, p. 6.


50 Interview with Kazatomprom president Mukhtar Dzhakishev, Kazakhstani Today, August 1, 2006.

51 Oleg Gulesky, «Post Box No. 79,» Oblastniya Gazeta (Irkutsk region), September 28, 2007.

52 V. Vandyshev, «AEXhK Meets All of the Conditions for the Creation of an International Uranium Enrichment Center,» Nuclear Branch Information and Exhibition Center, September 18, 2006.


56 The main and reserve power transmission lines to AEXhK were damaged by a lightning strike and power to the enrichment plant was cut on July 6, 2006; the enrichment plant was off-line for over six hours. Repairs and recovery operations were only completed 21 hours after the accident occurred. See «In Normal Mode,» AEXhK Press Service, July 9, 2007, http://www.aecc.ru/newsdetal.php? par=193 (last accessed on October 7, 2007).

57 «UxC Nuclear Fuel Price Indicators,» http://www.uxc.com/review/uxc_Prices.aspx (last accessed on April 7, 2007).

58 In the first half of 2006 AEXhK profits totaled 1.8 billion rubles (about $75 million). See «Receipts from the Realization of AEXhK Production in the First Half of the Year Totaled 1.8 Billion Rubles, Which is Lower than the Indicators for the Same Period Last Year,» RIA Sibirskiy Novosti, September 5, 2006.

59 Yulia Kudrina, «What is Preventing...»

60 Comments by Alexey Lebedev, Chairman of the IUEC Board of Directors, in his interview with author, April 14, 2008.

61 TENEX comments on draft article...; p. 7.
62 Ibid., p. 8.
67 «TENEX Director Alexey Grigoriev Appointed Director General of the Center for Uranium Enrichment in Angarsk,» Sibirskije Novosti, October 26, 2007.
68 Alexey Lebedev, Chairman of the IUEC Board of Directors, interview....
69 Interview of IUEC Director General...
73 Within the framework of the process of enlarging subjects of the Russian Federation, their number was reduced to 83 as of March 1, 2008.
74 In the opinion of the ratings’ authors, the greatest risks in Irkutsk region are tied to the incompleteness of legislation, the region’s high level of criminality, and environmental risks. «Rating of Investment Attractiveness of Russian Regions, 2004–2005,» http://www.raexpert.ru/ratings/regions/2006/ (last accessed on October 6, 2007).
79 «Nuclear Nonproliferation the International Uranium Enrichment...»
81 TENEX comments on draft article..., p. 8.
82 «By 2010 Kazatomprom Plans to Increase Uranium Extraction to 18,000 Metric Tons per Year – Company Head,» Interfax-Kazakhstan, April 2, 2007.
86 «Ukraine’s Share in the IUEC May Be 10 Percent– Mintopenergo,» Interfax-Ukraine, September 27, 2007.
89 «Ukraine May Already Begin the Paperwork to Join the International Uranium Enrichment Center This Year – S. Kiriyenko,» Prime-TASS, June 22, 2007.
91 «South Korea Agrees with Uzbekistan on Supplies of Uranium Ore,» Kazinform, September 28, 2006.
95 Interview of IUEC director general...