

DEVELOPMENT OF URANIUM MINING AND URANIUM PROCESSING IN THE RUSSIAN FEDERATION

РАЗВИТИЕ НА УРАНОДОБИВА И УРАНОПРЕРАБОТКАТА В РУСКАТА ФЕДЕРАЦИЯ

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Abstract: The Russian Federation average about 3000 tons of uranium per year from its own mines. Russian uranium mining companies work in Kazakhstan, Canada and other countries either directly or through companies they purchase. Its businesses export fuel in all parts of the world and are getting more stable on the world market despite the sanctions imposed.

Keywords: Uranium production, Russian Federation, mining,, domestic mining, regulation, safety, Export

1. Introduction

Russia has substantial economic resources of uranium, with about 9% of world reasonably assured resources plus inferred resources up to \$130/kg – 505,900 tonnes U (2014 Red Book). Rosatom reported ARMZ resources as 517,000 tU in September 2015, mostly requiring underground mining. Historic uranium exploration expenditure is reported to have been about \$4 billion. The Federal Natural Resources Management Agency (Rosnedra) reported that Russian uranium reserves grew by 15% in 2009, particularly through exploration in the Urals and Kalmykia Republic, north of the Caspian Sea.

Uranium production has varied from 2870 to 3560 tU/yr since 2004, and in recent years has been supplemented by that from Uranium One Kazakh operations, giving 7629 tU in 2012. In 2006 there were three mining projects in Russia, since then others have been under construction and more projected, as described below. Cost of production in remote areas such as Elkon is said to be US\$ 60-90/kg. Spending on new ARMZ domestic projects in 2013 was RUR 253.5 million, though in November 2013 all Rosatom investment in mining expansion was put on hold due to low uranium prices.

Russia uses about 3800 tonnes of natural uranium per year. After enrichment, this becomes 190 tU enriched to 4.3% for 9 VVER-1000 reactors (at 2004, now 13), 60 tU enriched to 3.6% for 6 VVER-440s, 350 tU enriched to 2.0% for 11 RBMK units, and 6 tU enriched to 20% (with 9 tU depleted) for the BN-600. Some 90 tU recycled supplements the RBMK supply at about 2% enrichment. This RepU arises from reprocessing the used fuel from BN, VVER-440 and marine and research reactors.

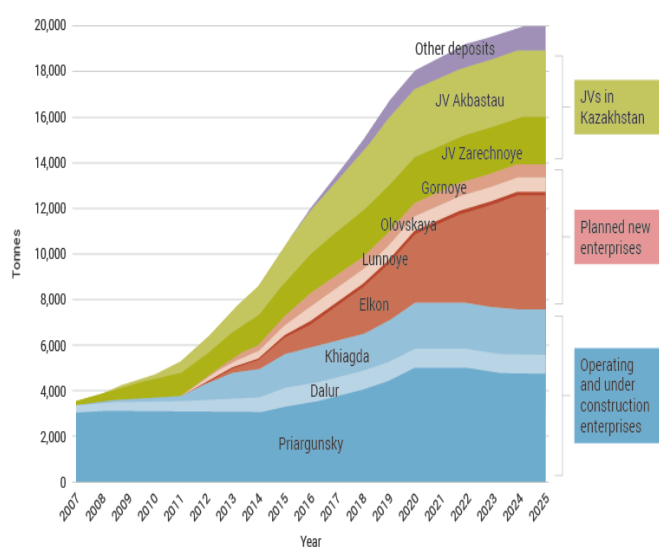
2.1. Uranium resources and mining

Plans announced in 2006 for 28,600 t/yr U3O8 output by 2020, 18,000t of this from Russia* and the balance from Kazakhstan, Ukraine, Uzbekistan and Mongolia have since taken shape, though difficulties in starting new Siberian mines makes the 18,000 t target unlikely. Three uranium mining joint ventures were established in Kazakhstan with the intention of providing 6000 tU/yr for Russia from 2007: JV Karatau, JV Zarechnoye and JV Akbastau (see below and Kazakhstan paper).

AtomRedMetZoloto (ARMZ) is the state-owned company which took over Tenex and TVEL uranium exploration and mining assets in 2007-08, as a subsidiary of Atomenergoprom (79.5% owned). It inherited 19 projects with a total uranium resource of about 400,000 tonnes, of which 340,000 tonnes are in Elkonskiy uranium region and 60,000 tonnes in Streltsovskiy and Vitimskiy regions. The rights to all these resources had been transferred from Rosnedra, the Federal Agency for Subsoil Use under the Ministry of Natural Resources and Environment.

JSC ARMZ Uranium Holding Company (as it is now known) became the mining division of Rosatom in 2008, responsible for all Russian uranium mine assets and also Russian shares in foreign joint ventures. In 2008, 78.6% of JSC Priargunsky, all of JSC Khiagda and 97.85% of JSC Dalur was transferred to ARMZ. In March 2009 the Federal Financial Markets Service of Russia registered RUR 16.4 billion of additional shares in ARMZ placed through a closed subscription to pay for uranium mining assets, on top of a RUR 4 billion issued in mid 2008 to pay for the acquisition of Priargunsky, Khiagda and Dalur. In November 2009 SC Rosatom paid a further RUR 33 billion for ARMZ shares, increasing its equity to 76.1%.

ARMZ Uranium Production Plans 2007



Source: World Nuclear Association

In 2009 and 2010 ARMZ took a 51% share in Canadian-based Uranium One Inc, paying for this with \$610 million in cash and by exchange of assets in Kazakhstan: 50% of JVs Akbastau, Karatau and Zarechnoye, mining the Budenovskoye and Zarechnoye deposits. (An independent financial advisor put the value of ARMZ's stakes in the Akbastau and Zarechnoye JVs at \$907.5 million.) Uranium One has substantial production capacity in Kazakhstan, including now those two mines with Karatau, Akdala, South Inkai and Kharasan, as well as small prospects in USA and Australia (sold in 2015). In 2013 ARMZ completed the purchase of outstanding shares in Uranium One Inc, and it became a full subsidiary of ARMZ. JSC Uranium One Group (U1 Group) is from December 2016 a 78.4% owned subsidiary of Atomenergoprom and apparently separate from ARMZ.

Following this, late in 2013 Rosatom established Uranium One Holding NV (UIH) as its global growth platform for all international uranium mining assets belonging to Russia, with headquarters in Amsterdam. It lists assets in Kazakhstan, USA and Tanzania, as well as owning and managing Rosatom's stake in Uranium One Inc. In 2013 it accounted for 5086 tU production at average cash cost of \$16/lb U₃O₈, and reported 229,453 tU measured, indicated and inferred resources (attributable share). In 2014 it produced 4857 tU and listed resources of 177,000 tU. The company plans to extend its interests into rare earths. Its 'strategic partner' is JSC NAC Kazatomprom.

ARMZ remains responsible for uranium mining in Russia. At the end of 2013 it was 82.75% owned by Rosatom and 17.25% TVEL. Exploration expenditure has nearly doubled in two years to about US\$ 52 million in 2008. In 2013 the government approved an exploration budget of RUR 14 billion (\$450 million) through to 2020, principally in the Far East and Northern Siberia. Deposits suitable for ISL mining will be sought in the Transurals, Transbaikal and Kalmykia. Other work will be in the Urals, Siberian, Far East Federal Districts (Zauralsky, Streltsovsky, Vitimsky and Vostochno-Zabaikalsky, and Elkonsky ore regions).

Rosgeologia, the Russian state-run geological exploration services company set up in 2011, has identified "promising" uranium deposits in the North-West Federal District of Russia following completion of a survey of the Kuol-Panayarvinskaya area on the border of the Murmansk region and the Republic of Karelia. It signed an agreement with Rosatom in 2015 to focus on uranium.

CJSC Rusburmash (RBM) is the exploration subsidiary of ARMZ. VNIPIPT is the subsidiary responsible for R&D and engineering of mining and processing plants.

In December 2010 ARMZ made a \$1.16 billion takeover bid for Australia's Mantra Resources Ltd with a prospective Mkuju River project in southern Tanzania, which was expected in production about 2013 at 1400 tU/yr, but is now deferred. This is now under UIH.

2.2. Domestic mining

In 2009 the government accepted Rosatom's proposal for ARMZ and Elkonsky Mining and Metallurgical Combine to set up the "open-type joint stock company" EGMK-Project. The state's contribution through Rosatom to the EGMK-Project authorized capital will be RUR 2.657 billion, including RUR 2.391 billion in 2009 and RUR 0.266 billion in 2010. EGMK-Project is being set up to draw up the project and design documentation for Elkonsky Mining and Metallurgical Combine (see below).

The Russian Federation's main uranium deposits are in four districts:

The Trans-Ural district in the Kurgan region between Chelyabinsk and Omsk, with the Dalur ISL mine.

Streltsovskiy district in the Transbaikal or Chita region of SE Siberia near the Chinese and Mongolian borders, served by Krasnokamensk and with major underground mines.

The Vitimsky district in Buryatia about 570 km northwest of Krasnokamensk, with the Khiagda ISL mine.

The more recently discovered remote Elkon district in the Sakha Republic (Yakutia) some 1200 km north-northeast of the Chita region.

Present production by ARMZ is principally from the Streltsovskiy district, where major uranium deposits were discovered in 1967, leading to large-scale mining, originally with few environmental controls. These are volcanogenic caldera-related deposits. Krasnokamensk is the main town serving the mines.

In 2008 ARMZ said that it intended to triple production to 10,300 tU per year by 2015, with some help from Cameco, Mitsui and local investors. ARMZ planned to invest RUR 203 billion (US\$ 6.1 billion) in the development of uranium mining in Russia in 2008-2015. It aimed for 20,000 tU per year by 2024. Total cost was

projected at RUR 67 billion (\$2 billion), mostly at Priargunsky, with RUR 4.8 billion (\$144 million) there by end of 2009 including a new \$30 million, 500 tonne per day sulfuric acid plant commissioned in 2009, replacing a 1976 acid plant.

2.3. Russian uranium mining

Production centre	2012	2013	2014	2015	2016	2017	2018	2019
Priargunsky	2011	2133	1970	1977	1873	1631		
Dalur	529	562	578	590	591	592		
Khiagda	332	440	442	488	540	693		plan 1000
Gornoye	-	-	0					
Olovskaya	-	-	0					
Elkon	-	-	0					
Lunnoye	-	-	0					
Total	2872	3135	2990	3055	3004	2916		

Trans-Ural, Kurgan region

A modest level of production is from Dalur in the Trans-Ural Kurgan region. This is a low-cost (\$40/kg) acid in situ leach (ISL) operation in sandstones. Uksyanskoye is the town supporting the Dalur mine. ARMZ's 2008 plan had production at Dalur by acid ISL increasing from 350 to 800 tU/yr by 2019 (expanding from the Dalmatovskoye field in the Zauralsk uranium district to Khokhlovskoye in the Shumikhinsky district, then Dobrovolnoye in the Zverinogolovsky district). In 2014 JSC Dalur completed further exploration of the Khokhlovskoye deposit and increased its resources from 4700 to 5500 tonnes. Production from it is planned to increase from 50 tU in 2015 to 200 tU by 2019. A mill upgrade was started in 2016. More than half of 2016 production was from the Ust-Uksyansky part of Dalmatovskoye field.

Dalur 'reserves' in 2013 were quoted by ARMZ at 9,900 tonnes. Rare earths and scandium are potential by-products. In 2016 geological exploration and pilot operations at the Dobrovolnoye deposit were completed, and a permit for development was received in June 2017, allowing construction of the plant. Its reserves are quoted as 7067 tU. After pilot operation to 2020, commercial operation is expected to maintain Dalur production at 700 tU per year to about 2025 after Dalmatovskoye and Khokhlovskoye are exhausted.

Transbaikal Chita region, Streltsovskiy district

Here, several underground mines operated by JSC Priargunsky Industrial Mining and Chemical Union (PIMCU – 85% ARMZ) supply low-grade ore to a central mill near Krasnokamensk. PIMCU was established in 1968, and produces some other metals than uranium. Since 2008 it has been an ARMZ subsidiary. Historical production from Priargunsky is reported to be 140,000 tU (some from open cut mines) and 2011 known resources (RAR + IR) are quoted as 115,000 tU at 0.159%U. In 2013 'reserves' were quoted by ARMZ at 108,700 tonnes. Production is up to about 3000 tU/yr, about one-tenth of it from heap leaching. In 2015 production was 1977 tU and costs were reduced by 11%, so that it hoped to break even in mid-2016.

The company has six underground mines, most of them operating: Mine #1, Mine #2, Glubokiy Mine, Shakhta 6R, Mine #8 with extraction from Maly Tulukui deposit, and Mine #6 (see below). ARMZ's 2008 plan called for Priargunsky's production to be expanded from 3000 to 5000 tU/yr by 2020.

Mine #1 production rate was increased in 2016. It is on the opposite side of the Oktyabrskiy settlement from mine #2 and about 2 km from it.

Mine #2 was making a loss in 2013 due to market conditions, so it was closed in order to concentrate on bringing mine #8 to full production. Stopping operations resumed in February 2015, with production target 130 tU for the year, from average grade 0.15%. It is now known as section 2 of mine #8. Some production has been exported to France, Sweden and Spain.

Mine #8 began producing in 2011, towards phase 1 target capacity of 400 t/yr by the end of 2014. The total cost of development is expected to be RUR 4.8 billion (RUR 3.5 billion for phase 1). Production was increased 22% in 2016.

Mine #6 will access the Argunskoye and Zherlovoye deposits which comprise 35% of the Streltsovskoye reserves of 40,900 tU, with much higher grade (0.3%U) than the rest. Production cost from mine #6 is projected at \$90/kgU. Future plans for Priargunsky are focused on development of mine #6.

Buryatia, Vitimsky district

JSC Khiagda's operations are at Vitimsky in Buryatia about 570 km northwest of Krasnokamensk, serving Priargunsky's operations in Chita region, and 140 km north of Chita city. They are starting from a low base – in 2010 production from the Khiagdinskoye ore field was 135 tU, rising to 440 tU in 2013 (fully utilising the pilot plant) and targeting 1000 tU/yr from 2018 with a new plant. These are a low-cost (US\$ 70/kgU) acid in situ leach (ISL) operations in sandstones, and comprise the only ISL mine in the world in permafrost. Groundwater temperature is 1-4°C, giving viscosity problems, especially when winter air temperature is -40°C. The main uranium mineralisation is a phosphate, requiring oxidant addition to the acid solution. In the Khiagdinskoye field itself there are eight palaeochannel deposits over 15 x 8 km, at depths of 90 to 280 metres (average 170 m). Single orebodies are up to 4 km long and 15 to 400 m wide, 1 to 20 m thick.

JSC Khiagda has resources of 55,000 tU amenable to ISL mining, with resource potential estimated by Rosatom of 350,000 tU, giving a mine life of over 50 years. In 2015 'reserves' were quoted by ARMZ at 39,300 tonnes U. The 2008 ARMZ plan envisaged production from JSC Khiagda's project increasing to 1800 tU/yr by 2019, but in 2013 the higher target was postponed. The 2018 plan is now 1000 tonnes. In 2014 JSC Khiagda continued construction of the main production facility and on the sulfuric acid plant, the first stage of which was commissioned in September 2015. Its final design capacity is 110,000 t/yr.

JSC Khiagda is currently mining uranium from the Khiagdin and Istochnoy deposits of the Khiagda ore field. Preparatory work for mining operations at the Vershinsky deposit is under way. In May 2018, JSC Khiagda announced that engineering and geological surveys ahead of the construction of mining facilities was under way at Kolichikan and Dybryn deposits. The other two fields in the immediate vicinity are Namaru and Tetrakhskoye. All these deposits occur over an area about 50 x 20 km. There are also plans to install plant for extracting rare earth oxides (REO) as by-product. The nearest towns are Romanovka, 133 km north of Chita, and Bagdarin.

Sakha/Yakutia, Elkon district

ARMZ's long-term hope is development of the massive Elkon project with several mines in the Sakha Republic (Yakutia) some 1200 km north-northeast of the Chita region. The Elkon project is in a mountainous region with difficult climate conditions and little infrastructure, making it a challenging undertaking. Production from metasomatite deposits is planned to ramp up to 5000 tU/yr over ten years, for RUR 90.5 billion (\$3 billion), and 2020 start up was envisaged, but this is now "after 2030". Elkon is set to become Russia's largest uranium mining complex, based on resources of over 270,000 tU (or 357,000 tU quoted by Rosatom in 2015). It will involve underground mining, radiometric sorting, milling, processing and uranium concentrate production of up to 5000 tU/yr.

Elkon Mining and Metallurgical Combine (EMMC) was set up by ARMZ to develop the substantial Elkonsky deposits. The Elkon MMC project involves the JSC Development Corporation of South Yakutia and aims to attract outside funding to develop infrastructure and mining in a public-private partnership, with ARMZ holding 51%. Foreign equity including from Japan, South Korea and India is envisaged, and in March a joint venture arrangement with India was announced. The Elkon MMC developments are to become "the locomotive of the economic development of the entire region", building the infrastructure, electricity transmission lines, roads and railways, as well as industrial facilities, from 2010. Of 15 proposed construction sites, three have been tentatively selected: at the mouth of Anbar River, Diksi Village and Ust-Uga Village. The building of four small floating co-generation plants to supply heat and electricity to northern regions of Yakutia is linked with the Elkon project in southern Yakutia.

There are eight deposits in the Elkon project with resources of 320,000 tU* (RAR + IR) at average 0.146%U, with gold by-product: Elkon, Elkon Plateau, Kurung, Neprokhodimoye, Druzhnoye (southern deposits), as well as Yuzhnaya, Severnaya, Zona Interesnaya and Lunnoye (see below). In mid-2010 ARMZ released JORC-compliant resource figures for the five southern deposits: 71,300 tU as measured and indicated resources, and 158,500 tU as inferred resources, averaging 0.143%U. ARMZ pointed out that the resource assessment against international standards will increase the investment attractiveness of EMMC. However, in September 2011 ARMZ said that production costs would be US\$ 120-130/kgU, which would be insufficient in the current market, and costs would need to be cut by 15-20%.

2.3. Further mine prospects

The Federal Subsoil Resources Management Agency (Rosnedra) was transferring about 100,000 tonnes of uranium resources to miners, notably ARMZ, in 2009-10, and 14 projects, mainly small to medium deposits, were prepared for licensing then. They are located mainly in the Chita (Streltsovskiy district), Trans-Ural (Zauralskiy district) and Buryatia (Vitimskiy district) uranium regions.

The projects prepared for licensing include:

Chita Oblast – Zherlovskoye, Pyatiletnee, Dalnee and Durulguevskoye.

Republic of Buratiya – Talakanskoye, Vitlausskoye, Imskoye, Tetrakhskoye, and Dzhilindinskoye.

Kurgan Oblast – Dobrovolnoye (now licensed).

Khбаровsk Krai – Lastochka.

Republic of Tyva – Ust-Uyuk and Onkazhinskoye.

Republic of Khakassia – Primorskoye.

All together these projects have 76,600 tonnes of reasonably assured and inferred resources, plus 106,000 tonnes of less-certain 'undiscovered' resources.

Rosnedra published a list of deposits in the Republic of Karelia, Irkutsk Region and the Leningrad Region to be offered for tender in 2009. In particular, Tyumenskiy in Mamsko-Chuiski District of Irkutsk Region was to be offered for development, followed by Shotkusskaya ploshchad in Lodeinopolskiy District of Leningrad Region. In Karelia Salminkskaya ploshchad in Pitkyaranskiy District and the Karku deposit were offered. None of these 2009 offerings had reasonably assured or inferred resources quoted, only 'undiscovered' resources in Russia's P1 to P3 categories and it appears that none were taken up. In 2016 the Karelia Ministry of Natural Resources and Ecology acknowledged only one uranium deposit "of no commercial interest" at Srednyaya Padma (Medvezhegorsk District) and announced that no mining was planned.

2.4. Foreign and private equity in uranium mining

In October 2006 Japan's Mitsui & Co with Tenex agreed to undertake a feasibility study for a uranium mine in eastern Russia to supply Japan. First production from the Yuzhnaya mine in Sakha Republic (Yakutia) is envisaged for 2009. Mitsui had an option to take 25% of the project, and was funding \$6 million of the feasibility study. Construction of the Yuzhnaya mine was estimated to cost US\$ 245 million, with production reaching 1000 tU/yr by 2015. This would represent the first foreign ownership of a Russian uranium mine. However, according to the 2016 Red Book, Yuzhnaya now appears to be part of the Elkon project (see above).

Following from previous deals with Tenex, in November 2007 Cameco signed an agreement with ARMZ. The two companies are to create joint ventures to explore for and mine uranium in both Russia and Canada, starting with identified deposits in northwestern Russia and the Canadian provinces of Saskatchewan and Nunavut.

In addition to ARMZ, private companies may also participate in tenders for mining the smaller and remote uranium deposits being prepared for licensing in Russia. ARMZ is open to relevant investment projects with strategic partners, and Lunnoye deposit is an example where a private company Zoloto Seligdara is partnering with ARMZ.

2.5. Conversion

Russia's total uranium conversion capacity is about 25,000 tU/yr, but only about half of this is used as of 2013.

TVEL plans to consolidate its conversion capacity at JSC Siberian Chemical Combine (SCC) at Seversk near Tomsk, where some capacity already operates. In 2012 Rosatom said it would spend RUR 7.5 billion to set up a new conversion plant at SCC Seversk, to commence operation in 2016. The new plant is designed to have a capacity of 20,000 tU per year from 2020, including 2000 t of recycled uranium. Public hearings on the project were under way in 2014. The 2015 edition of the World Nuclear Association Nuclear Fuel Report gives capacity then as 12,500 tU.

The main operating conversion plant has been at Angarsk near Irkutsk in Siberia, with 18,700 tonnes U/yr capacity – part of TVEL's JSC Angarsk Electrolysis & Chemical Combine (AECC). In anticipation of the planned new plant at SCC Seversk however, the Angarsk conversion plant was shut down in April 2014.

TVEL also had conversion capacity at Kirovo-Chepetsky Chemical Combine (KCCC) in Glazov, which was shut down in the 1990s. Since 2009 this has been a RosRAO site, for clean-up

The Elektrostal conversion plant, 50 km east of Moscow, has 700 tU/yr capacity for reprocessed uranium, initially that from VVER-440 fuel. It is owned by Maschinostroitelny Zavod (MSZ) whose Elemash fuel fabrication plant is there. Some conversion of Kazakh uranium has been undertaken for west European company Nukem, and all 960 tonnes of recycled uranium from Sellafield in UK, owned by German and Netherlands utilities, has been converted here. UK-owned recycled uranium has also been sent there.

2.6. Uranium fuel fabrication

TVEL has two fuel fabrication plants with combined capacity of 2800 t/yr finished fuel:

The huge Maschinostroitelny Zavod (MSZ) at Elektrostal 50 km east of Moscow – known as Elemash.

Novosibirsk Chemical Concentrates Plant (NCCP) in Siberia.

TVEL's Chepetsk Mechanical Plant (CMP or ChMZ) near Glazov in Udmurtiya makes zirconium cladding and also some uranium products.

Most fuel pellets for RBMK and VVER-1000 reactors were being made at the Ulba plant at Ust Kamenogorsk in Kazakhstan,

but Elemash and Novosibirsk have increased production. MSZ/Elemash produces fuel assemblies for both Russian and west European reactors using fresh and recycled uranium. It also fabricates research reactor and icebreaker fuel and in 2016 is producing the first fuel for the RITM-200 reactors in new icebreakers. VNIINM claims the fuel has greater energy density than previous icebreaker fuel.

Novosibirsk produces mainly VVER-440 & 1000 fuel, including that for initial use in China.

2.7. Regulation and safety

Two main laws govern the use of nuclear power: the Federal Law on the Use of Atomic Energy (November 1995 and Federal Law on Radiation Safety of Populations (January 1996). These are supported by federal laws including those on environmental protection (2002) and the Federal Law on Radioactive Waste Management (2011). The 1996 Federal Law on Radiation Safety of Populations is administered by the Federal Ministry of Health.

Rostekhnadzor is the regulator, set up (as GAN) in 1992, reporting direct to the President. Because of the links with military programs, a culture of secrecy pervaded the old Soviet nuclear power industry. After the 1986 Chernobyl accident, changes were made and a nuclear safety committee established. The State Committee for Nuclear and Radiation Safety – Gosatomnadzor (GAN) succeeded this in 1992, being responsible for licensing, regulation and operational safety of all facilities, for safety in transport of nuclear materials, and for nuclear materials accounting. Its inspections can result in legal charges against operators. However, on some occasions when it suspended operating licences in the 1990s, Minatom successfully overrode this. In 2004 GAN was incorporated into the Federal Ecological, Technological & Atomic Supervisory Service, Rostekhnadzor, which has a very wide environmental and safety mandate. It has executive authority for development and implementation of public policy and legal regulation in the environmental field, as well as in the field of technological and nuclear supervision. It controls and supervises natural resources development, industrial safety, nuclear safety (except for weapons), safety of electrical networks, hydraulic structures and industrial explosives. It licences nuclear energy facilities, and supervises nuclear and radiation safety of nuclear and radiologically hazardous installations, including supervision of nuclear materials accounting, control and physical protection. A 2011 overview is on IAEA website.

Safety has evidently been improving at Russian nuclear power plants. In 1993 there were 29 incidents rating level 1 and higher on the INES scale, in 1994 there were nine, and since then to 2003, no more than four. Also, up until 2001 many employees received annual radiation doses of over 20 mSv, but since 2002 very few have done so.

In 2008 Rostekhnadzor was transferred to the Ministry of Natural Resources and the Environment, but this was reversed in mid 2010 and it was brought back under direct control of the government and focused on civil nuclear energy. Following other changes in federal legislation, an IAEA Integrated Regulatory Review Service (IRRS) mission in 2013 said that Rostekhnadzor had made "significant progress" in its development since 2009 and had "become an effective independent regulator with a professional staff". Rostekhnadzor undertook to make the final IRRS report early in 2014 public.

Glavgosexpertiza, the Russian State Expert Examination Board, is the authority responsible for appraising design documentation and engineering services on behalf of the Ministry of Construction of Russia. Glavgosexpertiza ensures compliance of all major infrastructure construction projects with national technical regulations and statutory requirements.

Rosprirodnadzor, the Federal Service for Supervision of Natural Resources needs to give environmental approval to new projects, through its State Environmental Commission.

2.8. Exports:

fuel cycle

Soviet exports of enrichment services began in 1973, and Russia has strongly continued this, along with exports of radioisotopes. After 1990, uranium exports began, through Technobexport (Tenex). At 2015 Atomexpo it was announced that at the start of the year Rosatom's foreign portfolio totaled US\$ 101.4 billion, of which \$66 billion was reactors, \$21.8 billion was the contracted sales of EUP and SWU, and the remaining \$13.6 billion was attributable to the sales of fabricated fuel assemblies and uranium. Rosatom's goal is to gain half its revenue from exported goods and services.

Tenex expects to increase its share in the global market for front-end fuel cycle services to 40% by 2030, assisted by offering an 'integrated product' covering the entire nuclear fuel cycle, and to contribute up to half of Rosatom's foreign currency revenue. Tenex revenue in 2014 was over \$2.2 billion, and forward orders totalled almost \$23 billion, including almost \$6 billion in over 20 contracts with US utilities for enriched uranium product. Tenex sees the Asia-Pacific market as a growth area, using a new transport route through Vostochny Seaport, Primorye Territory.

In 2009 Tenex signed long-term enrichment services contacts with three US utilities – AmerenUE, Luminant and Pacific Gas & Electric – and one in Japan – Chubu. The contracts cover supply from 2014 to 2020. Then it contracted to supply enriched uranium product over the same period with Exelon, the largest US nuclear utility. By the end of 2010, the value of contracts with US companies rose to about \$4 billion, beyond the diluted ex-military uranium already being supplied to 2013 from Russian weapons stockpiles. In 2012, Tenex supplied about 45% of world demand for enrichment services and 17% of that for fabricated fuel. It exported fuel for 34 reactors as well as supplying 33 Russian ones.

general, plants and projects

Russia is engaged with international markets in nuclear technology, well beyond its traditional eastern European client states. An important step up in this activity was in August 2011 when Rosatom established Rusatom Overseas company, with authorized capital of RUR 1 billion. In mid-2015 it was split into JSC Rusatom Overseas Inc. and JSC Rusatom Energy International.

Rusatom Overseas Inc is responsible for implementing non fuel-cycle projects in foreign markets, though apparently it also promotes products, services and technologies of the Russian nuclear industry generally to the world markets. According to Rosatom, "Rusatom Overseas acts as an integrator of Rosatom's complex solutions in nuclear energy, manages the promotion of the integrated offer and the development of Russian nuclear business abroad, as well as working to create a worldwide network of Rosatom marketing offices." Rusatom Overseas planned to open some 20 offices around the world by 2015, as a market research front and shop window for all Rosatom products and services.

Rusatom Energy International acts "as a developer of Rosatom's foreign projects, which are implemented with the build-own-operate (BOO) structure" and is a shareholder in those project companies. One of the first projects that Rosatom is implementing using the BOO structure is the Akkuyu plant in Turkey. A second project is Hanhikivi in Finland.

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\$6.4 billion, up 20% from 2014. Rosatom's goal is to gain half its revenue from exported goods and services. Its long-term strategy, approved by its board in late 2011, calls for foreign operations to account for half of its business by 2030. It aims to hold at least one-third of the global enrichment services market by then, as well as 5% of the market for pressurized water reactor (PWR) fuel. The corporation said that it is "actively strengthening its position abroad for the construction of nuclear power plants." In April 2015 Rosatom said that it had contracts for 19 nuclear plants in nine countries, including those under construction (5). In September 2015 it said it had orders for 30 nuclear power reactors in 12 countries, at about \$5 billion each to construct, and it was negotiating for 10 more. It said that the total value of all export orders was \$300 billion. It aims to have orders for the construction of some 30 power reactors outside of Russia by 2030.

International collaboration

Russia is engaged with international markets in nuclear energy, well beyond its traditional eastern European client states. In June 2011 Rosatom announced that it was establishing Rusatom Overseas company, a new structure to be responsible for implementing non fuel-cycle projects in foreign markets. It could act as principal contractor and also owner of foreign nuclear capacity under build-own-operate (BOO) arrangements. It is vigorously pursuing markets in developing countries and is establishing eight offices abroad.

President Putin's Global Nuclear Infrastructure Initiative was announced early in 2006. This is in line with the International Atomic Energy Agency (IAEA) 2005 proposal for Multilateral Approaches to the Nuclear Fuel Cycle (MNA) and with the US Global Nuclear Energy Partnership (GNEP). The head of Rosatom said that he envisages Russia hosting four types of international nuclear fuel cycle service centres (INFCCs) as joint ventures financed by other countries. These would be secure and maybe under IAEA control. The first is an International Uranium Enrichment Centre (IUEC) – one of four or five proposed worldwide (see separate section). The second would be for reprocessing and storage of used nuclear fuel. The third would deal with training and certification of personnel, especially for emerging nuclear states. In this context there is a need for harmonized international standards, uniform safeguards and joint international centers. The fourth would be for R&D and to integrate new scientific achievements.

In March 2008 AtomEnergProm signed a general framework agreement with Japan's Toshiba Corporation to explore collaboration in the civil nuclear power business. The Toshiba partnership is expected to include cooperation in areas including design and engineering for new nuclear power plants, manufacturing and maintenance of large equipment, and "front-end civilian nuclear fuel cycle business". In particular the construction of an advanced Russian centrifuge enrichment plant in Japan is envisaged, also possibly one in the USA. The companies say that the "complementary relations" could lead to the establishment of a strategic partnership. Toshiba owns 77% of US reactor builder Westinghouse and is also involved with other reactor technology.

Regarding reactor design, Rosatom has said it is keen to be involved in international projects for Generation IV reactor development and is keen to have international participation in fast neutron reactor development, as well as joint proposals for MOX fuel fabrication.

3. Conclusions:

1. There are large uranium reserves in the Russian Federation, which represents more than 10% of the world's reserves, there are new promising areas that are testing the territory and developing uranium mines;
2. ARMZ is one of the largest operators in the world for the extraction of uranium and it has assets and owns many foreign

enterprises of the mining industry. Russia is among the leading countries in the processing of uranium and is one of the key players in the global market for nuclear fuel and nuclear materials.

3. Russia's total capacity for uranium conversion is about 25,000 tons / year, but only about half of this volume is used as of 2016. TVEL has two fuel production plants with a total capacity of 2,800 tons / year of finished fuel. It supports more than 80 nuclear power plants in Russia and abroad with fuel;

4. Russia is a nuclear-weapon state and the depositary state of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), in accordance with which the safeguards agreement has been in effect since 1985. The Additional Protocol was ratified in 2007. Safety at Russian nuclear power plants is obviously improving. Significantly higher is the maintenance personnel's skill and regulatory requirements for processing and preservation.

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