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Plutonium *Investigation*

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Russia's plutonium legacy - whether seen as an asset as the nuclear industry and many in Government still see it, or as a very expensive and dangerous liability, as critics characterise it - exists as a direct result of some bold but risky decisions by the former Soviet high command to match the United States in nuclear weaponry in the 1940s. All that has happened since in plutonium developments in the former Soviet Union, and now the Russian Federation (RF), may be traced to the atomic arms race, and super power military and economic competition. It is no coincidence that Russia has an entire government department - Minatom - the Ministry of Atomic Energy, dedicated to exploitation of nuclear energy.

In light of the hundreds of billions of dollars spent since the late 1940s on the construction of plants to manufacture and store plutonium, and fabricate it into warheads, which matches the expenditure on health

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and social welfare in the Soviet Union/RF, it is ironic that the RF is now increasingly dependent on its former military enemy, the U.S., to find the funding for expertise and technology to deal with plutonium today.

It is possible to say that in a very real way plutonium has penetrated the soul of Russia, so persistent is this nuclear explosive material in the environment, in people's bodily tissues, in the government's - if not necessarily the nation's - energy plans and in the fabric of Russia's developing commercial and security relations with western countries. It is separating out these inter-linked plutonium puzzles that this issue of Plutonium Investigation tries to achieve.

Plutonium and Nuclear Warhead production

While our map on pages 9-10 and the legend of Who's Who on page 13 give the bare details of the most important (known) nuclear installations plus institutions, some historical and infrastructural context is required to grasp the extensive and complex network that makes up the Russian plutonium programme, which is perhaps even more complicated than that in the US. The authors of the most accessible and detailed public study of the plutonium situation in Russia (hereafter JPRS, see ref. 1) stress that the problems of plutonium for Russia have a nation-wide scale. This is the direct result of the policy of the leadership of the former Soviet Union to build its atomic research and development infrastructure across the vast expanse of the country, which made many production plants essentially invisible both to Soviet citizens and the nation's ideological enemies in the West. Plutonium was created in the former Soviet Union in the late 1940s, only a few years after Glenn Seaborg first isolated it in the US. The first Soviet nuclear device, using plutonium, was exploded at a test site in Semipalatinsk, in what is now Kazakstan in 1949. The feed material for the weapon was created at a nuclear complex in Chelyabinsk Oblast in the Urals.

The Soviet atomic authorities - called the Ministry of Medium-Sized Machines (MMMB) to protect its true identity - went on to build thirteen industrial scale plutonium-production reactors, utilising a design encompassing graphite-cooled, water moderated 'channel' type reactors - five at Chelyabinsk, five more at Tomsk in Siberia, and a further three at Krasnoyarsk, even further East. JPRS records that various estimates put the plutonium production output of these reactors collectively at 140-180 metric tonnes ie enought to make between 34,000-45,000 warheads. Presently three of these reactors are still in operation, one at Tomsk, two at Krasnoyarsk, primarily to provide district and industrial heat to their neighboring cities, which suffer particularly severe winters. But they also continue to create collectively about two tonnes of 'excellent' weapons-grade plutonium a year as an unavoidable by-product of normal operation.

Joint US-Russia Plutonium Disposition Statement Moscow, 1 September 1998

"Progress in nuclear arms control has allowed the U.S. and Russia to reduce greatly the number of nuclear weapons in their arsenals. Presidents Clinton and Yeltsin today took a major step forward to ensure that these reductions are permanent and irreversible. They agreed today on the concrete steps to ensure that plutonium recovered from dismantled weapons will not find its way into the hands of terrorists or third countries seeking to build nuclear arms.

The U.S. and Russia each pledged to remove from their weapons programs and some 50 metric tons of plutonium each -- enough to make thousands of weapons -- so that it can never be used again in nuclear weapons. The Presidents agreed on principles to guide implementation of this conversion by building industrial-scale facilities in both countries. The disposition of the plutonium will be carried out either by consuming the plutonium as fuel in existing civil nuclear reactors or through mixing the plutonium with high-level radioactive waste and storing it in a long-term spent fuel repository. Appropriate transparency and international verification measures will apply to this program, as will stringent standards of safety, environmental protection, and material protection, control and accounting.

This program will build on the Agreement on Scientific and Technical Cooperation in the Management of Plutonium signed by Vice President Gore and then Prime Minister Kiriyenko in July 1998, as well as extensive ongoing cooperative research involving laboratories and scientists in both countries.

U.S.-Russian cooperation on plutonium disposition will be carried out in close cooperation and coordination with parallel efforts involving Russia and other G-8 countries. The Presidents directed their experts to initiate negotiations to transform these agreed principles into bilateral agreement that will lay out the concrete steps for plutonium disposition and govern their future cooperation in this area. President Clinton and President Yeltsin agreed to begin negotiations for this bilateral agreement promptly, with the intention of completing the agreement by the end of 1998."

(Source: White House media briefing

1 V.G. Vorobyiv, A.M. Dmitriyev, A.S. Dyakov, L. Popova, Yu. I. Yershov, D.P. Osanov "Plutonium In Russia: Ecology, Economics, Policy", published as a special edition of Arms Control & Proliferation Issues (JPRS report-TAC-95-005-L, February 1995)

In this report Plutonium Investigation has used the original reference names of the nuclear plants and sites. Many have been renamed since the Russian Federation was re-established as an independent state following the break-up of the former Soviet Union. The new names are listed alongside the former names in the box on installations on page 8

In the former Soviet Union the nuclear weapons production process involved dozens of different organizations in their development, design, and manufacture. The central body was the State Committee for Atomic Energy, supported by two ministries, one to build, the other to operate nuclear plants - and this remains under the Russian Federation - except that the central body has been renamed the Ministry of Atomic Energy, commonly called Minatom.

The two key operational institutes are: the all-Russian Scientific Institute of Experimental Physics, at Arzamas-16, located in Nizhegorodskaya oblast between Moscow and Chelyabinsk; and the All-Russian Scientific Research Institute of Technical Physics, at Chelyabinsk. They supported the production of nuclear warheads at least four sites located at Arzamas, Zlatoust-36, Penza-19, and Sverdlovsk-45, each of which were 'closed cities', secret sites whose existence was not widely known, and access to which was strictly controlled. The independent Washington DC-based Natural Resources Defense Council (NRDC) has estimated that the total warhead production capacity of these plants was around 7,000 a year.

In total there were ten closed cities involved in the nuclear research and production programme. Aside from the four listed above, Chelyabinsk-65 and -70, Krasnoyarsk-26 and-45, plus Tomsk-7 and Sverdlovsk-44 were central to the nuclear programmes, military and civil, since their construction between 44 and 54 years ago. Regarding plutonium specifically, the key plants are Chelyabinsk-65, Krasnoyarsk-26 and Tomsk-7 all of which have roles in plutonium production and reprocessing.

According to Alexander Bolsunovsky[2], based on different estimates: "Russia possesses now no less than 30,000 nuclear warheads. Russian-American agreements stipulate that each signatory should have not more than 5,000 nuclear warheads by the year 2000. Therefore the major part of the warheads is to be dismantled. This is already being done at the same plants, which once produced these warheads. For a long time location of these plants was kept secret in Russia but recently it became known that nuclear warheads are produced in cities Ekaterinburg-45, Penza-19 and Zlatoust-36. After dismantling of warheads, fuel pellets 'yields' are extracted (highly enriched uranium-235, which may be produced in Ekaterinburg-44, Krasnoyarsk-45, Angarsk and Tomsk-7".

According to Mr. Mikhailov, former head of Minatom, the total stock of highly enriched uranium was of about 1,200 tonnes of which 500 tonnes are in the process of being sold to the U.S.

Weapon grade plutonium was earlier produced in Chelyabinsk-40 and is still generated in Krasnoyarsk-26 and Tomsk-7 reactors. The spent fuel continues to be reprocessed because the aluminum cladding poses significant long term storage problems. Weapon plutonium shall be stored at Krasnoyarsk as dioxide. "Inadequate investments" states Bolsunovsky, "and absence of the project of a storage facility detain the construction. Today's conditions of weapon plutonium storage pose a serious risk."

Unlike the United States, initially Minatom was not interested in construction of a long term plutonium store, and dismantled weapon plutonium will be kept in temporary storage in the form that allows its fast use as fuel. Temporary stores of weapon plutonium are situated at the sites where in future there are planned to be - or are already being constructed - plants for MOX production. An analogous plant called "Complex-300" or "Shop-300", with an annual capacity of roughly 100 tonnes of MOX or 5 to 6 tonnes of plutonium throughput, is under construction at the industrial association 'Mayak' in Chelyabinsk-40. Building started in 1984 but was interrupted several times for lack of resources. Another plant for MOX fuel production with an annual through put of 100 to 300 tonnes of MOX had been planned at the Mining Chemical Combine in Krasnoyarsk-26. Stores of fissionable materials, plants for production of MOX fuel and plants for fast reactor fuel reprocessing pre-suppose nuclear plants which will use MOX fuel.

They could include the South Urals' fast breeder reactor BN-600 or the BN-800 which is under construction in Chelyabinsk-40 since 1985 (with uncertain chances of being completed). More recently, in particular VVER-1000 have been mentioned for MOX use: Kalinin-1 and -2, Balakov-1 to -4 currently in operation and Rostov-1 and -2 currently under construction. However, none of the VVER-1000 reactors have ever operated with MOX fuel and they do not have an appropriate license for such use. Weapon-derived plutonium is not going to be used as MOX fuel for some considerable time. Storage of dozens tonnes of weapons plutonium, of 30 tonnes or more of reactor plutonium for at least 15-20 years under conditions which allow their re-use, poses a real challenge to the international non-proliferation regime.

The use of MOX fuel, as shown by various studies - and in particular by the International MOX Assessment (IMA)[3] - reduces the safety margin in a nuclear plant. A development which should be very carefully analysed before making any firm decisions on MOX fuel use in reactors already having caused significant concern over their safety in the past.

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2 Institute of Biophysics, Krasnoyarsk Yadernyi Kontrol in "Nuclear Control" of 24 December 1996 in a study on 'Ways to Use Nuclear Materials after Warheads are Dismantled'.

3 J. Takagi et al., "Comprehensive Social Impact Assessment of MOX Use in Light Water Reactors" (IMA), CNIC, Tokyo, November 1997

Russia to Convert Three Plutonium Production Reactors by ENS (Environmental News Service)

In Moscow on September 24, 1997, Russian Federation Prime Minister Viktor Chernomyrdin and United States Vice President Al Gore wound up phase one of the ninth meeting of the U.S.-Russian Joint Commission on Economic and Technical Cooperation with the announcement that Russia would halt the production of plutonium at three of its reactors by the end of the year 2000. Actual conversion is expected to begin in 2000.

A major breakthrough of the Commission meeting, Gore said at a news conference, was that "after much hard work we took an important, perhaps even historic step this week when we reached agreement to halt the production of weapons-grade plutonium both in the United States and Russia."

The pact marked the first time that the U.S. and Russia had placed limits on the materials for nuclear warheads themselves rather than on their delivery vehicles such as missiles and bombers, as in the START and INF treaties.

Other such reactors that Russia is not currently using must remain permanently closed down. The U.S. has promised to provide some funding for the Russian halt of plutonium production. The U.S. Department of Defense will be providing technical assistance relating to the conversion of the cores of those three reactors to Minatom.

The reactors to be converted to civilian use are: ADE-4, ADE-5 (near the city of Seversk in the Tomsk Region) and ADE-2 (near city of Zheleznogorsk in the Krasnoyarsk Region). After the completion of the core modifications, these reactors will permanently cease operation at the end of their normal lifetimes.

In its negotiations on the reactor conversions the Gore-Chernomyrdin Commission took into account three important considerations. First, the two sides expressed their desire to cooperate with each other to prevent the accumulation of "excessive" stocks of plutonium and to reduce them in the future.

Next, they recognized that they were able to work constructively together with the knowledge of the intent of the government of the Russian Federation to take out of operation three operating reactors that produce plutonium. Because the three reactors provide heat and electricity to regions of Siberia where they are located, the Russian Federation intends to create alternative sources of heat and electricity to replace that presently supplied by the three reactors. Once each reactor is modified, it will utilize an alternative type of fuel including uranium derived from dismantled nuclear weapons.

The agreement also states that plutonium produced after December 31, 2000 at the three reactors, and any high-enriched uranium recovered from spent fuel discharged from the modified reactors, shall not be used in nuclear weapons.

In order to ensure the possibility of taking the three reactors the Russians will undertake to create alternative sources of thermal and electrical energy to replace these reactors by the time of their final shutdown. To assist this effort, the U.S. will encourage private sector participation in the creation of replacement sources of energy.

The total cost of the plutonium reactor conversion project is estimated to be US$150 million, divided between the U.S. and the Russian Federation. The U.S. was authorized to spend up to US$10 million in FY (fiscal year) 97 and, based on the meeting of appropriate project milestones with future congressional authorization providing up to an additional US$70 million on this project.

"I would like to talk specifically about cooperation in the field of conversion," the Russian Prime Minister said. "We came to the conclusion that this requires a broader approach in order to make a breakthrough in cooperation based on high technologies most of which - and I don't think I will be telling you a secret - have double uses."

(Source: ENS)

Nuclear Power production

The nuclear power generation programme grew out of the weapons production programme in the early 1950s. In fact the world's first nuclear generated electricity connected to a grid came from the AM-1 (Atom Mirny-peaceful atom) reactor at Obninsk, based at the Institute of Physics and Power Engineering, in 1954. Ten years later the two first reactors in Novovoronezh plant had capacities of 210 MWe and 365 MWe respectively, and two first reactors in Beloyarsk had 100 MWe and 200 MWe respectively. All four are shut down. Another experimental reactor was opened at Dimitrovgrad in 1969, but the first industrial scale nuclear power came from the second unit at Novovorenezh, commissioned in 1971. Since then the Soviet, now Russian, nuclear power plant programme has grown rapidly.

At present there are 29 reactors based on nine sites, eleven of which are 1,000 MWe RBMKs (the Chernobyl type-graphite moderated, water-cooled, channel plant); four are the smaller graphite moderated light water reactors (12 MWe each), one is a fast breeder reactor (BN-600); and the remainder are variations on the VVER pressurised water reactor, four first generation (VVER-440/230s capacity), two second generation VVER-440s, and seven of the larger output VVER-1000s. At the beginning of 1999 there were a further 12 nuclear plants officially under construction. However, most of these plants are highly unlikely to ever be completed (like the four 800 MWe fast breeder reactors listed...). Since 1990, only one reactor has come on line.

In 1998, the 29 nuclear power plants produced 103.5 TWh (billion kWh), hardly more than a quarter of the 58 French nuclear power plants and 4.4% down from 1997. Availability has been down by another 2.6% to reach 55.6%.

Last summer the then Russian prime minister, Sergei Kiriyenko, signed a decree which confirmed the nuclear power development programme outlined by the former government in 1997. The plan was adopted without any significant changes, although the budget allocated through 2005 was reduced by some US$800 million to US$8.5 billion. Given the programme to increase Russia's installed nuclear capacity from 1997's 21.24 GWe to 24.2 GWe in 2000 and 27.6 GWe by 2005, this represents about 7% of the estimated required funding. It remains unclear where the remaining funds would come from. Further increases outlined in the plan estimate 29.2 GWe of capacity by 2010, with the total national share of electricity provided by nuclear reaching a tentative 20% to 30% by 2030.

In autumn 1998 the Russian nuclear operators faced chronic financing difficulties, which led to maintenance cut backs, along with inability to pay for fresh fuel. The fuel fabricator, TVEL, was owed between US$20 million to US$43m by the plant operators Rosenergoatom (REA), the Russian nuclear power operating company, at the height of the payment crisis. In July 1998 the Russian government ordered REA to be restructured to deal with an escalating debt problem of over US$50m. Minatom and the national grid company, Unified Energy Systems of Russia (RAO-EES) were charged with the task. Last October the Russian lower house of Parliament (Duma) launched a unique inquiry into the appointment of a new director-general of REA, who had power generation experience, but none with nuclear operation. It is the first time legislators have thought it necessary to investigate a senior Minatom appointment. On top of this, on 10th December 1998 Nuclear Power Minister Yevgeny Adamov called for a criminal investigation into corruption and embezzlement at REA. Adamov said he had sent a letter to Prosecutor General Yury Skuratov in October 1998, asking him to look into the theft of millions of dollars from REA.

Spent Fuel and Plutonium

Although definitive figures are difficult to verify, it is reported that the current annual spent fuel arisings from Russia's 29 reactor units are roughly 790 MTHM. Similarly it is difficult to obtain definitive figures for plutonium creation in the power production reactors now operated by REA. The JPRS authors say that about 30 tonnes of reactor grade (in Russian parlance, 'energy grade') plutonium had been produced in the RBMK channel-type reactors as of the end of 1992; and that over the entire lifetime of these reactors about 175 tonnes of plutonium created in these reactors will have accumulated. They also estimate that the VVER reactors would have created about 18 tonnes of plutonium up to the time of publication in early 1993. They conclude that up to that point about 80 tonnes of fuel grade plutonium had been created in power generating commercial scale reactors.

At the end of 1998 Minatom made public its desire to raise funds to support the construction of the plutonium breeder based on the BN-800 design at

Mayak, following the decision by the nuclear regulator Gosatomnadzor to issue a construction license for the two-unit plant in November 1998. Limited site preparation for the Urals breeder project has been underway since the 1980s.

The U.S. Department of Energy under a contract with Amarillo National Resource Center for Plutonium is jointly working with the Russian Institute of Physics and Power Engineering on technical ways to develop the BN-800.

The JPRS authors suggest that the 100 tonnes of plutonium of all grades available for fuel use is the energy equivalent of "roughly the six-month volume of coal extracted in the former USSR on the 1980 level." It has also been argued by Minatom that the BN-800 at Mayak would use cooling water from one of the reservoirs built on the Techa river to keep radioactivity in sediments, by this to increase evaporation, which in turn is expected to lower the water level from the reservoir and prevent it from overflowing the dam, which separates a cascade of reservoirs from the cleaner part of Techa.

Nuclear Reactor Exports

Over the past few years Russia has been involved in attempts to sell nuclear power plants to India - controversially in the wake of the Indian nuclear bomb tests in May 1998. Russia found that its attempts to raise US$15 billion 'bailout' from the International Monetary Fund for non power related investments, were challenged by the US because of Minatom's insistence in pressing ahead with Indian nuclear exports deal, which would involve US$2.5 billion below-market financing by Russia for 85% of the work. Other controversial reactor export deals involve Iran, for which Minatom agreed in November 1998 to prepare technical documentation related to three new plants, after ministerial discussions in Iran. Russia has also completed a pact with the Ukraine in September 1998 to finish two VVER plants, which will involve some US$180 million in Russian financing. The Russian credits were said to be at much more favourable rates than the European Bank for Reconstruction and Development (EBRD). Russian ministers have said they want Minatom to be exporting up to half its goods and technologies by the beginning of 2000.

Plutonium accountancy and control

With its huge inventory of nuclear materials Russia has a massive problem in accurate accountancy and control at its disparate nuclear sites, and over its extensive transport routes. This has been recognised in a number of bilateral and multilateral deals it has concluded with foreign experts and international bodies such as the International Atomic Energy Agency (IAEA).

On 23 July 1997 the then US Energy Secretary Federico Peña signed a joint statement with the then Russian Minister of Atomic Energy, Viktor Mikhailov, extending a 1994 bilateral US-Russia accord covering over forty nuclear facilities in Russia and the Commonwealth of Independent States in a nuclear material protection, control and accounting program aimed at preventing theft of nuclear materials and weapons, by improving physical protection in fences, security sensors, portal monitors, radiation detectors, and accounting procedures. Research labs were also covered in a parallel accord with the Kurtchatov Institute, which also covers enhancing environmental safety and plutonium disposition options. [See Box on page 6 for more details on US-Russia co-operation since]

In April 1998 a center was opened in Obninsk to keep better track of Russia's stockpiles of uranium and plutonium. "We're not inventing anything new here," said Marc Cuypers, deputy director of the European Commission's Institute for Systems, Information and Safety. "It's a lot like a supermarket, except that our material happens to be extremely dangerous."

The Russian Methodological and Training Center, a joint project of Minatom, the U.S. Department of Energy and the European Commission got under way in 1995, when Russia was rife with reports of smuggling of uranium and plutonium after the weakening of physical protection measures, safeguards and general economic conditions with the fall of the Soviet Union.

While Russian officials insist weapons-grade nuclear material has never been stolen or sold, they do admit there were at least 30 thefts of radioactive substances in 1992-95 alone. Since then the smuggling of radioactive substances like cesium or cobalt has supposedly been stopped essentially by an internal information campaign in Russian nuclear establishments highlighting the fact that there was simply no market for this kind of material. However, the major concern of Russian officials interviewed by Plutonium Investigation is the potential trafficking on the Eastern borders (like to Iran) of weapons usable materials.

Minister Adamov has even admitted openly that Russia's borders have become for all practical purposes "transparent", saying "the weakening of our ability to manage nuclear material has been immeasurable." By introducing the Moscow center, Russian leaders hope to create "a radical break in technology, a change to modern means" that will close those borders to illegal and dangerous trade, Adamov said.

There have been many instances alleging that plutonium from Russsia has been smuggled abroad, for example in August 1998 six grams of plutonium were seized and eight people apprehended by Turkish police when they tried to sell the material for US$ 1 million. Although it is technically possible to trace back to source by using isotopic 'fingerprint' techniques the origin of plutonium samples, this procedure is not always used by investigators to clear up plutonium smuggling cases.

The facility aims to train specialists to accurately measure, to a 0.1 percent margin of error, the weight, chemical content, and isotope levels of plutonium or uranium. The Russian nuclear operators are now confident of keeping track of plutonium, protecting it and developing skills to use computers that assign each nuclear material item a bar code. Participants say the center - and possible facilities like it in the future - will improve Russia's system of accounting for nuclear material to international standards. Full legislation is required in the Duma to provide the framework laws to cover nuclear stockpile management. At the Uranium Institute Annual Conference in September 1998 in London, Minatom minister Adamov, asserted that computerised inventory control techniques were now fully in place at Russian nuclear sites.

In 1994 the US Federal Bureau of Investigation (FBI) opened an office in Moscow to assist in combating international crime.

At the IAEA's General Conference on 22 September 1998, a statement on behalf of Russia, the United States and the IAEA was issued reviewing progress made under a joint initiative inaugurated by their predecessors in 1996 to investigate technical, legal and financial issues associated with IAEA verification of weapon-origin fissile material designated as no longer required for defense purposes.

It covered developments by Russia to develop acceptable methods and technology for transparency measures, including appropriate international verification measures. It asserted that during the past two years, substantial progress had been made under the trilateral initiative toward resolving technical problems associated with IAEA verification of classified forms of plutonium, which could include nuclear weapon components. Together with integrated monitoring capabilities, these verification measurements would permit the IAEA to conclude that weapon-origin fissile materials submitted to verification remain removed from use in nuclear weapon programs.

Minister Adamov invited the United States and the IAEA to send experts during the next year to workshops at Minatom facilities in Russia at Arzamas-16 and at the Mayak Production Association. In addition to work on technical issues, the parties are seeking to develop a model verification agreement. Using that model as the basis for negotiations, the IAEA verification regime being created for weapon-origin fissile materials will be implemented through a bilateral agreement between the IAEA and each State, covering verification any weapon-origin fissile material, or any other fissile material released from defense programs in the two States.

The parties are also considering options for financial arrangements. One option is an IAEA Nuclear Arms Control Verification Fund, proposed by its Director-General.

The three parties agreed that work over the next year would proceed for verification activities to commence as needed. They agreed that the three Principals would meet again in September 1999 to review progress and plan the next steps in this initiative. As part of the bilateral co-operation, in November 1998 a team of senior U.S. officials got their first look at a vast storage site being built at Mayak - with American help - to prevent 6,000 bombs' worth of Russian nuclear material falling into unauthorised hands. The unique Mayak Fissile Material Storage Facility is planned to be ready to receive the first plutonium and weapons-grade uranium in 2002. When full, the storage depot will hold 25,000 containers in house-high steel tube "nests" encased in concrete inside a building the size of an aircraft hangar, according to a Reuters report. There will eventually be a second depot alongside. The nuclear material will be delivered by rail and the aim is to store it indefinitely. Senator Richard Lugar, one of the delegation - who set up the Nunn-Lugar Cooperative Threat Reduction Program in 1991 along with Senator Sam Nunn, said - "Our Department of Energy and Department of Defence have worked with officials here to bring that security. We have observed it physically and we are impressed."

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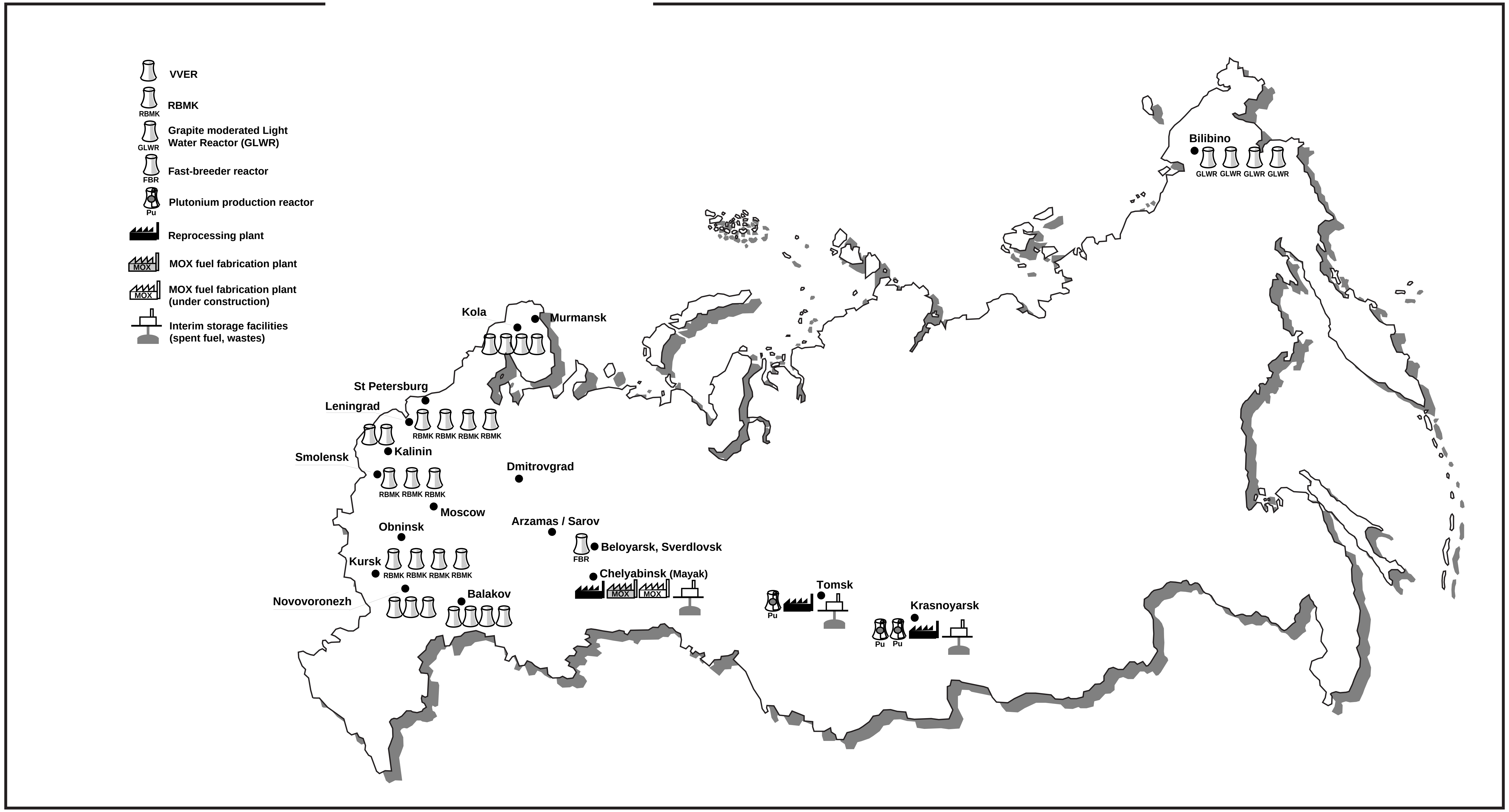

29 OPERATING NUCLEAR POWER PLANTS (status 1 April 99)
- 11 RBMK reactors
- 13 VVER reactors
- 1 Fast Breeder Reactor (FBR)
- 4 Graphite Moderated Light Water Reactors (GLWR)

3 PLUTONIUM PRODUCTION REACTORS

3 OPERATING REPROCESSING PLANTS
- Chelyabinsk (RT-1, nominal capacity 400t/a VVER fuel, real throughput ≈200 t/a)
- Krasnoyarsk (plutonium production reactor fuel reprocessing)
- Tomsk (plutonium production reactor fuel reprocessing)

1 OPERATING MOX FUEL FABRICATION PLANT AND 1 UNDER CONSTRUCTION
- Chelyabinsk (fast breeder reactor MOX plant operating; 100t/a lignt water reactor MOX plant under construction)

3 SITES WITH INTERIM STORAGE FACILITIES FOR SPENT FUEL AND WASTE
- Chelyabinsk
- Krasnoyarsk
- Tomsk

Congress has provided US$222 million for the project and is thought likely to top that up when necessary. This scheme is not seen as gifts to the Russians by the US administration, rather as "gifts to ourselves and to the world."
Mayak spokesman Yevgeny Ryzhkov asserted: "We pay great attention to security. There have been no cases of fissile material being lost or stolen." This reassurance clearly runs counter to minister Adamov's expressed concerns Ryzhkov said Mayak employees earned on average US$100 a month and, unlike elsewhere in Russia, were mostly paid on time. He said to his knowledge 'no key scientists had moved abroad.'

Nuclear Imports

For many years Russia, when the USSR, has imported nuclear materials for both commercial processing, such as uranium hexafluoride from France for commercial enrichment, and spent fuel from its satellite states in the former Comecon eastern bloc. Recently there have been many stories and rumours suggesting:

- Russia might import nuclear waste from Switzerland, substantiated by Greenpeace earlier this year with leaked documents from inside Minatom;
- a major international store for foreign radioactive waste is being proposed by Pangea, a US-based company which has also proposed international nuclear dumps for Argentina and Australia;
- new consignments of spent fuel from Bulgaria, which has brought objections from over 200 organisations inside Russia and other eastern European environment groups;
- spent fuel from the United States and Japan;
- and plutonium from both Japan and Germany in deals that would make Russia huge amounts of foreign capital. One proposal even involved the dismantling of an entire plutonium store and fuel fabrication plant from Hanau in Germany and reconstructing it in Russia. However, the proposal has been opposed by Minatom.

The difficulty is that most of these schemes are just - more or less wild - ideas, not reality. Some of the schemes that are real have led to trouble. The Siberian region around Krasnoyarsk last autumn banned a shipment of spent fuel from a Ukrainian power station. Aleksandra Kulenkova, deputy to Governor Aleksander Lebed, ordered the ban because the compensation offered to handling the fuel was well below international rates the local nuclear operators believed prevailed. Krasnoyarsk receives US$275 per kilo of fuel while the price elsewhere is closer to US$1,000 per kilo. Lebed has sought an increase in fees from US$103 million to US$168 million. The agreements on nuclear materials management and storage were signed on a country-to-country basis, without apparent consultation of the region.

The Bulgarian deal is the most realistic, as it appears that the spent fuel storage situation in Bulgaria is even more chronic than in Russia. According to Bellona, the price tag for reprocessing alone of the spent fuel, excluding transportation and insurance expenses, amounts to US$18.7 million. Bellona indicates that between 1979 and 1988 Bulgaria sent 21 shipments of spent nuclear fuel to the Mayak plant for reprocessing. Until 1988, Russia handled the spent nuclear fuel on the so-called 'zero-value' principle, assuming that the value of the plutonium and uranium extracted from the fuel covered the reprocessing expenses. A few years later the Soviet Union collapsed, and from 1991 the Mayak plant started to demand money for reprocessing. Bulgaria then suspended its shipments to Mayak, but in November 1997 the country, faced with a shortage of on-site spent fuel storage facilities, was forced to return to exporting its problem by renewing the contract with Russia.
Transit countries have been less than thrilled. The first train consisting of eight carriages and carrying 240 VVER-440 spent fuel assemblies sealed in containers left Kozloduy in mid September 1998, heading for Mayak. Bulgaria pays US$640 per kg of fuel to be reprocessed, up to a total of US$18.7 million. Expenses for insurance and the transit through Moldova come in addition. Moreover, the Moldovan parliament went strongly against transit in summer last year. Permission was eventually granted, but only for one shipment.

The storage facilities for VVER-440 reactors' fuel are almost full, while the two VVER-1000 have some storage place left. Given no shipments to Russia, all the onsite storage facilities will be full by 2001. The second train to be sent to Russia was scheduled for the beginning of 1999. Bulgaria has sought ways to change the transport route, negotiating with Romania on this issue. Romania agreed in principle, although the question had to be finally settled in the Romanian parliament. In addition, according to decree no. 733, dated 29 June 1995 and signed by the Russian President, Bulgaria has to take back the waste generated during reprocessing within a 30 year period after shipment.

Bulgaria is among the four countries continuing to ship spent fuel for reprocessing at Mayak - the others are the Czech Republic, Slovakia and Ukraine. Another former foreign customer, Finland, decided in 1995 to build a storage facility for spent nuclear fuel generated at the Soviet-designed Loviisa Nuclear Power Plant. Hungary is likely to halt shipments as a new dry storage facility is under construction there.

By 31 March 1999, the Bulgarian State Committee on Energy, together with the Bulgarian Academy of Science, had to prepare a national strategy for the safe management of spent nuclear fuel and radioactive waste, covering a period of 30-50 years to come. The Russian government and some Duma members have been preparing the legal ground to permit a change to Russian nuclear law allowing the country to legally accept foreign nuclear waste for final disposal. Confidential letters, obtained by one MP and the Socio-Ecological Union and released in February 1999, show that the leaders of Russia's main political parties and heads of several key parliamentary committees are backing proposals to remove legislation banning the importation of radioactive waste for storage or disposal into the Russian Federation. These plans were strongly criticised by the environmental movement. The leaked correspondence shows that Duma State Member, Sergey Shashurin, received significant high level support for amending Article 50 of Russia's "Law on Protection of the Environment", which currently bans the importation of nuclear waste for storage and final disposal, to: "The importation, with the aim of reprocessing, storage or disposition, of spent fuel, radioactive waste and materials from other countries can only be realised with the permission of the Government of the Russian Federation in accordance with intentional rules and recommendation of the International Atomic Energy Agency (...) ensuring the economic benefit of the Russia Federation and the safety of the environment." Letters backing the new wording have been signed by the leaders of Russia's main political parties - except the social democratic "Yabloko" party. The proposal is clearly linked to clandestine talks being held between Minatom and representatives of the European nuclear industry.

In other leaked documents, released earlier in 1999 by Greenpeace, the President and Vice-President of Minatom told representative of Swiss nuclear utilities that it "would like to offer worldwide services for final disposal. Proposed amount: US 10 billion equal to approximately 10,000t of spent nuclear fuel from Switzerland, Germany, Spain, South Korea, Taiwan and possibly Japan." Each consignment of spent fuel imported would add to the existing stockpile of plutonium.

In other developments the Kurtchatov Institute and the US Science Applications International Corp (SAIC) of Virginia, have jointly proposed a monitored retrievable spent fuel store might be built at Krasnoyarsk-26. They are seeking funding under the US Energy department's Nuclear Cities Initiative. Valentin Ivanov, deputy minister of atomic power, has also announced he would like to take spent research reactor fuel from European reactors for processing at Mayak. In 1995 Russia took responsibility for the spent fuel recovered from Iraq's reactors as part of an international deal with the IAEA.

Plutonium Separation

There are three main plants, the oldest at Chelyabinsk-65, in the Urals, where the Mayak Production Association is located; at Tomsk-7 and at Krasnoyarsk-26, both in Siberia. The Mayak complex started in 1948, producing plutonium for the Soviet atomic bomb program. In 1977, the RT-1 reprocessing plant for handling VVER-440, BN-350 & -800 fast reactor fuel was commissioned. There have been several recorded serious radiological accidents at Mayak, including a very severe explosion on 29 September 1957 in a high activity storage tank for reprocessing waste. The local Techa River and Lake Karachay are significantly contaminated with plutonium wastes, which have spread their contamination to vegetation, animal and human tissue over an extensive area in the region. The second plant is at the Krasnoyarsk Mining Chemical Combine, which was opened in 1950, to produce and process plutonium. In October 1998 Minatom's deputy minister Valentin Ivanov announced that after more than a decade of planning at Krasnoyarsk-26, the second full scale reprocessing plant for VVER-1000 spent fuel, RT-2, had been cancelled for economic and technical reasons. Instead the Mayak complex would be modified to cope with the VVER-1000 fuel. A spent fuel store - opened in 1985 - still operates at the Krasnoyarsk-26 site. There is evidence of radioactive contamination of the Yenisey river. At Krasnoyarsk, as at Tomsk-7, the pumping of radioactive wastes underground has been a routine practice.

The third plant, the Tomsk-7 Siberian Chemical Combine, was opened in 1953, again primarily for the weapons program. Significant radioactive contamination has also occurred, but data is not as accessible as for the Urals plants. There are said to be fifty storage facilities on the Tomk-7 site. An accident is reported to have occurred in a tank in the reprocessing plant in April 1993, when plutonium and high activity wastes were released to the environment.

There are concerned citizen groups at each of the three regions. The Movement for Nuclear safety in Chelyabinsk, the Ecological Initiative in Tomsk and the Krasnoyarsk Kray Ecological movement - along with the nationwide Socio-Ecological Union - have all raised concerns over environment and public health, as well as safety of plutonium management.

In March 1998 the Center for Nuclear Ecology and Energy Policy in Moscow joined with US groups, the Center for Safe Energy in California, and the Nuclear Information and Resource Service in Washington, DC. to collaborate on opposition to the development of MOX plutonium fuels fabrication plants in Russia, as part of a plutonium management strategy.

The Future

Russia still has a huge nuclear infrastucture stretching across thousands of kilometres and several time zones. Its economy is facing very difficult times, due to modernization and a changing world, and under such circumstances there will inevitably arise various plans to exploit this huge investment in a technology that did seem to provide energy security for a golden period in the 1970s. But, as elsewhere, the nuclear industry is moribund, with finances for existing let alone new projects hard to achieve. The pressure to complete joint ventures with nuclear operations outside Russia, in the US, Japan, France, Germany and the UK in particular is very strong. Hence the pressure to develop plutonium (MOX) fuel from the huge plutonium stocks now in Russia, to try to make an asset out of a liabilty. The challenge is to provide a secure management plan that does not require reuse of this prime nuclear explosive material.

Russia Stops Construction of Plutonium Storage Site for Environmental Violations

The Russian Goskomekologia (State Committee on Environment) stopped the construction of the U.S. funded plutonium storage site in Mayak on 10 April 1998. The reasons for this rather spectacular action remain unclear.

The storage site, which has been under construction for three years, is intended to be an interim storage facility for plutonium from nuclear warheads. It is funded by the U.S. Department of Defence (DoD) under the Co-operative Threat Reduction program (CTR), and is one of the cornerstones of U.S. nuclear non-proliferation efforts in Russia. Up to then, the U.S. had provided US$55 million to the construction, which will cost some US $250 million. The first stage was expected to be completed by the end of 2000. The storage will hold 50 000 containers with plutonium from 12 500 nuclear warheads.

According to Goskomekologia the construction can continue after officials prepare new technical and environmental documents and receive a positive finding from the State committee on Environment. The construction work has been going on without the formal Environmental Impact Assessment having been formally completed. According to independent sources, there are some indications that the Assessment department had wanted its "share" from the American finances.

Yury Golovin, a consultant to Mayak, has said in an interview with Moscow Times that they could have performed this study in about a month, but due to the 'spotty' financing from the Russian side, this has not been done. An ecological study conducted by researchers from Mayak would not have been legally valid, critics argue, as Russian law requires an impact survey from an independent body.

Source: Bellona Foundation, SEU

Minatom - Ministry of Atomic Power

A 'superministry' based on the merger of various nuclear research & development organisations, with over 25 major departments, including : nuclear fuel production (TVEL); R&D on nuclear fuel; future power plant design; operation of power plants (REA); experimental development; co-ordination centre for atomic machine building; enterprise development (Sredmashinvestconcern); physical protection of nuclear enterprises and materials; nuclear exports (Techsnabexport); nuclear weapons design and testing; and information and data management (Tsniiatominform).

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MAYAK Production Association

Nuclear fuel manufacture & reprocessing.
RU-454065 Chelyabinsk-65
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Mining & Chemical Combine Krasnoyarsk

Nuclear reactor operation, fuel storage & reprocessing.
53 LENIN UL., RU-660033 KRASNOYARSK 33
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Siberian Chemical Combine (Sibkhimkombinat) Tomsk-7

Nuclear reactor operation and fuel reprocessing.
RU-634030 TOMSK 30

Rosenergoatom (REA)

National nuclear plant operating organisation.
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Gosatomnadzor (GAN)

National nuclear safety and safeguards regulation organisation.
TAGANSKAYA UL. 34, RU-109147 MOSCOW
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Center for Nuclear Ecology & Energy Policy of the Socio-Ecological Union (SEU)

The SEU is one of Russia's largest and most effective environmental organisations. The nuclear energy department has been instrumental in producing and disseminating independent information in Russia. SEU has co-ordinated and directed the release of the Russian version of the International MOX Assessment (IMA) report (see ref. on p.3).

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Greenpeace Russia

As in many other countries, Greenpeace is active in Russia on nuclear issues. Over the past few months it has released some exclusive information on negotiations on spent fuel shipments and reprocessing.

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Alexey V. Yablokov served as a chairman of the special Presidential Commission on the radioactive dumping problem in 1992.
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SEU member organisations concerned about plutonium and MOX

>The best way to contact them is by e-mail

Ecodefense!

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Will have an anti-MOX camp in summer 1999.
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FIGURES OF THE MONTH

The French Minister for Industry has just published the latest figures on the status of foreign spent fuel reprocessing at La Hague. While the Japanese fuel under contract has been entirely delivered, the situation is more complicated concerning the German clients. The German utilities have signed up for UP2 and UP3 "baseload customer" contracts to be carried out until the year 2000 and for post-2000 contracts. According to other sources, about 4,435 tonnes of the fuel under the UP2 and UP3 baseload customer contracts have been delivered until the shipments were interrupted in May 1998. About 320 tonnes of fuel have been shipped to La Hague under post-2000 contracts.

Foreign spent fuel delivered and reprocessed at La Hague (as of 31 December 1998, in tonnes of heavy metal)

Client Country	delivered	reprocessed
Germany	4 653	3 822
Japan	2 944	2 642
Belgium	656	592
Switzerland	595	455
Netherlands	263	226
Total	**9 111**	**7 737**

Source: French Minister of Industry, answer to a parliamentary question, Journal Officiel 15 March 1999

Glenn T. Seaborg, Nobel Laureate-The 'father of plutonium', 1912-1999

Nobel prize winner Glenn Seaborg was a many-sided man: one of America's great scientific geniuses and one of the world's intellectual elite. He was born in Ishpeming, Michigan, of Swedish immigrant parents, on 19 April, 1912. His family moved to California 10 years later, to improve educational chances. In 1929 he started studying chemistry at the University of California at Los Angeles (UCLA), and in 1934 tranferred to another UC campus at Berkeley, to study for his PhD, gained in 1937 with a thesis titled "The Inelastic Scattering of Neutrons". He stayed on at Berkeley as an academic research assistant, and later became a professor. He recalled later "Among the isotopes that we discovered were iodine-131 and iron-59 and among the useful isotopes that we characterized was cobalt-60. In addition, during this period, Emilio Segre and I discovered technetium-99m, which eventually became the most used isotope for diagnosis in medical applications."

In 1941, with colleagues, Joseph W. Kennedy and Arthur C. Wahl, Seaborg discovered the unstable element 94 - named plutonium, after Pluto, the God of the Underworld - by bombarding neptunium with deuterons, using a machine called the 'Cyclotron'. Seaborg later recalled "The critical chemical identification that constituted the discovery of this important element was performed on the stormy night of February 23, 1941, in room 307, Gilman Hall, Berkeley. That room was dedicated as a National Historic Landmark just twenty-five years later."

"We demonstrated on March 28, 1941, that this isotope is fissionable with slow neutrons, produced with the thirty-seven-inch cyclotron. This demonstrated the utility of plutonium as the explosive ingredient in a nuclear weapon and, I hope, more important, opened the use of uranium as a nuclear fuel for breeder reactors to meet the future energy needs of the world."

Seaborg and his colleagues discovered ten elements: plutonium (element 94 - a co-discovery with Edwin M. MacMillan), americium (95), curium (96), berkelium (97), californium (98), einsteinium (99), fermium (100), mendelevium (101), nobelium (102), and seaborgium (106).

In 1942, Seaborg left Berkeley to begin groundbreaking work on the Manhattan Atomic Bomb Project at the University of Chicago with many other leading scientists of the day. There, Seaborg was the section chief in charge of finding a method for chemically extracting enough plutonium-239 from uranium to be used in nuclear energy. This was a difficult task, because of the chemical similarity of uranium and plutonium. Seaborg and his colleagues pioneered the technique of 'ultramicrochemical' analysis, which is used in working with minute amounts of radioactive material. Seaborg wrote "Among the accomplishments of our Chicago group was the first isolation of a visible amount of a plutonium compound on August 20, 1942; this also constituted the first isolation of a visible quantity of any synthetic element."

Ultimately by 1944, they were successful in isolating large amounts of plutonium, enough for the construction of two nuclear weapons. They also found that tiny amounts of plutonium existed in pitchblende and carnotite ores. Seaborg was also an important influence in the decision to use plutonium instead of uranium. Although Seaborg and other scientists worked on developing nuclear weapons, they were active in the crusade for the control of nuclear arms due to the atomic bomb's capacity for mass destruction.

In 1944, Seaborg devised the actinide concept, which is the principle that regulates the prediction of the chemical properties and placement of the heavier elements. Using this concept, Seaborg and his colleagues were able to predict the chemical makeup of more transuranium elements, and found americium (95) and curium (96), for which Seaborg received patents. He is the only person to ever receive patents for chemical elements. After returning to Berkeley in 1946, Seaborg assembled a group of leading scientists, and under Seaborg's guidance as associate director of Berkeley's Lawrence Radiation Laboratory, they worked to discover more transuranics. In the period from 1948 to 1959, the elements berkelium (97) through nobelium (102) were discovered, and in 1974, scientists working under Seaborg discovered element 106, which is now named seaborgium after Seaborg.

In 1958 Dr. Seaborg was appointed Chancellor of the University of California at Berkeley and served in that capacity until his appointment as Chairman of the US Atomic Energy Commission in 1961 by President Kennedy. He served for 10 years on the AEC, a key decade when the US commercial reactor program, which it promoted, was expanded rapidly. He recalled his AEC appointment "within a few days I was plunged into a new kind of chemistry, that of national and international events." He had a decade earlier been appointed by President Harry S Truman to serve on the first General Advisory Committee (GAC) to the Atomic Energy Commission for a term extending from January 1947 to August 1950. This first GAC played an important role in helping to establish a number of the basic policies of the AEC.

Most notable among his awards are the Nobel prize for discovery of the chemistry of transuranium elements, which he shared in 1951 with his colleague Professor E.M. McMillan, and the Enrico Fermi Award for his outstanding work in nuclear chemistry, and leadership in scientific and educational affairs. He also received over 50 honorary doctorates from academic institutions.

In 1959 he was appointed by President Eisenhower to be a member of the President's Science Advisory Committee (PSAC), on which he served until January 1961, and to the National Science Board of the National Science Foundation (1960-1961).

Seaborg said he was " privileged to collaborate with President Johnson in reducing the level of production of fissionable material for our nuclear weapons production program as part of a concentrated move toward arms limitation in this important field. Under the leadership of President Johnson and President Nixon, the Atomic Energy Commission played a significant role in the attainment of the Non-Proliferation Treaty (NPT)." Seaborg served in 1972 as president of the American Association for the Advancement of Science and in 1976 (the centennial year) as the president of the American Chemical Society.

In his 1958 book, The Transuranium Elements, Seaborg wrote: "The story of plutonium is one of the most dramatic in the history of science. It was discovered and methods for its production were developed during the last war, under circumstances that makes a fascinating and intriguing story. It is, of course, a continuing story, and added chapters will have to be written at a later date."

Plutonium *Investigation* continues this tradition.

WORDS OF THE MONTH

"Today reprocessing is the only operational solution for the end of the [fuel] cycle, by opposition to the storage of spent fuel. It allows to recover, in view of their utilisation the recyclable materials (uranium and plutonium), to condition the wastes in a safe manner and to reduce their radiotoxicity and volume."

The French Reprocessing Company COGEMA in its press dossier dated 1 April 1999

"The United States and other countries need to question the often-quoted statement that the reprocessing of spent fuel and the recycling of plutonium will ease radioactive waste management problems. They should not proceed with plutonium activities based on this unsubstantiated benefit."

Final sentence of the conclusion of a study by B.G.Chow, G.S.Jones, RAND, 1999 (see Worth Reading)

WORTH READING

Brian G. Chow and Gregory S. Jones, "Managing Wastes With and Without Plutonium Separation", RAND, 1999, 45 pages

The study compares plutonium fuel strategies (once through MOX and multi-recycling) with low enriched uranium once-through mode operation from the waste management point of view. The authors have established a kind of eco-audit of alternative fuel management taking the waste production from all steps into account. The analysis uses "cost as a proxy for evaluating whether reprocessing 'eases waste management' - the cheaper are the sum of the costs of conditioning and disposal of wastes generated in these steps, the 'easier' is the waste managed."
The results are striking. Plutonium fuel cycles, as compared to spent fuel direct disposal, generate:
- 20-30% less in the waste volume of mill tailings;
- 5-10% more low-level waste;
- 90-150% more intermediate-level waste;
- 7% less to 44% more heat from high-level waste and spent fuel;
- 20-25% higher total waste disposition costs.

Conclusion: "The reprocessing and the use of plutonium actually make waste management more difficult". Surprise?

Gregory S. Jones, Brian G. Chow and S. Rae Starr, "Does Burning Weapons Plutonium Generate Hotter Waste and Consume More Repository Space?", RAND, November 1998, 20 pages

The issue is already defined in the title. The authors look at the implications of the US government weapons plutonium disposition strategy. In particular the question of the final consequences for the final storage of the difference waste categories. The results show that the MOX option leads to 20-56% more space in the repository compared to the direct disposal option (immobilisation of plutonium with high level waste). The main cause for this costly difference is the additional build up of americium-241. One of the technical items which certainly should retain more attention in the debate over the least problematic plutonium disposition option.

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❏ "La France Nucléaire 1997", Mary Byrd Davis, WISE-Paris, 256 pages; 120 FRF + 25 FRF for postage

❏ "Comprehensive Impact Assessment of the Use of MOX Fuel in Light Water Reactors", Jinzaburo Takagi, et al., CNIC, Tokyo, 335 pages; 400 FRF (NGOs 160 FRF) + 60 FRF postage + VAT for Europe (contact CNIC for US and Asia, fax: 81-3-53 30 95 30).
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