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Pugwash Issue Briefs

highlight important issues which lie at the intersection of science, technology and public policy.

Intended for wide circulation to policy makers and analysts, the media, NGOs, the academic and research communities, as well as the Pugwash community, *Pugwash Issue Briefs* will contain articles, commentaries and conclusions that emanate from the broad range of Pugwash workshops and conferences held each year.

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I S S U E B R I E F

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Eliminating Excessive Stocks of Highly Enriched Uranium

This is the second *Pugwash Issue Brief* to focus on the dangers posed by terrorist acquisition of nuclear materials and the ramifications for international security should a terrorist group detonate a nuclear device in the heart of a major city. The first, published in September 2002, was entitled *Nuclear Terrorism: The Danger of Highly Enriched Uranium (HEU)*.

This report by Morten Bremer Maerli and Lars van Dassen is a summary of a longer study published in April 2004 by the Swedish Nuclear Power Inspectorate (SKI) and submitted to the Swedish Ministry of Foreign Affairs in the hopes of stimulating greater involvement on the part of European countries in efforts to assist the Russian Federation in downblending and eliminating excess stocks of HEU. The report had its origins in a meeting organized by the Swedish Pugwash Group in May 2002, which led to the creation of the *HEU Elimination Study Group*. Members of the group met in Como, Italy in September 2002 (hosted by the Landau Network-Centro Volta) and in Moscow, Russia in February 2003 (hosted by the Russian Pugwash Group) to discuss with key Russian officials and to refine proposals that could lead to

concrete action on the part of European governments in reducing the dangers posed by excess stocks of HEU in Russia. The efforts should supplement and not substitute for ongoing US-Russian initiatives to eliminate HEU. A doubling of the current downblending rate is both feasible and desirable.

Despite international attention and promises of support for efforts in Russia to secure and eliminate HEU, the report notes that much work remains to be done, as expeditiously as possible. The dangers posed by the spread of HEU to those who would carry out terrorist attacks with nuclear weapons are far too great for either complacency or inaction.

The authors and members of the study group would like to express their gratitude to the Swedish International Development Agency (SIDA) for funding the project, and to the Swedish Ministry of Foreign Affairs for helping to promote greater interest and cooperation in efforts to eliminate HEU.

For more information on this and other issues of concern to the Pugwash Conferences, please visit the Pugwash website at www.pugwash.org.

Jeffrey Boutwell, *Executive Director
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Eliminating Excessive Stocks of Highly Enriched Uranium

by Morten Bremer Mærli and Lars van Dassen

The ease of producing crude gun-type nuclear explosives with highly enriched uranium (HEU)—and hence a definitive risk of nuclear terrorism—is a fact steadily gaining recognition within the international community.¹ With access to HEU, non-state actors could be capable of producing nuclear yields in the lower kiloton range (see *Pugwash Issue Brief* vol. 2, no. 1, September 2002).² Detonated in a densely populated area, the consequences would be devastating.

The weapons, unlike biological and chemical weapons, have a deadly finality. There are no antidotes and very limited protection against a nuclear blast. And since a crude nuclear explosive would be relatively small, hard to detect, and deliverable by non-conventional means the risk of nuclear terrorism must be stopped at its source: the excessive stocks of fissile material that currently exist in many countries around the world, most notably Russia.

Hence, the formula for avoiding nuclear terrorism is simple and clear: deny non-state actors fissile material. Three steps need to be taken in order to reach this end:³ first, ensure that all stocks of plutonium and highly enriched uranium everywhere are properly secured and locked up, so that they cannot be sold to, seized by, or

diverted to terrorists; second, ensure no more fissile materials are being produced; and third, destroy as much of these stocks as possible.

So far, the (limited) attention given to the stockpile issue has focused mostly on protecting and controlling fissile material through cooperative threat reduction activities. Despite unprecedented cooperation during the last decade, less than half of the material potentially vulnerable to theft has been protected by physical security upgrades.⁴ Efforts to stop the production of HEU through the negotiation of a verifiable Fissile Material Cut-Off Treaty (FMCT) are deadlocked, in large part because of serious reservations about the treaty on the part of the Bush administration.

This *Pugwash Issue Brief* deals with the third step which is the most economically attractive and effective method to deal with the threat of nuclear terrorism: the elimination of excessive stocks of HEU. It builds on the report *Eliminating Stockpiles of Highly Enriched Uranium: Options for an Action Agenda in Co-operation with the Russian Federation*. The report was submitted to the Swedish Ministry for Foreign Affairs April 2004, and published by the Swedish Nuclear Power Inspectorate.⁵

The report—and this Issue Brief—investigate both *why* and *how* concerned states, most notably European states, should and could eliminate a major threat by encouraging the down-blending of HEU to low enriched uranium (LEU). Special attention is given to Russia due to its vast HEU stocks which in many cases are under unsatisfactory levels of security. Given the economic difficulties affecting Russia and the Russian nuclear complex there are special concerns about this material being adequately secured.⁶

The proposed EU involvement in encouraging Russia to down-blend its HEU should bolster, not substitute, the ongoing US-Russian efforts. The cooperation should build upon the 1993 US-Russian HEU agreement to eliminate 500 tons of Russian HEU. After a decade of

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cooperation, well-functioning working schemes for the down-blending and needed transparency provisions have been put in place under the US-Russian deal. These experiences constitute important lessons for further efforts to eliminate HEU. EU involvement could potentially encourage Russia to increase the amount of HEU that it has put aside for down blending and could persuade Russia to expedite the current process. A doubling of the elimination speed seems feasible, using existing Russian infrastructure.

In the proposed scheme for cooperation between Russia and the EU, the HEU should be down-blended to a level where it is “proliferation safe;” that is below 20% enrichment in uranium-235. Uranium enriched below this level is not suited to sustain chain reactions that result in a nuclear explosion. Hence, manufacturing nuclear explosive devices is not feasible unless the material is re-enriched. This is a process that only resourceful states can handle—terrorist groups can hardly accomplish this procedure. Interestingly, there is a growing perception in Russia that large stocks of HEU are not required for national security and that they could, in fact, constitute a source of danger.

Nuclear stocks and nuclear policies

The end of the Cold War has dramatically reduced the risk of a nuclear war. Yet, the legacy from this era continues to pose challenges to international security. There are more than 30,000 nuclear warheads either operational or in reserve stocks and stockpiles amounting to millions of kilograms of weapons-grade nuclear material (both HEU and plutonium). The prospects of both horizontal and vertical nuclear proliferation have not ceased to exist.⁷ Moreover, this situation has greatly accentuated a new nuclear threat: the possibility of terrorist uses of crude nuclear explosive devices.

At the end of 2003 there were more than 3,700 metric tons of plutonium and highly enriched uranium in 60 states—a quantity large enough for hundreds of thousands of nuclear weapons.⁸ New materials are being produced, causing the total to grow each year. Due to the fact that HEU has mainly been produced for military purposes in nuclear weapon states, only a minuscule amount (roughly 1%) of all HEU



stocks come under international control of the International Atomic Energy Agency (IAEA). At the same time, there have been several cases of theft of kilogram quantities of this weapons-useable material.

Only a few countries, notably Britain, France and Germany, have publicly declared their civil stocks of HEU. The largest amount of “unirradiated HEU”, (i.e. “fresh HEU, or HEU that has not been burned in a reactor) is found in Russia. The exact figure is not known. Unofficial estimates vary between slightly above 1,000 to 1,500 tons. At the upper limit of these estimates, a possible 1,500 tons of Russian HEU may represent the equivalent of some 60,000 to 80,000 warheads.⁹

Russia has declared 500 metric tons of highly enriched uranium in excess to its national security needs. By December 31, 2004, 231.5 metric tons of Russian weapons-grade uranium, the equivalent of 9,261 nuclear warheads, has been recycled into fuel or use in commercial US nuclear power plants under an ongoing US-Russian deal.¹⁰ Even after being fully implemented by 2013 the deal will cover less than 40% of existing Russian HEU stocks. Additional HEU elimination efforts to speed up the destruction of this highly proliferation attractive material are thus highly desirable and urgently needed.

Russian nuclear facilities

.....
“Nothing could be more central to US and world security than ensuring that nuclear warheads and their essential ingredients – plutonium and HEU – do not fall into the hands of terrorists....”
.....

Matthew Bunn
Managing the Atom Project
Harvard University
.....

The threat from HEU

The main barrier for states and terrorist groups to acquire nuclear explosive capabilities is the considerable difficulty of producing the fissile materials (HEU and plutonium) needed for nuclear weapons; Of these two materials, HEU is the most likely choice for potential nuclear terrorists. Theft of unirradiated HEU is by far the most direct shortcut for actors seeking nuclear explosive capabilities. There are several reasons for this:

- HEU is the only material that makes it easy to manufacture crude nuclear explosives. Anybody with access to sufficient quantities of HEU of high enough quality will have a good chance of achieving a kiloton-range nuclear explosion.
- HEU exists in large quantities throughout the world, in many cases under unsatisfactory levels of security and physical protection.
- HEU detection, e.g. at boarder-crossings and checkpoints, is difficult due to the low levels of radiation emitted.
- The radiation levels from fresh uranium are low and the handling of HEU involves minimal health hazards (as long as criticality is avoided).

Important efforts have been made to improve the security of fissile material and to destroy and render HEU inaccessible to potential terrorists and proliferating states. Some of these programs have made remarkable progress. Yet, they are moving too slowly and without the needed comprehensiveness. According to the findings of an independent review panel in January 2001, the most urgent unmet national security threat to the United States is the danger that weapons of mass destruction or weapons-useable materials in Russia could be stolen and sold to terrorists or hostile nations.¹¹

This threat exists to all nations, not only the US. Some experts maintain that Europe is as much at risk as America with regard to large-scale terrorism.¹² Insecure nuclear weapons-grade material anywhere is a threat to everyone, everywhere.¹³ Its proximity to areas of potential nuclear leakage could make Europe particularly vulnerable and exposed.

Acquiring fissile material for a nuclear explosive device is by far the hardest part for potential nuclear terrorists, yet it is also the easiest step to control. Reducing the threats from HEU is straightforward, from a technological point of view. As opposed to plutonium disposal, the elimination of HEU is achieved by blending it down, that is mixing it with natural or depleted uranium to LEU. LEU cannot be used to manufacture nuclear explosive devices. This LEU would have to be (re)enriched, which is a difficult process beyond the capabilities of sub-national terrorist groups and most states.

Past HEU diversion

In February 2002, representatives of the U.S. intelligence community stated to the U.S. Congress that “weapons-grade and weapons-usable nuclear materials have been stolen from some Russian institutes.”¹⁴ The law enforcement representatives acknowledged that undetected smuggling has occurred, although they were unable to know the extent or magnitude of such incidents.

According to the IAEA, 18 cases involving the theft of plutonium and uranium have occurred over the last decade, many of which originated from the former Soviet Union. The vast majority of incidents confirmed by states involve plutonium or HEU in far too limited quantities to produce a nuclear explosive device. However, it is possible that terrorist groups have accumulated some small quantities of fissile material, and it is also possible that black market HEU that has been intercepted may represent only a small portion of larger quantities that are still available for sale.

In December 1998 the Russian Federal Security Services intercepted an attempt to divert 18.5 kg of “radioactive materials that might have been used in the production of nuclear weapons.”¹⁵ Russian officials, stating that the perpetrators “could have done serious damage to the Russian state”, later confirmed this attempt, and made it the first confirmed case that apparently involved a conspiracy to steal enough materials for a bomb in a single act. The material involved was fresh HEU.

While the number of confirmed seizures remains low (some five to six cases annually involving plutonium or HEU), the mere fact

that there exists a viable black-market for fissionable material is worrisome. Law enforcement authorities only detect failed smuggling attempts. More sophisticated smugglers and new smuggling routes cannot be excluded, e.g. through the southern border of Russia. Experts maintain that the current illicit trafficking picture is “just the tip of the iceberg.”¹⁶ Specialists from the Russian law enforcement authorities have identified poor physical protection as the primary cause of nuclear thefts, along with the acute shortage of funds allocated for nuclear material protection, control and accounting (MPC&A).¹⁷ This means that in many cases there is not a layered defence with increasing screening closer to the HEU storage.

While the most proliferation attractive material is within the Russian nuclear weapon complex, most progress has been made at facilities outside the complex. Some estimates indicate that if security control is not enhanced, Russia’s nuclear material will not be “completely secure until 2029.”¹⁸ Past deficient accounting practices make inventory control challenging, and the insider threat remains. According to the August 2000 report by the Russian nuclear regulatory agency, Gosatomnazor, a Russian resident of Elektrostal (the fuel-fabrication facilities) near Moscow was detained in an attempt to try to sell 3.7 kilograms of HEU enriched to 21%.¹⁹

Incentives for HEU elimination

The primary incentive for European engagement in HEU elimination should stem from its long-standing promotion of non-proliferation and the recent concerns over nuclear terrorism. In particular, Europeans should be interested in making the Russian nuclear disarmament and non-proliferation efforts irreversible, more effective and faster. If this is the case, additional European funds will have to be made available for nuclear security. European parties must make security considerations prevail over (short-term) economic incentives and commercial benefits possibly associated with the uses of the uranium.

Expedition of the HEU elimination is clearly an economic and a political issue for the Russians as well. Russia expects an estimated additional 5.5 to 6 billion US dollars from the com-

pletion of the existing HEU-deal with the United States.²⁰ Financial incentives –in the context of a broader economic cooperation with the European Union—could improve the incentives for increasing Russian cooperation on nuclear disarmament. An extra benefit for Russia would be the reduction of the domestic threat of nuclear terrorism.

But it may be viewed inappropriate to create more advanced facilities and employ more people for a relatively short period, with a perspective to close facilities and lay off employees afterwards.²¹ Revenues associated with the down-blending could, however, be earmarked to conversion and down-sizing of a vast nuclear weapon complex, to create new, peaceful jobs in the domestic nuclear industry, or simply allocated to physical protection at existing stocks of fissile material.

However, there are those who maintain, like many Russians do, that Russia would have no interest in undermining its strategic reserve of materials. Maintaining stocks of HEU could be essential for national security, both for assuring the availability of materials for nuclear warhead components and for naval nuclear propulsion. The HEU may be viewed as a state asset based on the weapons potentials, production investments, and its possible applicability in (commercial) nuclear power plants. To some, eliminating the material may thus seem to be at odds with national security considerations and reasonable practices.

Incidents confirmed to the IAEA Illicit Trafficking Database (ITDB) by participating Member States (by category of material) 1993–2003

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
Nuclear Material	33	44	23	17	15	8	8	12	11	8	3	182
Other Radioactive Material	22	23	18	8	14	24	31	37	37	35	51	300
Both Nuclear and Other Radioactive Material	0	2	1	0	0	3	6	2	6	2	1	23
Radioactively Contaminated Material	1	0	0	1	3	3	7	5	3	4	3	30
Other	0	0	1	0	0	0	1	0	0	1	2	5
Total	56	69	43	26	32	38	53	56	57	50	60	540

Moreover, even if the excessive stocks of HEU were to be viewed as a security risk, security and non-proliferation issues other than HEU elimination are currently perceived as more important by key Russian actors. The primary nuclear security priority for the Russian Ministry for Atomic Energy (Minatom) and the Russian government is the dismantlement of nuclear submarines, as well as the safe unloading, transporting and reprocessing of the spent fuel from these vessels.²² The second priority is the disposal of excessive stocks of plutonium. Dealing with stocks of HEU only comes third on the priority list, along with the fulfillment of Russia's obligations under the Chemical Weapons Convention: the elimination of 40,000 chemical weapons.

Apart from the HEU elimination efforts, practical project implementation and progress in all other priorities remains painfully slow—despite the fact that overarching agreements have been put in place and donors stand ready to provide funding. The current HEU elimination work is, however, moving ahead in accordance with the mutually agreed schemes. From the Russian point of view, there may thus be a limited need to deal with the HEU stocks.

For the time being there are no Russian stocks of HEU declared as excessive to national security needs that are not covered by the existing HEU elimination co-operation between Russia and the United States—in effect making additional downblending impossible. No further declarations of excess HEU stocks are currently envisioned. Cash, however, may change such perspectives.

Analysis of the history of the first Russian HEU excess declaration in conjunction with the US-Russian HEU deal may provide hope that external actors may indeed influence such vital Russian decisions, and that there actually is more HEU available for a coming HEU excess declaration. Indeed, before the US in 1993 indicated its willingness to buy and eliminate Russian HEU surplus, no stocks were identified by Russia as excessive. Fresh European funds may thus not only improve Russian interest in HEU stockpile accountability, it may actually facilitate the process of Russia identifying additional stocks that could be declared as excess and slated for elimination.

Growing HEU elimination interests

Recently, the elimination of HEU has become the object of multilateral agendas and declarations. But, most international commitments are still at a declaratory level. The practical implementation and realization of these pledges are essential.

In April 2002, the Preparatory Committee meeting for the 2005 Review Conference of the Nuclear Non-Proliferation Treaty (NPT) stated that international commitment is needed to ascertain the security of fissile materials and thereby reduce the risk of terrorist use of these materials. The G-8 summit in Kananaskis, Canada, June 2002, launched a new Global Partnership against the Spread of Weapons and Materials of Mass Destruction. 20 billion USD were pledged over the coming 10 years to support specific cooperation projects, primarily in Russia, to address non-proliferation, disarmament, counter-terrorism and nuclear safety issues.

Among the priority concerns of the G8 are the safe and secure disposition of fissile materials.

The Multilateral Nuclear Environmental Programme in the Russian Federation, or MNEPR, was signed in Stockholm in May 2003. The agreement paves the way for projects in management of radioactive waste and spent nuclear fuel from the Northern Fleet nuclear submarines. As such, it is likely to be a major step forward for Russia and its European partners in tackling nuclear safety and security problems, including the safe and secure handling and storage of naval HEU.

In July 2003, the Swedish government made public its initiative for establishing an independent international commission on weapons of mass destruction for which the former Director General of the IAEA, Dr. Hans Blix, has been appointed as Chairman. The purpose of the “WMD Commission” is to provide new impetus to the international efforts involved in disarmament and non-proliferation of weapons of mass destruction and missiles. Reduction of security risks associated with excessive stocks of HEU could thus naturally form an integral part of the work of the Commission.

UN Security Council resolution 1540, adopted by consensus April 28, 2004, is another important example. It seeks to prevent the

spread of Weapons of Mass Destruction.²³ The resolution requires all UN member states to develop and maintain effective measures to account for and secure WMD-related items in production, use, storage and transports.²⁴

Preferred security-building HEU approach

The inherent proliferation risks of unirradiated HEU can be reduced in a number of ways. One approach could simply be to establish centralised and highly protected storage facilities for all the materials. This option, however, will be costly and only be effective for short-term or immediate purposes. It would require the availability of (fresh) funds over decades to come, in order to ensure sustained nuclear security. It does not reduce the stocks, and therefore not the long-term threats associated with HEU.

All facilities containing HEU continuously need upgrades, overhauls and well-trained guards. With the rapid societal transformations, there is no guarantee that it will be easy or even possible to maintain the needed security effectiveness of the nuclear weapons-usable materials. While adequate physical protection systems are a minimum requirement for avoiding HEU falling into the hands of unauthorized users, physical protection as such is not a viable and final solution to the proliferation risks.

A second potential approach could be to grind and dissolve HEU in the oceans and thus “give the materials back to nature.” Though HEU dumping would represent minuscule releases of radioactivity and no harm to health and environment, such efforts would clearly represent an up-hill political battle. Most likely, it would be very hard to convince public opinion that any released amount would be minuscule compared to the existing billions of tons of uranium-235 in the oceans. Moreover, new security risks may emerge. The logistics of land and sea transports could create situations where the HEU is vulnerable and prone to theft, sabotage and accidents. Proper accountability in conjunction with the discharges may also be a challenge.

A third approach is defined by the ongoing US-Russian HEU deal whereby the military HEU is down-blended, commercialised, and

burned in civilian nuclear power reactors. This solution has merits, as the electricity (and thus the financial) potential of the HEU is utilized. However, as seen, strong commercial considerations may impede a swift and focused elimination process. Besides, given the diverging political views on nuclear power within Europe, a full-fledged commercialisation of the issue may be neither feasible nor desirable.

For the European actors, the ideal option is to put itself outside the political and commercial shortcomings of the three potential options mentioned above. A European approach for the elimination of unirradiated HEU should:

- Consider security—not economy—as the first objective for HEU elimination.
- Be permanent and irreversible in the sense that it converts HEU into a form where it can never again be used for nuclear weapons purposes.
- Make sure it is environmentally sensitive by accommodating sound environmental standards and practices.
- Limit unnecessary risks relating to HEU transport, handling, and management.
- Allow strict (Russian) ownership and custody of the HEU and the down-blended HEU at all times.
- Not rule out any future (Russian) commercial exploitation of the down-blended HEU, for instance as a source of revenue by using LEU as a commercial and civilian fuel.

This means that Europeans could suggest a scheme for HEU elimination to appropriate Russian counterparts with a view of transforming HEU into LEU through rapid down-blending in Russia. Instead of establishing a commercial structure of Russian and European companies that market these products, the down-blended LEU should remain in the ownership of the Russian Federation. Ideally, the funds obtained by Russia in this manner should be used for securing remaining fissile material and restructuring of the Russian nuclear weapons complex for peaceful purposes. Clauses reflecting this may be contemplated by European parties. In other words, European parties should make available adequate financial incen-

Ten Largest Consumers of Nuclear Power

Country	No. Units	Total MW(e)
USA	109	99,784
France	56	58,493
Japan	59	38,875
Germany	21	22,657
Russian Federation	29	19,843
Canada	22	15,755
Ukraine	15	12,679
United Kingdom	12	11,720
Sweden	12	10,002
Republic of Korea	10	8,170
Total	335	297,978
World	432	340,347

tives to motivate Russia to eliminate HEU by down-blending it at Russian facilities. The highly enriched uranium should be down-blended to a level where it is “proliferation safe”; e.g. at least below 20% enrichment in uranium 235, outside of any market considerations.

Russia should retain the right to decide if, when, and to whom to sell the residual down-blended materials for possible future commercial purposes. Here, it has to be ascertained, however, that the LEU cannot be re-enriched to any plus 20% level. This could be ensured through international (possibly IAEA) verification and monitoring. In addition, it has to be inscribed as a precondition for any deal on additional HEU elimination that no new HEU is produced in Russia. To ensure this, the implementation of a comprehensive non-production transparency regime is needed.

The proposed approach will be a great achievement for security and non-proliferation, while also accomodating the nuclear energy opposition in some European states. Moreover, it will supplement, and not substitute, ongoing US-Russian HEU elimination practices. As such, it should neither interfere with this cooperation, or directly influence HEU markets or market prices.

Russian de-enrichment capacities

Russian HEU activities are scattered at a range of different facilities, at different locations (see map on page 3). All Russian facilities that produced HEU for nuclear weapons are located in Russia’s closed nuclear cities. Nuclear material is scattered throughout Russia at more than 53 sites and in more than 300 buildings.²⁵ Most of them have 1,000 kilograms or more of HEU stored or in use, while a few facilities are listed as having smaller quantities of tens or hundreds of kilograms.²⁶ Smaller amounts, ranging between grams and a few kilograms of HEU exist at several other research institutions in Russia.²⁷

In 1989, the Soviet government announced the cessation of production of HEU for nuclear weapons. Currently, Russian uranium is enriched to low levels at the Angarsk Electrochemical Combine in Irkutsk, at the Electrochemical Plant in Zelenogorsk (formerly Krasnoyarsk-45), the Ural Electrochemical

Combine in Novouralsk (formerly Sverdlosk-44) and the Siberian Chemical Combine.²⁸ Historically, all of these, with the exception of Angarsk, produced HEU for weapons. Currently, the main product of all four uranium enrichment facilities is low-enriched uranium for nuclear fuel. In addition to enrichment activities, all but the Angarsk facility are engaged in down-blending of the HEU into LEU under the US-Russian HEU Agreement.

Current HEU down-blending under the US-Russian co-operative deal takes place at the rate of approximately 30 tons per year. The remaining quantities covered by the HEU-deal could thus be down-blended within some eight years.

With the existing technology and installations the blending down of HEU to a type of LEU which is no longer suitable for the manufacturing of nuclear explosive devices could be speeded up. An additional amount for down-blending equal to that encompassed by the present Russian-US HEU deal seems feasible. Hence, the current Russian HEU elimination capacity could be doubled. This is confirmed by estimates of the Russian Ministry of Atomic Energy, showing that from a technical point of view it is possible to expedite de-enriching. An increase by a factor of two could be achieved with minimal changes of existing installations and procedures. A more substantial acceleration—possibly by a factor of five—could be achieved by marginal changes requiring small investments.²⁹

HEU elimination costs and financial arrangements

The financial arrangements in conjunction with European funded HEU elimination in Russia, need to be negotiated thoroughly by the parties involved. But it is useful to specify what might be the terms of such an agreement. Overall costs relate to down-blending services, transportation, storage, control, verification, and administrative expenses.

A European-Russian agreement may encompass direct payments to Russia for every quantity of HEU that is de-enriched to 20%, or slightly below 20% (where any possibility of explosive uses can be excluded).³⁰ At a price of perhaps US \$10 for each gram of high-grade

HEU that is eliminated, \$10 billion would be needed for the elimination of the approximately 1,000 tons of HEU remaining in Russia. For national security reasons, however, Russia would retain some HEU in its down-sized nuclear arsenal. Some 500 tons, outside the ongoing elimination activities, could be feasible.

Only de-enrichment down to approximately 20% should be paid by donors. Payments could be considered interest-free loans, to be repaid by Russia *if* (or when) the material gets further de-enriched and treated to qualify as marketable LEU for sale to facilities worldwide for the production of electricity. Further de-enrichments to make commercial fuel out of the LEU will have to be paid for by Russia. This would have the advantage of creating tight borders between what the donors and Russia do for security reasons and what Russia does for commercial reasons at a later stage. Furthermore, with this scheme it might be possible to reduce the costs for the Russian down-blending services.

Another flexibility could be added by negotiating paying for Russian HEU-originated fuel not by financial transfers from donor states, but by deducting existing Russian state debt to would-be donors. Possible “Debt for Nonproliferation Swaps” have been proposed at past G-8 Meetings. To Russian actors, such proposals may be attractive, though details would still need to be worked out. For the scheme to work, enough transparency should be provided by Russia to verify that the production of new HEU has definitely stopped, and secondly, that the de-enriched HEU is properly measured, accounted for and safeguarded (possibly by the International Atomic Energy Agency).

Transparency and verification measures have been successfully implemented under the ongoing HEU-deal.³¹ Under this agreement there are three transparency objectives for the U.S. Department of Energy (DOE). Firstly, that the HEU is extracted from nuclear weapons. Secondly, that the same HEU is oxidised. Finally, that the HEU is blended into LEU. For Russia, the primary transparency objective is that the LEU is fabricated into fuel for commercial nuclear power reactors in the United States.³² After the initial two years of operation, all measurements under the existing HEU-agree-

ment have been consistent with the declared HEU enrichment levels.³³ The addition of key transparency arrangements in 1995 was undoubtedly aided by the \$100-million cash advances to the Russian Ministry of Atomic Energy.³⁴

The urgent need for innovative nuclear security thinking

The most effective approach to reduce the danger of nuclear terrorism and further state nuclear proliferation is to eliminate—as drastically and as quickly as possible—the existing stocks of unirradiated (fresh) highly enriched uranium (HEU) by converting them into low enriched uranium (LEU).

The largest obstacle to manufacturing and detonating crude nuclear explosive devices is the difficulty to acquire the basic “raw material” for such devices—weapon-grade HEU. Technical barriers, in terms of what it takes to design a nuclear explosive device, are unlikely to suffice as an adequate measure to deny new actors (including terrorists) nuclear capabilities. Currently, less than half of nuclear bomb-making material in Russia is under the protection of comprehensive security upgrades, leaving enough material to make tens of thousands of weapons poorly secured. Once the material is missing, it is difficult—if not impossible—to interdict.

European parties should thus, as early as possible, provide Russian authorities with the financial incentives needed for the blending down of HEU stocks currently outside the scope of the ongoing US-Russian HEU elimination agreement. A scheme where additional Russian HEU is down-blended to LEU, kept in Russian custody and ownership and then stored in Russia under international control, is feasible and likely to provide the quickest results. A doubling of the existing elimination rate seems feasible, using existing Russian facilities.

The resulting LEU is thus decoupled from the market and market fluctuations that could have effected the pace of the HEU elimination. To European donors, security concerns should thus prevail over isolated economic benefits from uranium trade. European actors should focus on the single and clearly defined goal of non-prolif-

“Committed terrorists [have] found a way to exchange commitment for complexity. It is a powerful tool.”

Richard L. Garwin, Ph.D.,
consultant to the U.S.
government on matters of
military technology and
arms control

“The reduction of nuclear arsenals and the removal of the threat of worldwide nuclear destruction is a measure of the power and strength of a great nation.”

Jimmy Carter

“The national security team (should) give nuclear terrorism priority over every other threat to the United States.”

President George W. Bush,
October 2001

eration and avoid possible gaps in the nuclear energy issues. To further other non-proliferation goals, requirements could be formulated to ensure that the revenues of the Russian Federation from the HEU elimination are used to improve Russian nuclear security.

If additional HEU elimination efforts are to be initiated, then it is likely to require an initial push from the European side. In this regard, the Russian willingness to address fissile material disposition under the auspices of the G-8 could provide the political openings needed for improved HEU elimination. Proposals of debt swaps for nuclear non-proliferation swaps are also of high interest in conjunction with additional HEU elimination.

Before any practical HEU elimination efforts are implemented, however, further in-depth assessments are needed. They should be performed by key qualified Russian experts once the needed political interest has been generated. Ongoing HEU elimination work shows that satisfactory HEU verification schemes are feasible with the required intrusiveness to gain confidence in non-diversion, and at the same time taking into consideration legitimate Russian security concerns.

The absence of acts of nuclear terrorism does not allow for complacency. The only thing that can compensate for a late start will be accelerated efforts in the future. Irrespective of the different history, strategic considerations and priorities of different parities, common ground can probably be reached through innovative security thinking. Accelerated HEU elimination may be accomplished through the common denominator of mutual, regional, and global security benefits. Eventually, closer relations between Russia and the EU have the potential of doing more good to Russian-EU relations and perceptions of security than traditional Cold War perspectives of security and strategic nuclear reserves.

Endnotes

- ¹ The threat was inter alia emphasised by the UN high-level panel to propose collective action to meet new global challenges, in their December 2004 report. See <http://www.un.org/secureworld/>.
- ² A comprehensive discussion of the issue of nuclear terrorism is also given in Morten Bremer Mærli, *Crude Nukes on the Loose? Preventing Nuclear Terrorism by Means of Optimum Nuclear Husbandry, Transparency, and Non-Intrusive Fissile Material Verification*, Dissertation for the Degree of Dr.Philos, Faculty of Mathematics and Natural Sciences, University of Oslo, Norway, March 2004. <http://www.nupi.no/IPS/filestore/664.pdf>
- ³ Ashton B. Carter, “How to Counter WMD”, *Foreign Affairs*, September/October 2004, 77.
- ⁴ Matthew Bunn, Anthony Wier, and John P. Holdren. *Controlling Nuclear Warheads and Materials: A Report Card and Action Plan*. Washington, D.C.: Nuclear Threat Initiative and the Project on Managing the Atom, Harvard University, March 2003. http://www.nti.org/e_research/cnwm/overview/cnwm_home.asp
- ⁵ The report may be down-loaded from www.ski.se/dynamaster/file_archive/040511/4e8cb165a0a960aba648aaf3479fe05e/2004%5f15.pdf Authors were Gunnar Arbman, Francesco Calogero, Paolo Cotta-Ramusino, Lars van Dassen, Maurizio Martellini, Morten Bremer Mærli, Alexander Nikitin, and Jan Prawitz
- ⁶ Jeffrey Boutwell, Francesco Calogero, Jack Harris, “Nuclear Terrorism: The Danger of Highly Enriched Uranium (HEU)—*Pugwash Issue Briefs* Volume 2, Number 1, September 2002 <http://www.pugwash.org/publication/pb/sept2002.pdf>
- ⁷ Canberra Commission on the Elimination of Nuclear Weapons, 1996. <http://www.dfat.gov.au/cc/cchome.html>;
- ⁸ David Albright and Kimberly Kramer, “Stockpiles Still Growing”, *The Bulletin of the Atomic Scientists*, November/December 2004, 14.
- ⁹ This is a very rough estimate. The number depends on the kind of nuclear weapons in question. If one, for instance, assume that an HEU implosion device requires 10 kg, which is a very conservative estimate—the equivalent is 150,000 warheads. On the other hand, thermonuclear weapons may have 30-40 kg HEU or so in their secondaries, giving an equivalent of some 40,000 warheads. Some 50 kg HEU suffice for a crude nuclear explosive device, giving an equivalent of some 30,000 such devices.
- ¹⁰ See USEC’s “Megatons to Megawatt” program, at http://www.usec.com/v2001_02/HTML/megatons.asp
- ¹¹ Howard Baker and Lloyd Cutler, “A Report Card on the Department of Energy’s Non-Proliferation Programs with Russia”, the Secretary of Energy Advisory Board, United States Department of Energy, January 10, 2001,

- <http://www.ceip.org/files/projects/npp/pdf/DOERussiaTaskForceReport011001.pdf>. The swift and effective elimination of Russian excess HEU was among the key recommendations of the review panel.
- ¹² Therese Delpech, "International Terrorism and Europe", Chaillot Papers, No. 56, December 2002; Harald Müller, "Terrorism, proliferation: a European threat assessment", Chaillot Papers No. 58, Institute for Security Studies, European Union, March 2003; Alexander Kelle, Annette Schaper, "Terrorism using biological and nuclear weapons: A critical analysis of risks after 11 September 2001," PRIF Report n. 64, 2003.
 - ¹³ Matthew Bunn, Anthony Wier, and John P. Holgren. *Controlling Nuclear Warheads and Materials: A Report Card and Action Plan*. Washington, D.C.: Nuclear Threat Initiative and the Project on Managing the Atom, Harvard University, March 2003. http://www.nti.org/e_research/cnwm/overview/cnwm_home.asp
 - ¹⁴ National Intelligence Council, Annual Report to Congress on the Safety and Security of Russian Nuclear Facilities and Military Forces, February 2002, p. 2., quoted in Tom Z. Collina and Jon B. Wolfsthal, "Nuclear Terrorism and Warhead Control in Russia", *Arms Control Today*, April 2002, http://www.armscontrol.org/act/2002_04/colwolfapril02.asp
 - ¹⁵ Scott Parrish and Tamara Robinson, "Efforts to Strengthen the Export Controls and Combat Illicit Trafficking and Brain Drain," *Nonproliferation Review*, Spring, 2000 and Matthew Bunn, "The Next Wave: Urgently Needed Steps to Control Warheads and Fissile Materials." Carnegie Endowment for International Peace, 2000.
 - ¹⁶ BBC, "Fears over missing nuclear material", March 7, 2002, <http://news.bbc.co.uk/1/hi/world/americas/1859560.stm>
 - ¹⁷ V.A. Orlov, "Exports Control and Nuclear Smuggling in Russia", in G.K. Bertsch and W.C. Potter, (eds.) *Dangerous Weapons, Desperate States*, New York: Routledge, 1999.
 - ¹⁸ Sen. Dick Lugar at the Nuclear Threat Initiative Conference: "Reducing the Threats from Weapons of Mass Destruction and Building a Global Coalition Against Catastrophic Terrorism", Moscow, May 27, 2002.
 - ¹⁹ Incident quoted in William C. Potter and Elena Sokova, "Illicit Trafficking in the NIS: What's New? What's True?", *Nonproliferation Review*, Summer 2002, p. 116.
 - ²⁰ Asserted during a meeting 21 February 2002 with former Russian Minister of Atomic Energy Viktor Mikhailov.
 - ²¹ Former Russian Minister of Atomic Energy Viktor Mikhailov.
 - ²² Former Russian Minister of Atomic Energy Viktor Mikhailov.
 - ²³ For the resolution text, see <http://www.state.gov/t/np/rls/other/31990.htm>
 - ²⁴ All resolutions issued under the Chapter VII of the UN Charter, as UNSC resolution 1540 was, are binding to UN members. All member states now are accountable (Khripunov 2005, 60).
 - ²⁵ Joseph Cirincone, John Wolfstahl and Miriam Rajkumar, *Deadly Arsenals: Tracking Weapons of Mass Destruction*. Carnegie Endowment for International Peace, p. 116.
 - ²⁶ John Wolfsthal, Cristina-Astrid Chuen, and Emily Ewell Daughtry (eds.) *Nuclear Status Report 2002*, pp. 75-175.
 - ²⁷ The number of facilities where HEU is located will be much larger if the many locations for strategic and tactical weapons are included.
 - ²⁸ According to the database of the Center for Non-proliferation Studies, <http://www.nti.org/db/nis-profs/russia/fissmat/enrichme/overview.htm>
 - ²⁹ Personal communication with Richard Garwin and Matthew Bunn, Spring 2003.
 - ³⁰ Jeffrey Boutwell, Francesco Calogero, Jack Harris, "Nuclear Terrorism: The Danger of Highly Enriched Uranium (HEU)" – *Pugwash Issue Briefs* Volume 2, Number 1, September 2002 <http://www.pugwash.org/publication/pb/sept2002.pdf>
 - ³¹ Transparency provisions for the HEU deal are outlined and specified in a set of Annexes to the main agreement covering: Requirements for a bilateral US-Russian Transparency Review Committee, Requirements for notification of visits and related arrangements, Procedures of US monitoring activities at specified Russian down-blending facilities, Procedures of Russian monitoring activities at specified US recipient facilities, Procedures of Russian monitoring activities at specified US fuel fabrication facilities, Forms for accountability records, Procedure for blind sample analysis, Description of analytical methods for determining the uranium content and assays of enrichment of uranium-235, Procedures for the use of tags and seals, Technological process descriptions, Description of financial arrangement for transparency activities, Requirements for monitoring equipment, Description of radioactive standards, Procedures for exchange of HEU material reports between Russia and the US.
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