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# Disposition of Excess Military Nuclear Material

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## Overview

Nuclear material in military stockpiles is the largest category of nuclear fissile material that has been produced in the world. In 2012 the global stockpile of highly enriched uranium (HEU) was estimated to be about 1440±125 tonnes and of separated plutonium 495±10 tonnes.[1] Most of this material was produced as part of military programmes and a large fraction of it remains available for military purposes. About 940 tonnes of HEU and almost 140 tonnes of plutonium are in nuclear weapons or weapon components or available for warhead production. This amount of material is equivalent to more than 55,000 nuclear weapons.

Verified and irreversible elimination of weapon-usable nuclear material is one of the essential elements of the nuclear disarmament effort. The Action Plan adopted at the 2010 Nuclear Non-Proliferation Treaty (NPT) Review Conference calls on nuclear-weapon states to declare fissile material designated as no longer required for military purposes, and to place this material under safeguards to ensure that it remains permanently outside military programmes.[2] All states are also encouraged to develop verification arrangements that would ensure irreversible elimination of military materials.[3] In addition to supporting the nuclear disarmament process, these steps could also be a stepping stone towards a fissile material control regime that would stop production of new military material and begin elimination of the existing stocks.

After the end of the cold war, the United States and Russia, the two states that possess the largest stockpiles of military fissile materials, declared more than 700 tonnes of HEU and almost 100 tonnes of weapons-grade plutonium as excess to military requirements. They also have made significant progress in setting up programmes to eliminate the excess material—more than 550 tonnes of military HEU had been eliminated by the end of 2011.[4] The United Kingdom is the only other state that declared some of its military material as excess to

1 International Panel on Fissile Materials, *Global Fissile Material Report 2011: Nuclear Weapon and Fissile Material Stockpiles and Production*, 2012, pp. 2–3.

2 2010 NPT Action Plan, action 16.

3 Ibid., action 17.

4 International Panel on Fissile Materials, *Global Fissile Material Report 2011: Nuclear Weapon and Fissile Material Stockpiles and Production*, 2012, pp. 8–9, 17.

national security needs. However, unlike the United States and Russia, the United Kingdom has not yet made arrangements for elimination of this material.

The experience of the US-Russian programmes to eliminate fissile materials suggests that there are no significant barriers that would prevent nuclear-weapon states from declaring more of their military material as excess to military purposes. At the same time, these programmes have demonstrated the difficulty of disposing of weapon materials in a safe, secure and economically efficient way. This paper presents an overview of the current programmes and some of the problems they have encountered.

## Declarations of excess HEU

The United States declared more than 370 tonnes of HEU as excess to its weapon requirements. The first declaration, made in 1996, stated that 174.3 tonnes were not required for military purposes. About half of this amount was weapon-usable material and the remaining half was uranium with lower that weapons-grade enrichment levels.[5] In the second declaration, made in 2005, the United States pledged to remove up to 200 tonnes of HEU "from further use as fissile material in U.S. nuclear weapons". The bulk of this material, 160 tonnes, was designated for use in naval propulsion reactors.[6] However, only about 100 tonnes of this HEU will be available before 2050. This leaves 210 tonnes of HEU that the United States designated for elimination as excess to its military needs.

Elimination of the excess HEU in the United States is done by down-blending it with natural or low-enriched uranium (LEU) to produce LEU that is then used to fuel power, research or special-purpose reactors.[7] By 2013 the United States expects to complete down-blending of 135 tonnes of its HEU. Elimination of the remaining material is scheduled to be completed by 2050. The current blend-down rate is about 3–4 tonnes annually, which corresponds to the rate of dismantlement of weapon components.[8]

The United States invited the International Atomic Energy Agency (IAEA) to monitor parts of its HEU elimination programme. As a result, the IAEA conducted a verification experiment that monitored down-blending of about 50 tonnes of HEU at two US facilities. This arrangement, however, has not been made permanent. Also, the IAEA had no access to the US Department of Energy facilities that carry out most of the current down-blending activities.[9]

Russia's only declaration of excess HEU was made as part of the US–Russian HEU-LEU deal, also known as the "Megatons to Megawatts" programme. In this arrangement, reached

5 The total equivalent amount of 93.5% HEU was less than 115 tonnes. Thomas B. Cochran, "Disposition of Fissile Material from Nuclear Weapons", presentation at ISODARCO-Beijing Seminar on Arms Control, 28 October 28–2 November 1998, <http://docs.nrdc.org/nuclear/files/nuc_10289801a_202.pdf>.

6 US Department of Energy, "DOE to Remove 200 Metric Tons of Highly Enriched Uranium from U.S. Nuclear Weapons Stockpile", 2005.

7 International Panel on Fissile Materials, *Global Fissile Material Report 2007: Developing the Technical Basis for Policy Initiatives to Secure and Irreversibly Reduce Stocks of Nuclear Weapons and Fissile Materials*, 2007, p. 30.

8 International Panel on Fissile Materials, *Global Fissile Material Report 2011: Nuclear Weapon and Fissile Material Stockpiles and Production*, 2012, p. 9.

9 International Panel on Fissile Materials, *Global Fissile Material Report 2007: Developing the Technical Basis for Policy Initiatives to Secure and Irreversibly Reduce Stocks of Nuclear Weapons and Fissile Materials*, 2007, p. 30.

in 1993, Russia designated 500 tonnes of its military-origin HEU for down-blending to LEU that will be used to produce fuel for US civilian power reactors. The first shipment of LEU to the United States took place in 1995 and by the end of 2011 the programme had successfully eliminated 442.5 tonnes of HEU. The down-blending will be completed in 2013.[10]

As part of the US–Russian umbrella agreement that regulates the HEU-LEU deal, the United States monitors the key stages of the process during regular visits to the facilities that are involved in the programme.[11] Russia also conducts visits to the US fuel fabrication facilities to ensure that the LEU is not diverted from civilian use. The IAEA is not involved in the transparency and verification activities.

Even after the United States and Russia complete elimination of the material that has already been declared excess, the remaining stock of HEU would exceed any reasonable military requirements. The United States will have about 200 tonnes of HEU available for weapons, and Russia more than 600 tonnes.[12] This corresponds to about 8,000 and 24,000 nuclear weapons respectively. Given that the US and Russian nuclear arsenals are about half that size already, both states could declare more HEU as excess to national security requirements.

Other nuclear-weapon states have not declared any of their HEU as excess to military purposes. The amounts of material of these states is much smaller—France is estimated to have 26 tonnes of military HEU, the United Kingdom almost 20 tonnes, and China about 16 tonnes. Given that France has declared that it has fewer than 300 nuclear warheads in its arsenal and the United Kingdom stated its intention to retain no more than 160 operationally deployed warheads, each state could declare at least several tonnes of HEU as excess to weapons purposes. The same applies to China, whose nuclear arsenal is estimated to include about 180 deployed weapons.[13]

France and the United Kingdom regularly declare their holdings of civilian HEU to the IAEA, as part of their annual INFCIRC/549 declarations. According to these declarations, France and the United Kingdom had 4.6 tonnes and 1.4 tonnes of civilian HEU respectively.

## Disposition of excess military plutonium

The United States declared in 1996 that it had designated 52.5 tonnes of plutonium as excess to its military requirements. Of this amount, only 38.2 tonnes is weapons-grade plutonium that is a potentially weapons-usable material. Most of the rest of the material is in waste, in spent fuel and in other forms.[14] In the 1990s, the United States and Russia

10 International Panel on Fissile Materials, *Global Fissile Material Report 2011: Nuclear Weapon and Fissile Material Stockpiles and Production*, 2012, p. 8.

11 Oleg Bukharin, "Understanding Russia's Uranium Enrichment Complex", *Science & Global Security*, vol. 12, no. 3, 2004, pp. 193–214.

12 This takes into account the US commitment of 160 tonnes of HEU for naval propulsion. International Panel on Fissile Materials, *Global Fissile Material Report 2011: Nuclear Weapon and Fissile Material Stockpiles and Production*, 2012, p. 9.

13 Hans M. Kristensen and Robert S. Norris, "Chinese nuclear forces, 2011", *Bulletin of the Atomic Scientists*, vol. 67, no. 6, 2011, pp. 81–87.

14 Thomas B. Cochran, "Disposition of Fissile Material from Nuclear Weapons", presentation at ISODARCO-Beijing Seminar on Arms Control, 28 October–2 November 1998, <http://docs.nrdc.org/nuclear/files/nuc_10289801a_202.pdf>.

reached an agreement to eliminate 34 tonnes of the excess weapons-grade plutonium in the possession of each state. The Plutonium Management and Disposition Agreement (PMDA) was signed in 2000 and finalized in 2010.[15]

According to the agreement, the United States will dispose of its weapons-grade plutonium by using it to produce mixed oxide (MOX) fuel for light water power reactors. To produce the MOX fuel, the United States is building a MOX Fuel Fabrication Facility (MFFF) at the Savannah River Site.[16] The facility, built by the French company AREVA, is expected to begin operation in 2018. However, the full-scale use of MOX fuel will probably not begin until 2025.[17] It will take about 13 years to eliminate all 34 tonnes of the surplus plutonium.

Russia has also made a commitment to eliminate "up to 50 tonnes" of its weapons-grade plutonium that it has declared excess. However, the US–Russian agreement covers only 34 tonnes of its weapons-grade material. Like the United States, Russia intends to use its plutonium to manufacture MOX fuel, but this fuel will be used in fast neutron reactors, BN-600 and BN-800, rather than in light water reactors.[18] Russia is yet to begin construction of the fuel fabrication plant, so it is highly unlikely that the programme will begin before 2018.

One important element of the PMDA agreement is that the disposition programmes will be offered for IAEA verification.[19] In August 2010 Russia and the United States forwarded a formal request to the IAEA to begin formal consultations that would allow each state "to implement verification measures" with respect to their disposition programmes.[20] The scope of the verification measures is yet to be determined. At this point it is not clear whether they would include implementation of IAEA safeguards at the plutonium storage facilities or be limited to the verification of the fuel fabrication process and the subsequent use of the fuel in reactors.

The only other state that declared excess plutonium is the United Kingdom. In 1998, the United Kingdom declared 0.3 tonnes of its weapons-grade plutonium excess to military needs and stated its intention to place it, together with 4.1 tonnes of non-weapons-grade material, under IAEA safeguards.[21] Apparently the United Kingdom has not yet concluded a safeguards agreement with IAEA that would cover the weapons-grade material.[22]

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15 "United States and Russia sign protocol to plutonium disposition agreement", IPFM blog, 13 April 2010, <www.fissilematerials.org/blog/2010/04/united_states_and_russia_.html>.

16 "Changes in U.S. Surplus Plutonium Disposition program", IPFM Blog, 20 July 2010, <www.fissilematerials.org/blog/2010/07/changes_in_us_surplus_plu.html>.

17 "U.S. plutonium disposition program: Uncertainties of the MOX route", IPFM Blog, 10 March 2011, <www.fissilematerials.org/blog/2011/03/us_plutonium_disposition_.html>.

18 "U.S.-Russian Plutonium Management and Disposition Agreement", IPFM Blog, 11 May 2010, <www.fissilematerials.org/blog/2010/05/us-russian_plutonium_mana.html>.

19 2000 Plutonium Management and Disposition Agreement as amended by the 2010 Protocol, article VII.3.

20 "Communication from the Permanent Missions of the Russian Federation and the United States of America regarding a Joint Letter regarding the Agreement concerning the Management and Disposition of Plutonium Designated as No Longer Required for Defense Purposes and Related Cooperation", IAEA document INFCIRC/806, 16 September 2010.

21 UK Ministry of Defence, *Strategic Defence Review*, 1998, chp. 4, para. 72.

22 The 4.1 tonnes of non-weapons-grade plutonium stored at Sellafield is probably covered by IAEA and Euratom safeguards established there. "IAEA Safeguards in the UK", Office for Nuclear Regulation, <www.hse.gov.uk/nuclear/safeguards/iaeauk.htm>.

As it is the case with HEU, the amounts of military plutonium in nuclear-weapon states are substantially larger than those required to maintain their nuclear stockpiles. After taking into account the excess material declarations, the plutonium stockpiles of the United States and Russia are estimated to be 38 and 88 tonnes respectively.[23] This corresponds to more than 30,000 nuclear weapons. Clearly, the two states could declare more plutonium as excess to military requirements.

The situation in other nuclear-weapon states is similar. The military plutonium stocks of France, the United Kingdom and China are estimated to be 6, 3.2 and 1.8 tonnes respectively. Given the size of their arsenals, France and the United Kingdom could probably declare several tonnes of their plutonium as excess. China might, in fact, need most of its weapons-grade plutonium to maintain its arsenal of nuclear warheads. However, it could probably still designate several hundred kilograms of the material as excess to national security needs.

## Implementing the NPT Action Plan

Declarations of excess military material made by nuclear-weapon states so far and the HEU and plutonium disposition programmes that are currently underway provide valuable lessons for the future efforts to implement the relevant items of the 2010 NPT Action Plan. First of all, these programmes demonstrate that elimination of excess military nuclear material could be an essential element of nuclear disarmament efforts. If properly structured, these programmes could serve as an important first step towards a comprehensive fissile material control regime. Second, even if these programmes deal with limited amounts of material, they provide a proving ground for technical, legal and institutional arrangements that would support verifiable and irreversible elimination of military nuclear materials. Last, but not the least, these programmes eliminate weapons-usable materials, making them unavailable to state military programmes or to terrorists.

The current programmes also demonstrated the challenges of meeting the goals of the NPT Action Plan. The states that have made the excess material declarations did not actually set aside the material in the form that would be available for IAEA safeguards, as is called for by the plan. It appears that all arrangements with IAEA participation will include verification of the process of converting the weapon material to a non-weapons form, rather than actual safeguards of storage facilities. Although this appears to be a reasonable practical arrangement, it might lead to a situation in which nuclear material is available for military use decades after it was committed for elimination. Nuclear-weapon states could address this problem by physically moving the excess material to a dedicated storage facility that would be placed under IAEA safeguards. However, facilities that provide adequate protection of the material would be rather expensive and the transfer of material could present a serious problem from the security point of view. Still, this approach should be explored, for example at the Fissile Material Storage Facility in Ozersk, Russia, which will store most of the Russian excess plutonium. This facility was constructed with US assistance and will be open to inspections under a bilateral US–Russian agreement.

23 International Panel on Fissile Materials, *Global Fissile Material Report 2011: Nuclear Weapon and Fissile Material Stockpiles and Production*, 2012, p. 17.

Transfer of the nuclear materials that are being eliminated in some cases could present a serious security risk. For example, in the US–Russian HEU-LEU deal, about 30 tonnes of HEU is shipped annually between various Russian facilities that participate in the programme.[24] While the programme reported no serious accidents so far, the risk associated with these shipments is quite significant. It is clear that future elimination programmes should be structured in a way that takes this risk into account.

While elimination of HEU is technically straightforward, disposition of plutonium presents a serious technical challenge. The route that was chosen by the United States and Russia—burning plutonium in power reactors—is rather controversial from the point of view of economics and long-term security. The current plutonium disposition programme will eventually amount to a substantial public subsidy to the use of plutonium in civilian nuclear power generation. For example, the cost of the US MOX Fuel Fabrication Facility is estimated to be $5 billion.[25] Also, the US and Russian governments are expected to finance most of the MOX fuel fabrication facility in Russia, whose cost is estimated to be about $2 billion. The US and Russian programmes will help create the infrastructure of a plutonium economy, which could result in a substantial increase of plutonium in circulation and therefore undermine the goals of the disposition efforts.

These issues illustrate the complexity of the task of elimination of nuclear materials. They also suggest the need of a comprehensive approach towards fissile material disposition. The requirements of the 2010 NPT Action Plan are the first step towards developing an efficient fissile material elimination programme. This effort, however, will require coordinated efforts of nuclear- as well as non-nuclear-weapon states and close involvement of the IAEA at the early stages of the process.

24 Pavel Podvig, "The fallacy of the Megatons to Megawatts program", *The Bulletin of the Atomic Scientists*, 23 July 2008.

25 Ed Lyman, "It's Time to Pull the Plug on the MOX 'Factory to Nowhere'", Union of Concerned Scientists, 16 February 2011, <http://allthingsnuclear.org/post/3332906391/its-time-to-pull-the-plug-on-the-mox-factory-to>.

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