

DISCUSSION PAPER: STRENGTHENING THE SECURITY OF PLUTONIUM

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Introduction

Plutonium (Pu) and high enriched uranium (HEU) are often discussed together because they are both used in peaceful applications and usable for military purposes. Either separated Pu or HEU can constitute the essential nuclear explosive element of a nuclear weapon, and the international nonproliferation regime considers both as “sensitive material,” that used for peaceful purposes should be subject to stringent export controls and international safeguards.

Minimizing the use of HEU has been recognized repeatedly as a globally shared objective, including by the Nuclear Security Summits (NSS), given that HEU can be readily usable in a nuclear weapon and is geographically widespread, in some cases in states and at facilities with poor security policies and practices. As a result, thousands of kilograms of HEU used in civil facilities have been down-blended and the number of states and facilities with HEU has been reduced significantly.

States signing on to the 2014 Hague NSS communiqué encouraged “States to minimize their stocks of HEU and to keep their stockpile of separated plutonium to the minimum level, both as consistent with national requirements.” However, the NSS and associated events (e.g.,

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the Nuclear Industry Summits) have not specifically addressed the security of plutonium in either their broader policy objectives or specific initiatives or “gift baskets.”

While states use weapons-grade (WG) plutonium (with 90/97% Pu 239) resulting from a very low fuel burn-up in reactors in their nuclear weapons programs, reactor-grade (RG) plutonium, despite posing additional technical challenges, is deemed to be weapons-usable by potential proliferators or terrorist groups interested in even low yield or less reliable nuclear devices. Irradiated plutonium contained in spent fuel could also be used in radiological dispersal devices (RDDs), although for practical reasons, other radiological sources would be a much preferred terrorist path.

The responsibility for nuclear security, including for plutonium, rests at the national and operational level, and policy decisions on the use of nuclear energy and fuel cycle options belong to each state. However, a strengthened global political consensus regarding plutonium is needed. Increased international cooperation can contribute to enhanced security worldwide in the near term with a longer-term goal of improved security through the responsible management of plutonium. The high-level policy goal that might be pursued in the context of the 2016 NSS is to **minimize inventories of separated plutonium and pursue policies of “no new separation without a credible re-use plan within a reasonable timeframe.”**

Therefore, keeping in mind the main terrorism and proliferation threats posed by plutonium, the 2016 NSS could explore ways to **minimize inventories of separated plutonium and pursue policies to optimize the path forward to such minimization efforts.** This goal would require states to draw down existing inventories toward minimal requirements for civil energy use and to balance any future plutonium separation with elimination or consumption of equivalent or greater amounts of separated plutonium. Each individual government should determine how best to achieve this goal. This approach would be complementary to the continued application of physical protection measures and to efforts to minimize the number and location of reprocessing facilities worldwide.

In advance of the 2016 NSS, this paper explores a range of options, grouped into five different thematic approaches, for advancing these policy objectives. These approaches are

intended to enhance the global security of plutonium while recognizing the potential for legitimate use in the framework of recycling strategies (under appropriate security and nonproliferation conditions), to stimulate the debate, and to support national and multinational initiatives.

The first theme relates to the adoption and implementation of security measures. The next two themes concern the minimization of existing and future stocks of separated plutonium. The fourth theme aims to address a key future challenge. The final theme is directly inspired by the IAEA-led conceptual work on a “multinational approach to the nuclear fuel cycle,” going a step further to include a global approach to possible sharing of irradiation capacities.

Theme 1: Ensuring Proper Security of Plutonium

Since the September 11, 2001, attacks, attention has been brought to the need to protect strategic or “critical” facilities and infrastructure that may be the target of terrorists. Nuclear facilities are obviously part of these.

However, physical protection measures and approaches had been already developed for nuclear materials well before 9/11. Security measures, including physical protection measures, address terrorism or malicious acts by individuals or sub-state organizations, as well as proliferation by states that may rely on theft of material from other states to support their proliferation efforts. The main concern related to the theft of nuclear material, including separated civil plutonium, is that of an illegal transfer to a proliferating state or the manufacture of an explosive device (Improvised Nuclear Device) by terrorists.

The Convention on Physical Protection of Nuclear Materials (CPPNM) dates back to 1980 and shows an early concern for the security of nuclear materials. At that time, in the context of the expanding use of nuclear energy and related international trade in nuclear material, the focus was on the need to protect material while in international transport. As early as 1999, some states expressed the need to amend the CPPNM to expand its scope to nuclear material in domestic use and to the protection of nuclear facilities against sabotage. In response, the International Atomic Energy Agency (IAEA) organized discussions that resulted in the 2005 Amendment to the CPPNM, which has yet to garner the needed ratifications to

enter into force.

Even prior to the CPPNM's adoption, the IAEA published recommendations on physical protection measures.¹ The IAEA guidance (INFCIRC 225, now on its 5th revision) identifies three types of risks that should be taken into consideration for the protection of nuclear material and nuclear facilities:²

- Unauthorized removal with the intent to construct a nuclear explosive device;
- Unauthorized removal which could lead to subsequent dispersal;
- Sabotage of a facility containing nuclear material.

Any state with separated plutonium holdings or unirradiated plutonium contained in fuels should ensure proper security measures are applied in accordance with all relevant IAEA recommendations, the CPPNM, and international best practices. States with civil plutonium holdings should ratify all relevant international agreements, such as the CPPNM and its 2005 Amendment, make political agreements, and comply with their commitments. Pending their entry into force, states should undertake to voluntarily implement these commitments.

As of today, nine states—Russia, the United States, Japan, China, the United Kingdom, France, Belgium, Germany, and Switzerland—have signed the IAEA's "**Guidelines for the management of Plutonium**" (INFCIRC 549), committing themselves to ensure "responsible" management of plutonium, including accountancy and reporting practices, implementation of physical protection measures, and application of specific conditions to authorize export, etc. These nine states expressed their "hope that other States which separate, hold, process or use plutonium in their civil nuclear activities will adopt similar policies."

In addition, states with civil plutonium should support and regularly apply for peer reviews and best practices exchanges, including IAEA International Physical Protection Advisory

¹ As early as in 1975, the IAEA published INFCIRC 225, "Physical Protection of Nuclear Material," designed to support its member states by recommending a set of practices and detailed processes to protect nuclear facilities and material. Although non-binding, the text of INFCIRC 225, since revised 5 times, complements the CPPNM, which reflects the graded approach to levels of protection described in INFCIRC 225. INFCIRC 225 has become a reference text in numerous bilateral agreements and in such cases becomes legally binding, and is referenced in the Nuclear Suppliers Group Guidelines (INFCIRC 254, Rev 10, Part 1, para. 10 and Annex C).

² "Nuclear Security Recommendations on Physical Protection of Nuclear Materials and Nuclear Facilities," IAEA Nuclear Security Series No. 13.

Service (IPPAS) and International Nuclear Security Advisory Service (INSSERV) missions. Facilities with civil plutonium should implement and, if possible, exceed IAEA recommendations, exchange best security practices (e.g., through participation in the World Institute for Nuclear Security [WINS]), and organize inter-operator peer reviews while protecting sensitive information.

International cooperation can also support states with technical or financial needs. As stated in paragraph 15 of INFCIRC 549, the signatories agreed “to exchange experience in implementing these guidelines with other governments who implement similar guidelines and, as appropriate, to cooperate with them in seeking solutions to any practical problems which may emerge.” This commitment should be understood as an effort to provide technical, but possibly also financial, solutions. Arrangements (or assurance) should be envisaged to deal with unexpected security, political, or commercial situations, for instance, by offering reprocessing and/or irradiation services as needed to avoid security concerns.

Theme 2: Managing and Reducing Existing or “Legacy” Inventories

Reducing stockpiles of existing, idle inventories of civil separated plutonium through recycling is the simplest concept currently envisaged, although some potential policies need further scrutiny for their technical and financial implications.

Inventories of civil separated plutonium may result from an accumulation of separated plutonium from spent fuel from civil reactors that has not yet been recycled or otherwise disposed of. Inventories may also increase from the “civilianisation” (or declaring excess) of former military, weapons-grade plutonium.

Under the Plutonium Management and Disposition Agreement (PMDA) signed in 2000, the United States and the Russian Federation each agreed to dispose of no less than 34 metric tons of weapons-grade plutonium by converting it into fuel for use in civil reactors that produce electricity. Russia was to use this plutonium in Mixed Oxide fuels (MOX) for light water reactors. In the United States, the majority of the plutonium was to be used as MOX, but a small amount was to be “immobilized.”

The PMDA and related protocols went into force in January 2011, but since then, disposition

paths have already changed. Russia has since decided to use the plutonium in its future breeder reactor program consistent with its national energy strategy, relying upon the use of both existing and planned Russian fast reactors. After re-examination of the different options and their costs, the United States decided to only use MOX fuels in light water reactors and not to proceed with the immobilization, “can in canister,” option. Both Russia and the United States planned to begin disposition activities by 2018. The U.S. started building a MOX Fuel Fabrication Facility (MFFF) and a Waste Solidification Building at the Savannah River Site. In 2013, unanticipated cost increases for the MOX project and plutonium disposition program led the U.S. government to halt the project and reassess the different options based on the factors of efficiency, technical feasibility, and possible costs. In April 2014, a report was published describing the situation and the different options. The MOX fuel option remains the most credible option for quick implementation but the U.S. government still must decide on the way forward.³

The situation in the United Kingdom reflects a combined situation, where approximately 120 tonnes of “accumulated” plutonium comes from the civilian sector, and more material comes from the military program. The UK Nuclear Decommissioning Authority (NDA) published a position paper in January 2014 in which it outlined its position on alternatives to the use of MOX fuel in light water reactors, the option that was previously identified as preferred.⁴ The January 2014 summary indicates “...this work has resulted in NDA concluding that reuse remains the preferred option and, based on the information provided and against our definitions, there are three credible reuse options: – reuse as MOX in light water reactors, reuse in CANDU EC6 reactors and reuse in PRISM fast reactors. We note all the technologies being considered have pros and cons and that no ‘perfect’ solution exists. It may be that a multi-track approach offers best value for money.”

At the same time, although all shortlisted options explicitly consider the reuse of the plutonium in reactors, no option was identified as the preferred one. The paper states that “there is insufficient understanding of the options to confidently move into implementation

³ U.S. Department of Energy, “Report of the Plutonium Disposition Working Group: Analysis of Surplus Weapon-Grade Plutonium Disposition Options” April 2014. “All of the non-MOX options may require further development and/or analysis (e.g., technology development, discussions with Russia, modification of federal legislation) during a standby period”

⁴ Progress on approaches to the management of separated plutonium”, NDA, January 2014.

and consider[ing] that significant further work must be undertaken, focusing on technical and commercial risks and uncertainties, to enable DECC and [the] UK Government to ultimately select and subsequently implement its preferred reuse option." As a result, NDA intends "to undertake technical studies over the next 1-2 years with the technology suppliers to establish a consistent level of understanding of risks and uncertainties for each option."

Those states that are committed to dealing with their existing inventories should make final decisions on a preferred option or options and implement those options as soon as practicable. It is, however, important that such commitment is maintained over a sufficient time span (i.e., for decades) and consider related facilities as "durable" to allow the implementation of the minimization process over the necessary period of time. Possible cooperation on a bilateral or multilateral basis (for instance between the United Kingdom, the United States, and France) to share expertise and facilities could lead to cost effective and more timely solutions.

Another approach, modelled on HEU minimization efforts, is to consolidate stocks of separated plutonium that are awaiting civil use in fewer states. Such an approach was taken by Japan at the 2014 NSS when it announced plans to return some weapons-grade plutonium located in the Tokai plant to the United States. Until states have immediate prospects to use separated plutonium located in other states' reprocessing plants, arrangements should be made to prolong their storage at the reprocessing plant site, under effective safeguards and security provisions.

Theme 3: Adopting Plutonium Utilization Policies to Minimize Separated Plutonium

If it is important to favour the implementation of policies to reduce existing inventories, it is also important to ensure that transitional separated plutonium (i.e., plutonium that has been separated from spent fuel but not yet made into fuel pellets or assemblies) quantities are commensurate with the working stocks necessary for the fabrication of fuel.

In parallel, once “plutonium fuel”⁵ is produced it should be shipped within a reasonable amount of time to the nuclear power plant (NPP). On site, its storage period should be minimized as much as possible before its use. Converting material early to a less sensitive, less-weapons-usable form and avoiding too much delay between separation and production of such fuels and their use would contribute to minimizing separated plutonium inventories, and make it more difficult to recover separated plutonium for possible illicit uses.

Commercial reprocessing contracts should only be accepted for states with the facilities necessary for credible and timely recycling to ensure that stocks will be minimized as much as feasible, while allowing for sufficient working stocks. This policy, (which is already adopted and implemented by the French authorities) should be adopted by possible other commercial reprocessing facilities worldwide.

In parallel, reprocessing facilities and their customers should adapt their operational schedules for processing, fuel fabrication, and fuel loading as much as possible to minimize long-term storage.

States having engaged in a recycling policy should consider their decision a national-security-related decision, and any delays or policy changes should be evaluated in terms of whether there are corresponding security or proliferation risks.

Once authorization has been given to an operator to sign a contract for the fabrication of plutonium fuels, governments should avoid any action that would delay or prohibit further implementation of such contracts, except for an unexpected safety reason. If an unexpected safety reason emerges, all means should be sought by the government to find alternatives or “fallback” solutions (domestically or even abroad) to ensure that a corresponding quantity of separated plutonium can be used in another NPP. This could take the form of “security contracts” between operators, supported by relevant provisions of nuclear cooperation agreements with other states and implementing arrangements involving industry and operators. These arrangements could take different forms: leasing, lending, giving the fuel

⁵ In this paper, reference will be made to “plutonium fuels” as a generic concept designating any type of fuel fabricated with separated plutonium. It encompasses “MOX” fuels that are today in use in light water reactors but also other types of fuels that may be developed for other existing reactors or fourth generation reactors in the future.

away, or exchanging fuel against electricity in a regional arrangement.

Theme 4: Considering Recycling Options for Vulnerable Spent Fuels

Separated plutonium, and to a lesser extent fresh plutonium fuels, are more sensitive from a security and proliferation point of view than spent fuels containing irradiated plutonium, because separated plutonium is more “directly” usable by proliferators or terrorists. However, there are some categories of irradiated plutonium that are less well-protected or are low burn-up fuels that should be secured, and if possible processed, with a higher priority to avoid being the target of theft or malicious act.

Although the IAEA only categorizes irradiated and non-irradiated plutonium, it may be valuable as a voluntary measure for states with low burn-up irradiated fuel (that could be efficiently used in nuclear weapons) to identify low burn-up spent fuel stored at their NPP sites. Depending on the security measures and conditions (e.g., risk of unrest, civil war, etc.), this spent fuel should be determined as “**priority spent fuel**” to be evacuated, shipped to a reprocessing facility, fabricated into plutonium fuel, and ultimately burnt in a safeguarded NPP.

An international cooperative initiative could be devised to establish an international framework and provide for financial resources to support processing arrangements, recycling arrangements, and the establishment of a network of “voluntary NPPs” using plutonium fuels. Adequate financial arrangements should be investigated to compensate for possible additional costs incurred by the NPP.

Theme 5: A Global Approach to Reprocessing/Recycling

Separated plutonium is the product of a two-step process: generation in a reactor and separation from the spent fuel in a reprocessing plant. To cover future needs as appropriate, a multinational approach for reprocessing facilities could be developed based on plans to recycle materials. In addition, any new reprocessing should be pursued in ways that explore technical approaches to minimize the ease with which terrorists could access or use the facilities or products for illicit purposes.

Consistent with the multinational approach debated in the IAEA in the mid 2000's,⁶ responsible management of plutonium using a recycling strategy resulting in increased reprocessing needs would require:

- the opening up of existing national facilities to foreign customers or investors;
- the expansion of existing facilities' capacities when needed and as possible;
- when/if a new facility is needed, the adoption of a multinational, regional approach, thus limiting the number of facilities and the dissemination of technology worldwide.

More creatively, or ambitiously perhaps, than the initiative described under Theme 4, an international initiative (or an initiative initially led by a few like-minded nations) could focus on multinationally-financed and -owned NPPs that would be dedicated to using plutonium fuels in order to use "priority spent fuels" plutonium or other "idle plutonium." Such NPPs could be light water reactors or other fourth generation reactors that would be sited in stable regions and placed under international IAEA safeguards on a permanent basis, even if located in a nuclear-weapon state.

Conclusion

A cooperative decision to dedicate a few reactors that could be loaded with plutonium fuel, either in states where reactors using these types of fuels already exist or in states with appropriate security and safeguards credentials, could help draw down existing inventories.

A reasonable agenda and practical initiatives for enhancing security of separated plutonium to be used in NPPs can be developed globally, involving different actors: states, international bodies, industry, and non-governmental organizations (NGOs). To this end, states should be responsible for timely implementation of their bilateral or international commitments.

Decisions of states on plans to manage their inventories should not be unreasonably delayed or impede pursuing practical steps to secure and eliminate plutonium inventories. States could also propose as a transparency measure to communicate on their possible holdings of low burn-up spent fuel and look for short/medium-term solutions for their use and disposal.

⁶ "Multilateral Approaches to the Nuclear Fuel Cycle, Expert Group Report submitted to the Director General of the International Atomic Energy Agency," INFCIRC 640, February 22, 2005.

More generally, states should support a global approach by creating a positive and predictable legal framework for plutonium security and utilization both domestically and internationally.

The IAEA should play a major role, not only in supporting improved security practices through financial support and facilitating exchanges between experts and industry, but also by promoting strengthened cooperation between its members to facilitate practical solutions and broadened debate, as was the case with the 2003 discussion of Multinational Nuclear Fuel Cycle Approaches. The G8, or the European Union on a regional basis, could also play a triggering role in industrial/governmental agreements to favour the sharing of plutonium fuel irradiation capacities (even building a multinational plutonium fuelled dedicated NPP), fuel swap arrangements, and other supporting schemes.

A “club” of reprocessors and of users of plutonium fuels could create a network to facilitate fuel swap arrangements to better fit industrial needs, and recycle “priority spent fuels” for other states on security and nonproliferation grounds. NGOs could deploy “advanced” thinking, stimulate the debate, and energize initiatives. A number of successful initiatives have been undertaken by NGOs, for example, to facilitate HEU security or promote increased awareness and exchanges on best security practices.

It is however important to create a cooperative climate and propose pragmatic approaches on these issues avoiding past dogmatic attitudes. The NSS is an excellent opportunity to involve the different communities—governments, industry, and NGOs—and enhance a sense of global responsibility, creating avenues for global and possibly more efficient responses.