## Arms reduction and the peaceful use of nuclear energy

*As the world's major military powers move to reduce their nuclear arsenals, important questions are being raised about the control and potential use of nuclear materials recovered from dismantled nuclear warheads. They include the possible role of the IAEA if recovered plutonium and highly enriched uranium were to be transferred for storage or use in the civilian nuclear power sector. The following selected excerpts reflect some of the current thinking among international analysts and observers.*

Very large amounts of plutonium and highly enriched uranium (HEU) will be released from weapons and spent reactor fuels in the next two decades. If current reprocessing plans are implemented, around 215 tonnes of plutonium will be separated (by) the year 2000, and a further 235 tonnes in the following decade. If weapon dismantlement proceeds as expected, another 150 tonnes of plutonium and 500 tonnes of weapon-grade uranium could be released. These quantities will be added to today's already substantial stocks of these materials. At present, there are no clear strategies for managing these unprecedented flows of material. This not surprising since they were not anticipated, at least in the context of weapon dismantlement...

"The HEU extracted from nuclear weapons and released from the large strategic reserves held by the USA and Russia will have the greatest impact on nuclear fuel markets...The HEU in warheads due to be dismantled will translate into about 2 years' supply of enriched uranium fuel for the world's light water reactors, and will raise billions of dollars for the governments selling it (money that could help meet the costs of weapon dismantlement). The effects on fuel prices, and on demand for natural and depleted uranium, will depend on many factors, not least of which will be the rate at which the HEU is delivered to the market. The expectation is that this 'windfall' of enriched uranium will prevent fuel prices rising significantly above today's low levels for many years to come. Besides the public interest in more information, there is therefore also a strong commercial desire for data.

"While there is a ready market for HEU, it still presents security problems. The extraction of HEU (and plutonium) from warheads, its conversion from weapon- to reactor-grade material, its transportation between sites and between Russia and the USA under the agreement concluded in 1992 (whereby the latter will purchase the majority of the former's HEU stock) — at all stages, strict monitoring and physical protection will be required to prevent HEU being stolen or diverted.

"The market is unlikely to be able or willing to absorb such large amounts of enriched uranium in just a few years. It nevertheless seems important that the dilution of HEU to low-enriched uranium should proceed ahead of consumption, so that the quantities of weapon-grade material are quickly reduced. Equally, all HEU stocks released from military programmes, and in the process of dilution, should be placed under IAEA safeguards.

"The reduction of plutonium stocks will be much more difficult. The radiological hazards associated with plutonium increase substantially the costs of fabricating the mixed-oxide (MOX) fuel elements containing plutonium. Furthermore, the use of plutonium involves some sacrifice in fuel efficiency in power reactors since higher burnups can be achieved with conventional enriched uranium fuels. The prospect of so much diluted HEU entering the market will make the burning of plutonium even harder to justify on grounds of either commercial advantage or supply security. If current reprocessing schedules are followed, the scale of MOX fabrication capacity in Europe and Japan is also insufficient to prevent a substantial proportion of the plutonium emanating from reprocessing plants being left in store.

"While the material extracted from nuclear weapons will contain less of the radiologically troublesome isotopes of plutonium and will thus be easier to handle, the same disincentives will apply. In addition, neither Russia nor the USA have much commercial experience of plutonium recycling.

"It follows that if plutonium arisings cannot be absorbed commercially much of the plutonium will have to be treated as waste. Hitherto, the assumption guiding many R&D programmes in the nuclear field has been that plutonium is an asset. As a result, next to nothing has been spent on developing techniques for getting rid of plutonium once it has been separated. Various suggestions have recently been made, including burning up the plutonium in specially designed reactors, sequestering it in rock formations by carrying out underground nuclear explosions, mixing it with high-level wastes, and dispatching it to the sun. None of these options have yet received rigorous development and testing to find out whether

they are advisable on technical, economic and environmental grounds. A substantial international R&D effort is therefore going to be required to find acceptable solutions other than storage.

"While the control of HEU stocks will not be straightforward, plutonium presents special problems. The main stocks of HEU are the property of just two countries, the USA and Russia. In contrast, six countries (the USA, Russia, the UK, France, Germany, and Japan) will each possess tens of tonnes of separated plutonium, and a number of others will acquire smaller stocks. Many more countries, including both nuclear-weapon and non-nuclear weapon States, are therefore likely to acquire large stocks of separated plutonium.

"For all these reasons, the proposals mooted in the 1970s that an international plutonium storage scheme be established need to be looked at afresh. The possibility that plutonium (and HEU) could be brought under IAEA lock and key is also anticipated in Article XII.A.5 of the IAEA Statute. At the very least, all separated plutonium outside weapons and the weapon production system should automatically be placed under IAEA safeguards, wherever it is located."—**Messrs David Albright, Frans Berkhout, and William Walker, authors of *World Inventory of Plutonium and Highly Enriched Uranium 1992*, Stockholm International Peace Research Institute (SIPRI), Oxford University Press, 1993.**

## Non-proliferation issues & opportunities

The convergence of an increasing availability of weapons-usable nuclear material, decreasing economic justification for its use, the absence of reasons to be concerned about energy security, and continued anxiety about nuclear proliferation raise important questions about how to deal with the plutonium situation. The increased presence of highly enriched uranium resulting from its discharge from nuclear weapons raises comparable questions, but they are generally seen to be manageable although not entirely trouble free. A large and sudden release of blended down uranium could disrupt the uranium market and have a severe impact on enrichment service contracting, but this should be manageable and it does not contribute to, and in fact helps to resolve, a proliferation issue by creating a resource to address energy security concerns.

"Plutonium does not enjoy the same status as HEU. Commercial-grade plutonium, although less efficient and perhaps more unwieldy and risky to handle, still poses a proliferation problem...

"Stockpiled plutonium is widely regarded as an 'attractive nuisance' to be avoided. Those who oppose using plutonium agree that the least satisfactory solution is nationally stockpiled separated plutonium. Some argue that it is better left in spent fuel; others that it is better to burn it up in a reactor, and at least derive its energy benefit. Plutonium use or disposal is still an open issue, plagued by a large number of questions related to safety, security, and environmental consequences to which there are no easy answers, at least in political terms.

"The urgency in addressing the problem is driven by the projected release of approximately 200 tons of already separated plutonium from dismantled warheads. To this one can add a sizeable, but in comparison more modest 80 tons of separated reactor-grade plutonium. If present plans are implemented, the civilian reprocessing plans of France, Britain, and Japan will more than double the stock of separated plutonium by the end of the decade. No matter how one cuts it this means enough material for several thousand nuclear weapons. In a world of sovereign States, marked by uncertainties, instabilities, and insecurities, this cannot be but worrisome.

"One might be inclined to separate these issues, to treat military plutonium one way and civil another. Or one might look at the plutonium problem wholistically...

"I take the position that the issue of plutonium management needs to be addressed *now*, and *comprehensively*. The United States and Russia have a critically important opportunity to advance the cause of non-proliferation by placing discharged fissile material released from warheads under international controls. They should come to grips with the question of consigning this material to exclusively peaceful use or disposal; and they should agree on, and implement, the establishment of a storage arrangement subject to international verification to validate that all dismantled warhead material is placed in storage and remains there unless and until released for peaceful purpose or disposal and then subject to IAEA safeguards.

"By committing all of their retired warhead material to an international verification and control regime, the USA and Russia would at a stroke demonstrate the feasibility of international storage and verification, and establish a powerful

precedent for dealing with *all* fissile materials not actually in civil use everywhere, including weapons States' civil fissile material. At the same time, by accepting unprecedented new inspections and controls of their fissile materials they would deflate the argument that the non-proliferation regime is discriminatory because it imposes different rules on the nuclear-weapon States than on the non-nuclear weapon States. The storage arrangement would be open to all States and the objective would be to bring all plutonium of whatever origin and whatever State into the system. The other nuclear-weapon States should be called upon to follow, as should all States with separated plutonium on their territory or under their jurisdiction. But the decision to pursue this path should be taken in the first instance by the United States and Russia and not made contingent on the agreement of all other potential parties. The action of the weapons States would be a powerful motivating force. It would only be a matter of time before material outside the regime would be seen as lacking legitimacy, and that alone would have a meaningful impact on non-participating States."—**Dr Lawrence Scheinman, Professor of Government and Associate Director of the Peace Studies Programme, Cornell University, USA, in "Nuclear Non-Proliferation Implications of International Political Change and Decisions Related to Nuclear Disarmament", a paper presented at the International Workshop on Nuclear Disarmament and Non-Proliferation: Issues for International Action, sponsored by Tokai University, Princeton University, and the Federation of American Scientists, Tokyo, March 1993.**

## International inspection & verification

One option for enhancing controls on material from dismantled warheads would be to register the material for regular safeguards inspections by the IAEA. Russia, which is a member of the IAEA, could declare the existence of (its) highly enriched uranium to the IAEA once it is removed from weapons and enters the civilian sector. (The IAEA does not safeguard military nuclear material.) The IAEA maintains material balances on nuclear materials and facilities declared in accordance with safeguards agreements between the Agency and Member States. Once the material is demilitarized, the IAEA could place it under safeguards regardless of which options for storage or sale are eventually selected. IAEA safeguards could complement other bilateral and/or multilateral verification measures designed to minimize risk of diversion. So far, however, verification measures have not been implemented for the dismantlement process and materials from dismantled warheads have not come under safeguards."—**Messrs Zachary Davis, Marc Humphries, Carl Behrens, Mark Holt, and Warren Donnelly in "Swords Into Energy: Nuclear Weapons Materials After the Cold War", a report to the US Congress by the Congressional Research Service, Library of Congress, October 1992.**

Warhead elimination involves a sequence of related steps, including disabling, tagging, transportation, storage, dismantlement, and disposing of the highly enriched uranium and plutonium. Existing Soviet dismantling capacity is 1500 to 4500 warheads per year, whereas US capacity is 2000 to 4000 annually. However, the capacity of Russia to dismantle nuclear warheads under the prevailing conditions of economic and political upheaval may be far less than the theoretical potential, as with other Russian industries.

"It is important that verification go along with and be an integral part of the elimination process. The purpose of verification is to give reasonable assurance that there is no cheating and that warheads and fissile materials are what and where they are claimed to be. Regular warhead verification inspections should be carried out by bilateral or multilateral teams from countries involved in the agreed-on reductions, as well as third parties, such as the International Atomic Energy Agency or non-nuclear weapons States. There could also be international control or UN control of warheads and nuclear weapons materials."—**from "Warhead Dismantlement and Plutonium Disposal", in *Plutonium: Deadly Gold of the Nuclear Age*, by a special commission of the International Physicians for the Prevention of Nuclear War and the Institute for Energy and Environmental Research, Cambridge, Massachusetts, 1992.**

## Finding common solutions

World inventories of nuclear weapons are on the order of 50 000 warheads, predominantly in the United States and Russian arsenals (either deployed or in storage). These warheads contain on the order of 1000 tonnes of HEU and

220 tonnes of plutonium. Each tonne of HEU or plutonium in warheads could (depending on the conversion efficiency of the devices) yield about 10 megatonnes of explosive power. The same tonne of HEU or plutonium diluted down to reactor-grade or mixed-oxide fuel and used in a typical 1000-MWe power plant would generate a bit more than one reactor-year of power. World reactor capacity today is about 330 000 MWe. Thus, if one could suddenly convert all the uranium and plutonium in the world's nuclear arsenals to civilian use, it would provide little more than 4 years' worth of total world nuclear power production.

"Of course, weapons will not all be destroyed abruptly, nor will all the material be made available to commercial markets. Instead, only part of the total arsenal will be destroyed and various types of weapons, containing differing amounts of HEU, will be selectively retired and dismantled over a period of years. The rate of dismantlement, the ultimate scope of it, and the subsequent uses of fissile material will depend on a host of technical, economic, and policy variables...

"In both the USA and Russia, nuclear weapons are deployed by military agencies, but weapons assembly and dismantlement are handled by civilian or quasi-civilian agencies: in the USA by the US Department of Energy (US DOE) and in Russia by the Ministry of Atomic Energy (Minatom). It is notable that both agencies are also involved in commercial nuclear fuel cycle activities.

"Dismantlement in the USA is projected by US DOE to proceed at about 2000 warheads per year; Russian officials estimate their capacity at about 1500 to 2000 warheads per year. Both rates assume use of one daily work shift at dismantlement facilities, the main constraint on dismantlement rates. Either side could thus increase its rate three-fold, though neither seems likely to do so.

"At these rates, the USA and Russia will each 'mine' between 15 and 20 tonnes of high enriched uranium and five to eight tonnes of weapons-grade plutonium per year. The precise figures depend on the types of warheads being dismantled.

"It is possible —indeed likely — that the products of weapons dismantlement will not simply add to world supply, but rather displace part of it. High enriched uranium can be thought of as a storehouse of electricity, in the form of enrichment services; the enrichment component currently accounts for about two-thirds of the value of the material. For owners of gaseous diffusion plants — which are extremely electricity intensive — blending of HEU could displace large amounts of expensive power. The costs avoided by utilizing HEU in this way may be greater than the material could be worth if blended down and sold directly in the market, especially if such sales led to further price declines in an already depressed market...The most likely disposition of weapons plutonium is indefinite storage. But in principle, high-purity plutonium could also be swapped for the lower quality product that might otherwise derive from the reprocessing of spent fuel, perhaps resulting in significant cost savings to those wishing to use mixed-oxide or breeder fuels.

"If the disposition of surplus plutonium from weapons dismantlement and civilian nuclear programmes are converging problems, it may make sense to look for common solutions that have economic, security, and perhaps political benefits for everyone. A number of proposals have been advanced for dealing with the plutonium arising from dismantlement, all of them costly and — unlike the situation with HEU — thus far without positive incentives to handle the job safely... At the same time, large amounts of civil plutonium already safeguarded in a storable denatured form — spent fuel — are scheduled to enter operating, newly completed, and planned reprocessing plants in Europe and Japan. This situation presents a challenge that must have a rational and perhaps mutually advantageous solution.

"It is an irony of history that civil nuclear technology, that had its birth in early weapons programmes but later followed a separate evolutionary path, now finds that path again intersecting that of nuclear weapons programmes. We must work to find ways to ensure that the evolution of civilian nuclear power continues, just as we would like to see an unthreatening twilight fall on the arms race. To do so successfully will require that those nations with the largest stakes be willing to rethink their economic, security, and programmatic objectives and find co-operative solutions to both problems."—**Dr Thomas L. Neff, senior member of the Center for International Studies, Massachusetts Institute of Technology, in the paper "Disposition of HEU and Plutonium from Nuclear Weapons", *Uranium and Nuclear Energy 1992*, proceedings of the 17th international symposium held by the Uranium Institute, London, September 1992.**