# A Proposal for the Disposition of Russian Excess Plutonium from Weapons

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Presented
at the

Third Pugwash Workshop
on
The Status and Future of the Nuclear Weapons Complexes
of Russia and the USA

March 24-26, 1996

Moscow

## PREFACE

National stockpiles of separated plutonium, including excess plutonium from weapons and separated "civil" plutonium and highly-enriched uranium, may act as a barrier to very deep reductions and eventually elimination of nuclear weapons held by declared and undeclared weapon states. In addition, separated stocks of weapon-usable fissile materials under insecure storage and use pose a serious risk of theft and subsequent use by rogue states. In an effort to address these concerns, over the past couple of years NRDC has presented several variants of a mixed-oxide fuel (MOX) proposal designed to cap and draw down inventories of separated plutonium. The common thread of these proposal variants is that they take advantage of the fact that today it is cheaper to store and dispose of spent fuel directly, than it is to reprocess the spent fuel, recover and recycle the plutonium and unused uranium, and then store and dispose of the fission product waste. Under these proposals the customer is charged a fee equivalent to, or slightly less than, the cost of reprocessing services, but the customer's plutonium-bearing spent fuel is stored intact in a form suitable for ultimate direct disposal, and the plutonium and uranium that is normally recovered through reprocessing, is supplied from existing stocks--the plutonium from stocks of excess plutonium from weapons. The revenues accruing to the new enterprise from the sale of fuel cycle services -- at a modest discount from prevailing prices for spent fuel reprocessing and commercial MOX fuel fabrication – should exceed its combined costs for long-term storage of spent fuel and MOX fabrication using weapon-grade plutonium. This competitive advantage is sustained even if allowances are made on the one hand, for the value of the uranium that would have been obtained through reprocessing, and on the other, for the reduction in long-term storage costs for separated plutonium. While detailed calculations are needed to confirm this concept, it appears at least plausible to design a program in which disposing of the excess plutonium from weapons as MOX fuel pays for itself, or conceivably earns a profit.

The first proposal variant of this concept was published by my colleague, Christopher E. Paine, and me in *Controlling the Atom in the 21st Century,* edited by David P. O'Very, Christopher E. Paine and Dan W. Reicher, (Boulder, CO: Westview Press, 1994), pp. 25-28. A second variant directed toward disposing of U.S. excess plutonium was presented at an American Nuclear Society conference in Washington, D.C. on November 16, 1994. Two months ago Chris and I, together with Jack Edlow of Edlow International, drafted a new variant directed at disposing of excess Russian plutonium. This Pugwash paper elaborates on this latest proposal.

## I. INTRODUCTION.

The issue of what to do with the Russian (and U.S.) plutonium from retired nuclear weapons is unresolved and somewhat contentious. Because of economic considerations and divergent views regarding the acceptability of commercial plutonium use, it will not be possible to find a solution acceptable to all parties to the nuclear energy debate. Some compromises will be necessary. At a minimum the proposal must meet basic criteria of acceptability of the parties directly involved; and to attract real interest, the proposal must go beyond these minimum criteria and offer rewards to all parties. It must be viewed as a ``win-win'' solution. Below we outline such a proposal involving three governments--Russia, the United States and Germany—and utility customers. It is designed to reduce Russian stocks of excess plutonium from dismantled weapons and to limit the amount of additional plutonium separated in civil nuclear programs. The United States is reviewing several options for reducing its excess plutonium stocks and is expected to choose one or more options in 1996.

## II. PROPOSAL REQUIREMENTS.

We begin by identifying what we believe are the minimal elements defining acceptability, and the additional elements of a ``winning'' proposal for the disposition of Russian excess plutonium, as seen by the three governments participating in the construction of a MOX plant and the utility customers.

**Russia (Minatom):** To be minimally acceptable to Minatom, we assume the proposal must meet the following conditions:

1) The plutonium not in difficult-to-recover form should be burned as MOX to obtain useful energy. Scrap residues and some plutonium in solutions could be directly disposed of as waste.

2) Employment opportunities for nuclear fuel cycle workers at Minatom facilities must not be precipitously reduced.

3) Implementation cannot cost more than the expected revenues.

For a winning strategy, from Minatom's point of view:

4) Minatom must be able to show a reasonable return on its investment.

**United States:** To be acceptable to the U.S. Government, including the Congress, the proposal must meet the following conditions:

1) The U.S. Government financial contribution must be limited to several tens of millions of dollars.

2) Assuming the U.S. makes such a financial contribution, the strategy must result in a significant net reduction in the amount of separated plutonium in Russia. This means that Russia must defer further chemical separation of plutonium while it draws down its stocks of separated plutonium.

For a winning strategy, from the U.S. point of view:

3) The strategy should advance other U.S. nonproliferation objectives, e.g., reducing the global stocks of separated weapon-usable fissile material.

4) The U.S. should be able to recover its financial contribution through future sales.

**Germany:** To be acceptable to Germany, the proposal must meet the following conditions:

1) The German government's financial contribution must be limited.

For a winning strategy, from the German point of view:

2) The proposal should contribute to the solution of the German spent nuclear fuel disposal problem.

3) Germany should be able to recover its financial contribution through future sales.

**Utility Customers:** To be acceptable to utility customers, the proposal must meet the following condition:

1) The combined cost of spent fuel management and MOX fuel fabrication services must be commercially competitive with other vendors.

For a winning strategy, from the utility customer point of view:

2) The combined cost of spent fuel management and MOX fuel fabrication services must be lower than competing fuel cycle options, and the nuclear waste should not be returned to the customer.

## III. THE PROPOSAL.

The basic proposal involves the following key elements:

1) Russia, the United States and Germany would share in the cost of construction of a new MOX plant at Ozersk (Chelyabinsk-65), Russia. The plant would be operated by Minatom and German nuclear industry personnel, with U.S. participation in an oversight

capacity. Any use of the MOX plant, including subsequent use after the proposed weapon-grade plutonium campaign is completed, would be by the joint agreement of Russia, the United States and Germany.

2) Ozersk would offer spent fuel services, i.e., equivalent to "reprocessing," and MOX fuel fabrication services, with preference given to Russian VVERs and German utilities. Foreign utility customers would pay a price competitive with (or below) the cost of commercial reprocessing services plus MOX fuel fabrication. MOX could be offered for use in Russian VVERs at a price less than that charged foreign customers.

3) The customer would deliver to a suitable site in Russia (not necessarily at Ozersk) spent fuel in universal dry casks suitable for direct disposal. The spent fuel would remain in Russia under Minatom ownership for eventual processing or direct disposal in a geologic repository.

4) The customer would obtain title to "equivalent" quantities of plutonium and uranium. The plutonium would come from excess separated weapons plutonium in Russia, with equivalence defined in terms of the amount of fissile isotopes. (As indicated below, the fissile plutonium inventory in 150 tonnes (t) of spent fuel is roughly equal to the fissile plutonium in one tonne of weapon-grade plutonium.) The uranium equivalence would be based on the feed and SWU value of the uranium in the spent fuel. Alternatively, the customer could receive a credit for the uranium in the spent fuel.

5) The customer's swapped plutonium would be fabricated into MOX at the new Ozersk MOX plant.

## IV. DISCUSSION.

The MOX plant could be constructed with the following proposed division of labor and equipment. Siemens, or another German firm, would be engaged as the architect-engineer. Germany also would contribute the glove boxes and other salvageable components from the Seimens Hanau plant. Minatom would have primary responsibility for construction of the building shell--the foundation and concrete work. The United States would have primary responsibility for supplying the ventilation system. Germany and the United States, perhaps working with Russia through the joint U.S.-Russian lab-to-lab program, would be responsible for supplying the physical security and material accounting and control systems.

In order to make this a winning proposal from the U.S. point of view, Russia should agree to defer further chemical separation of plutonium while the MOX plant is operating in order to draw down Russian stocks of separated plutonium. At Ozersk there would be new employment opportunities constructing the MOX plant, and workers from the RT-2 plant, which would be placed on standby, could be reemployed at the MOX plant. At Seversk (Tomsk-7) and Zheleznogorsk (Krasnoyarsk-26) it is anticipated that through core conversion the remaining

plutonium production reactors can switch to a higher burnup, 20%-enriched, fuel that would not be reprocessed in the near future in any case.

One metric tonne of heavy metal (1 tHM) spent low-enriched uranium (LEU) fuel contains about 9-10 kg of reactor-grade plutonium (RGPu) -- 0.9-1.0 percent of the total heavy metal -- which in turn is about 70 percent fissile. Thus, the customer would receive 1 t WGPu (94 percent fissile), which would be converted into MOX at Ozersk, per 134-150 tHM spent LEU fuel delivered to Russia.[1] To convert 50 t of excess WGPu into the "spent fuel standard" would result in the storage of about 6,700-7,500 tHM spent LEU fuel.

In order to make this a winning proposal from the point of view of foreign utility customers, Minatom would take title to the spent fuel (in exchange for an "equivalent" amount of plutonium and uranium) . No spent fuel or waste would be returned to the customer, but would be retained in Russia for long-term storage followed by either geologic disposal or reprocessing. For some utilities the Russian spent fuel management ("reprocessing") and MOX fabrication option should be more attractive than reprocessing contracts at THORP or La Hague, if only because the waste is not returned to the customer.

Although some will opposed any proposal that involves retaining foreign spent fuel for disposal in Russia and will argue that this violates the draft Law on Radioactive Waste Handling, this is not an unattractive option for Russia. In effect, Russia is simply moving its weapon plutonium into a better storage medium, spent fuel, and getting paid for doing so. Russia would retain additional fission products in the spent fuel, but the alternative would be for Russia to continue to incur unreimbursed costs to store and ultimately dispose of its separated plutonium. The burden of disposing of the fission products and plutonium in spent fuel in a geologic repository is not that different from the burden of disposing of the weapon-grade plutonium in a geologic repository. Moreover, the physical security requirements associated with long-term storage of spent fuel are less than those associated with long-term storage of separated plutonium

For non-proliferation reasons it would be preferable for Russia to commit not to process the spent fuel exchanged under this policy. However, there are some in Russia that have characterized Russian plutonium as a "national treasure." They will be reluctant to sell it or even swap it for spent fuel. But if Russia retains the right to process the spent fuel after the completion of the excess plutonium-to-MOX program, then Russia will not have given up this "treasure," but only swapped it for an equal amount of plutonium in a different physical and chemical form.

This proposal can be broadened to incorporate one or more other proposals for addressing the long-term risks of spent fuel storage. The U.S. National Academy of Sciences, for example, has noted that "[l]ong term steps will be needed to reduce the proliferation risks posed by the entire global stock of plutonium, particularly as the radioactivity of spent fuel decays."[2]

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[1] 1 t Pu*0.94/(0.009*0.7) = 149 tHM spent LEU fuel.

[2] Committee on International Security and Arms Control, National Academy of Sciences, *Management and Disposition of*

In this regard the Academy proposed that new agreements be pursued to, among others, "create an international safeguarded storage regime under which all civilian fissile materials not in immediate use would be placed in agreed safeguarded storage sites, with agreed levels of physical security.[1] Similarly, there are several proposals for the development of an Internationally Monitored Retrievable Storage System (IMRSS) for spent fuel under International Atomic Energy Agency (IAEA) safeguards. And I continue to argue that the United States and Russia should begin to jointly develop, at least on a research and demonstration basis, a safeguards regime that would eventually cover all fissile materials in all weapons states. Making the Russian spent fuel storage site under this plutonium disposition proposal an IMRSS under IAEA safeguards the would broaden the political support for both proposals. Moreover, it would provide an impetus for the creation of a similar IMRSS in the United States, e.g. underground at Yucca Mountain.

## V. ECONOMIC CONSIDERATIONS.

The cost of reprocessing power reactor spent fuel at THORP or La Hague is on the order of $1000/kgHM spent fuel . Spent fuel storage and disposal is unlikely to exceed one-half that amount. Thus, with the cost of reprocessing so much higher than the cost of its storage and direct geologic disposal, the revenues under this proposal would more than offset the initial MOX plant investment and return a profit to Minatom. There is an ample "profit margin" to enable the MOX plant consortium to negotiate a discount to cover any penalty a utility might have to pay to cancel an existing reprocessing contract.

## VI. CONCLUSION.

An integrating program, whereby Russia offers foreign utilities spent fuel management services and MOX fuel fabrication services, can provide Russia with a unique opportunity to profit from the disposition of its excess plutonium from retired nuclear weapons. The U.S. and Germany might assist Russia with the financing, construction and operation of the MOX plant. Over the life of the MOX plant the revenues from the supply of MOX fuel would be used to recover the investments made by the international partners that financed its construction.

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*Excess Weapons Plutonium*, (Washington, D.C.: National Academy Press, 1994), p. 17.

[1] Ibid., *Executive Summary*, p. 9.