Natural Resources
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Proposal

for the

DISPOSITION OF U.S. PLUTONIUM FROM WEAPONS

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INTRODUCTION:

The issue of what to do with the plutonium from retired nuclear weapons is unresolved and somewhat contentious. Because of the widely divergent views it will not be possible to find a solution acceptable to all parties. Some compromises will be necessary. This memo outlines a proposal that is designed both to eliminate U.S. plutonium stocks and to reduce the amount of additional plutonium separated in civil nuclear programs.

To convert U.S. stocks of plutonium in excess of military requirements into a waste form that meets the "spent fuel standard," the principal options currently under consideration are:

(i) the vitrification option, and

(ii) irradiation of mixed-oxide fuel ("MOX").

The vitrification option is appealing because it does not lend support, either directly or indirectly, to the continued commercial use of weapons-usable fissile material. On the other hand, choosing the vitrification option for disposal of U.S. surplus plutonium is unlikely to influence the choice of the Russian Ministry of Atomic Energy (Minatom), which favors the MOX option; nor is it likely to convince the U.K., France and Japan to abandon the continued separation of plutonium and its commercial use as a reactor fuel. With respect to the MOX option, the question is whether a program can be constructed that both disposes of the excess military stocks of plutonium and reduces, rather than increases, the commercial separation and use of plutonium globally.

Vitrifying the excess U.S. military plutonium, or burning it as MOX in U.S. or Canadian reactors in a once-through cycle, meets the "spent fuel standard," but neither of these approaches will advance another U.S. non-proliferation objective, namely, to cap and draw down the inventory of separated civil plutonium. The proposal outlined below is designed to meet the spent fuel standard and to reduce the growth in the separated stocks of civil plutonium in Europe and Japan by relying on the MOX option and the substitution of U.S. weapon-grade plutonium (WGPu) for civil plutonium that otherwise would be separated at reprocessing plants in Europe and Japan. We can get two bites out of the apple by structuring a program that removes the incentive to reprocess spent fuel. It makes no sense for the U.S. (or the Russian) government to implement a program of turning separated plutonium into spent fuel while utilities and government-owned corporations in Russia and other countries continue to separate plutonium from spent fuel. There is a better way to meet the objectives of all parties.

THE PROPOSAL:

The U.S. Government would offer to supply fresh MOX fuel to foreign reactor operators in exchange for an equivalent quantity of spent fuel, at a price equivalent to, or below, the sum of the current market prices for reprocessing and MOX fuel fabrication.

This offer would be directed primarily at Japanese and European utilities that are likely to contract with Cogema and BNFL for a second round of spent fuel reprocessing. In effect, the U.S. would compete directly with BNFL and Cogema for reprocessing services, but would provide these services at an equivalent or reduced price without actually reprocessing any spent fuel.

The U.S. Department of Energy (DOE) or (and) the U.S. Enrichment Corporation (USEC) could serve as the agent(s) for the sale of U.S. supplied materials and services.

ANALYSIS:

One metric tonne of heavy metal (1 tHM) spent low-enriched uranium (LEU) fuel contains about 9 kg of reactor-grade plutonium (RGPu) -- 0.9 percent of the total heavy metal -- which is about 70 percent fissile. The composition of fissile plutonium (fPu) in light water reactor (LWR) fresh MOX ranges from about 3-6 percent.

We roughly estimate the market prices for various nuclear services as follows:

Reprocessing:	$ 900/kgHM (post-2000 at THORP)[1]
MOX fabrication:	$1300-3000/kgHM[2]
Plutonium interim storage:	$ 650-2000/kgPu-y (new facility)[3]
	$ 140-300/kg-y (marginal storage cost at existing site)[4]
Plutonium transportation:	$ < 2000/kgPu
Pu metal to PuO_2 conversion:	$9000/kgPu
Spent fuel transportation:	$ < 10/kgHM (excluding transport casks)
Transport/storage casks:	$ 40/kgHM
Spent fuel storage/disposal:	$ 250/kgHM (including transport/storage casks)[5]

[1] Brian G. Chow and Kenneth A. Solomon, "Limiting the Spread of Weapon-Usable Fissile Materials," RAND, 1993, p. 34; current reprocessing charges are much higher, i.e., 1400-1800/kgHM.

[2] Ibid., p. 32.

[3] The low figure is from the Chow and Solomon, RAND, p. 68.

[4] Operating expenses; Chow and Solomon, RAND, p. 68.

[5] Assumes 1 mil/kwh (DOE's charge to U.S. utilities); a 1 GWe power plant operating at a 70 % capacity factor produces 6 billion kwh/y and about 25 tHM/y spent fuel.

DOE: For our analysis we assume that DOE will declared that 50 t WGPu are in excess of military needs. At a fresh fuel enrichment of 4%, this could be used to make 1,250 tHM MOX. In making this available on the commercial market, DOE would agree to take in return an equivalent amount of spent LEU fuel. There are several alternatives for defining what constitutes an equivalent amount. The fresh MOX and spent LEU fuel can be equated in terms of the equivalent mass of either the (a) heavy metal, (b) plutonium, or (c) fissile plutonium in the fresh MOX and spent LEU fuel. The economics and the spent fuel storage requirements are both strongly dependent upon the choice.

In return for supplying 50 t WGPu as MOX, under option (a) DOE would agreed to accept 1,250 tHM spent LEU fuel, for which DOE would be paid $1.125 billion (the avoided cost of reprocessing 1,250 tHM spent fuel), plus the going rate for MOX fabrication services. DOE would not lose money on the MOX fabrication, provided it could contract with U.S. nuclear fuel fabricators and charge fuel customers at roughly the same rate including a modest service charge to cover DOE's management costs. DOE would be obligated to pay approximately $450 million for the conversion of the plutonium metal as pits into plutonium oxide, plus several tens of millions of dollars in associated transportation costs. DOE also would be obligated to pay the cost of interim storage and disposal of the spent fuel, but this would be offset by not having to pay for the cost of interim storage of the excess military plutonium. The spent fuel transportation cost is a small fraction of the disposal cost and can be neglected. In any case at 1 mil/kwh the spent fuel disposal cost is about $250/kgHM, or $310 million for 1,250 tHM.

Under option (b), in exchange for 50 t WGPu as MOX, DOE would accept (50tPu/0.009=) 5,556 tHM spent LEU fuel, for which DOE would receive (5556tHM*$900/kg*1000kg/t=) $5 billion (the avoided reprocessing costs). The spent fuel disposal cost in this case would be (5556tHM*$250/kg*1000kg/t=) $1.4 billion.

Under option (c), in exchange for 50 t WGPu as MOX, DOE would accept (50tPu*0.94/(0.009*0.7)= 7,460 tHM spent LEU fuel, for which DOE would receive (7460tHM*$900/kg*1000kg/t=) $6.7 billion. The spent fuel disposal cost in this case would be (7460tHM*$250/kg*1000kg/t=) $1.9 billion.

To summarize, for supplying 50 t WGPu as MOX:

Equivalence:	(a) HM	(b) Pu	(c) fPu
MOX (tHM)	1,250	1,250	1,250
Spent LEU fuel (tHM)	1,250	5,556	7,460
Avoided Reprocessing Cost	$1.1 billion	$5.0 billion	$6.7 billion
Spent fuel Disposal Cost	-0.3 billion	-1.4 billion	-1.9 billion
Pu metal to PuO_2 Cost	-0.45 billion	-0.45 billion	-0.45 billion
Pu transportation	-0.1 billion	-0.1 billion	-0.1 billion
DOE ''profit''	$0.25 billion	$3.0 billion	$4.25 billion

From a technical standpoint option (c) makes the most sense and offers the greatest economic return. Under any of the above options there is an ample "profit margin" to enable DOE to negotiate a discount rate to cover any penalty the utility might have to pay to cancel an existing reprocessing contract. In reality, if the U.S. were to adopt this proposal, BNFL and Cogema might lower their reprocessing price to be more competitive. If DOE rejected this proposal, but fabricated MOX for U.S. utilities, then DOE would incur the cost differential between MOX fuel and LEU fuel, which could amount to $1000/kgHM, or $1.25 billion to convert 50 t of WGPu into 1,250 tHM of fresh MOX fuel.

Foreign Utilities: A foreign utility would pay the same, or less, than it would if it contracted with BNFL or Cogema for reprocessing services. Using DOE services would have the added advantage of not having to take back the waste after 10 years.

BNFL plans to process about 700 tHM/y, or 7,000 t over ten years. The plutonium content in this amount would be approximately (70000 tHM*0.009=) 63 t RGPu, which contains 44 t fPu. Thus, under option (c), the conversion to MOX of 50 t WGPu, which containing 47 t fPu, could offset the entire second round of reprocessing contracts at BNFL.

MOX Fabrication: There are currently no U.S. nuclear fuel fabricators making MOX fuel. Fabrication of MOX in the United States may be costly, or impossible due to difficulties in obtaining appropriate Nuclear Regulatory Commission (NRC) licenses. Alternatively, DOE could contract with European MOX fabricators. Contracting with BNFL or Cogema would soften the loss of reprocessing contracts incurred by this initiative.

The Transportation and Waste Disposal Issues: A potential "show stopper" is the need to import and store foreign spent fuel. One has only to look at the difficulties

experienced by the RERTR program. However, there is an important difference between this proposal and the RERTR program. Under this proposal DOE would not be adding to the existing waste storage or disposal burden. Rather, DOE would be exchanging or substituting waste forms -- WGPu for spent fuel -- both of which require interim storage and disposal.

DOE could explore the option of interim storage of the spent fuel outside of the United States. The contracts, for example, could call for shipment of the spent fuel to the U.S. only after an interim monitored retrievable storage (MRS), or permanent geological disposal, facility has been licensed. The interim spent fuel storage cost should not be significantly different regardless of whether the initial storage was in the U.S. or abroad.

Storage and disposal foreign spent fuel in the United States would be subject to provisions of the Nuclear Nonproliferation Act of 1978 (NNPA), specifically "Subsequent arrangements involving direct or indirect commitment of the United States for storage or other disposition of foreign spent nuclear fuel in the United States," (42 USC 2160(f)), the so-called "McClure amendment." This provision requires the Secretary of Energy to submit any such subsequent arrangement, or generic plan, to Congress and gives Congress the opportunity to reject the plan within 60 days of continuous session.

The impact on the geologic repository (Yucca Mountain) would be marginal, since DOE would be adding only 1,250 to 7,460 tHM, or less than ten percent to the 70,000 tHM capacity. There is essentially no net burden to the U.S. in terms of nuclear waste management since DOE must dispose of the WGPu in any case.