Opportunities to minimize stocks of nuclear-explosive materials*

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One legacy of the Cold War is 1350-1950 tonnes of highly enriched uranium (HEU) and 250 tonnes of separated plutonium, virtually all produced by the Soviet Union and the U.S. An additional 250 tonnes of separated plutonium is a legacy of the nuclear-energy establishment's premature vision of a future powered by plutonium breeder reactors (see Figures 1 and 2).

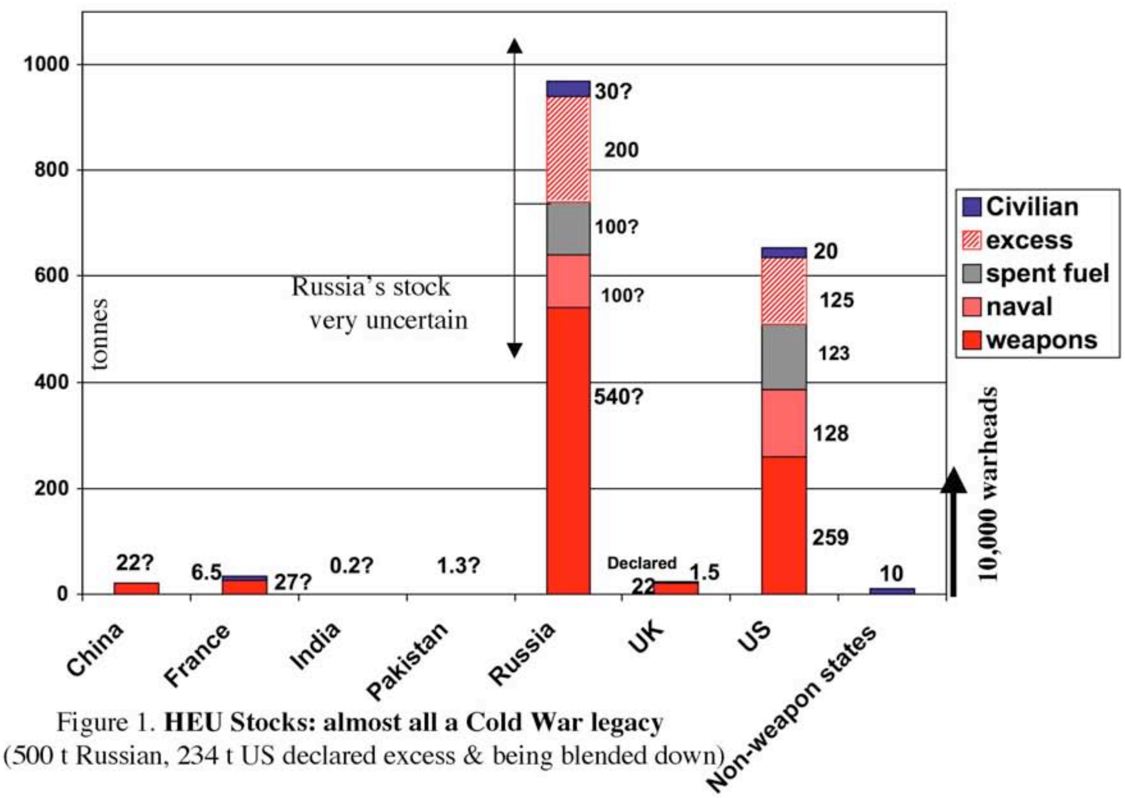


Figure 1. **HEU Stocks: almost all a Cold War legacy**
(500 t Russian, 234 t US declared excess & being blended down)

These stocks are vastly in excess of the world's needs today and should be reduced to make nuclear disarmament irreversible and minimize the danger of theft and sale to would-be nuclear countries or terrorists. In this talk, I discuss four policies to facilitate these reductions:

* Sources of the numbers quoted here may be found in *Global Fissile Materials Report 2006* www.fissilematerials.org. Discrepancies reflect refinements that will be presented in *GFMR 2007*,

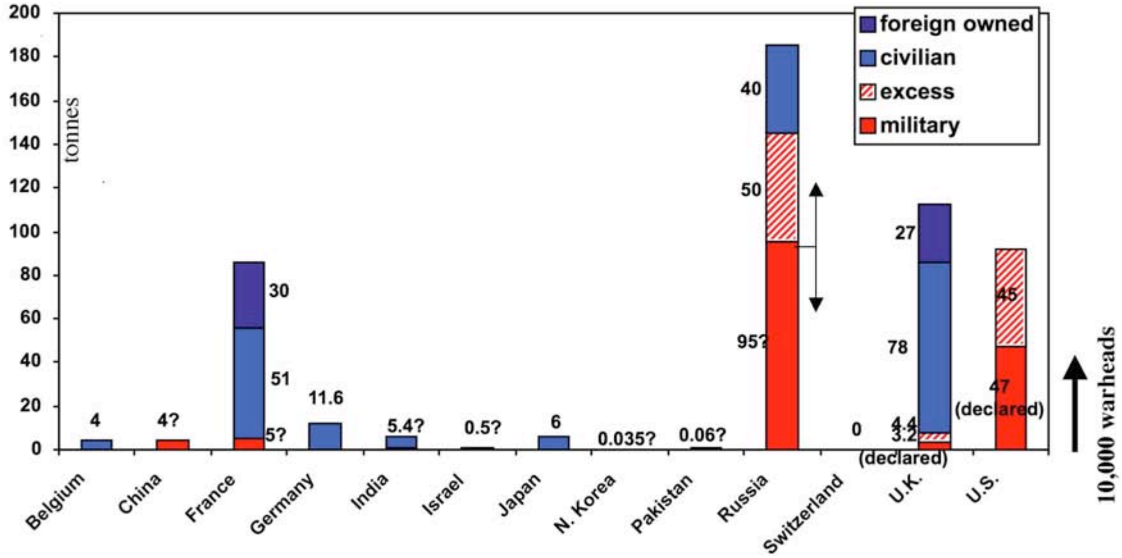


Figure 2. **Separated plutonium: Half is civilian**
(Mostly in Russia, U.K, France and US)

1. Russia & U.S. should reduce their weapons stocks of HEU and plutonium to reflect their warhead reductions;

2. Russia, U.K. & U.S. should fuel their next-generation nuclear-propelled ships and submarines with low-enriched uranium (LEU) fuel, as France is beginning to do;

3. Reprocessing should be discontinued where there is no near-term use for separated plutonium; and

4. Needed HEU-fueled research reactors should be converted to LEU and unneeded ones decommissioned.

Reduce weapon stocks. Because of the downsizing of their Cold War nuclear arsenals, Russia and the U.S. have stockpiles of fissile materials far in excess of what they need for weapons. Russia has declared 500 tonnes of HEU and 34-50 tonnes of plutonium to be excess of its military needs. The U.S. has similarly declared 234 tonnes of HEU and 45 tons of plutonium excess. The two countries are eliminating most of their excess HEU by blending it down to low-enriched uranium for use in power-reactor fuel. Their plutonium-disposition programs are stalled, however.

More weapons HEU and plutonium could be declared excess. If we assume that an average modern nuclear warhead contains 4 kg of plutonium and 25 kg of HEU and add an extra 20 percent for working stocks and research and development, it would require only about 30 tons of plutonium and 180 tons of HEU to support the stockpile of approximately 6,000 warheads that the U.S. expects to have in its active and reserve stockpiles in 2012. If Russia and the U.S. reduced to 1000 warheads each, they would only require 30 tons of plutonium and 5 tons of HEU each. (See Figures 3 and 4.)

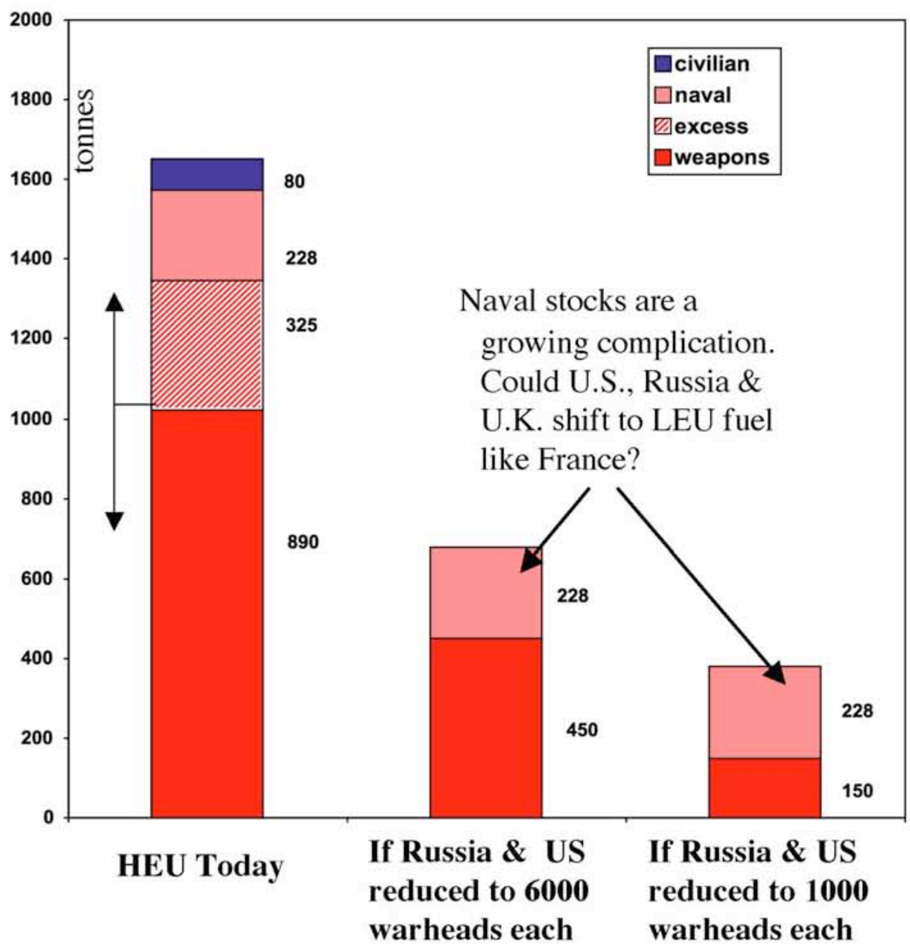


Figure 3. **Global HEU stocks**: **What if Russian and U.S. military stocks reflected warhead reductions?** (non-Russian/U.S. stocks total about 90 tonnes)

Convert naval propulsion reactors to LEU. The U.S. and U.K. fuel their naval propulsion reactors with weapon-grade HEU. Russia fuels its naval and icebreaker reactors with medium-enriched but still weapon-usable HEU. The U.S. has declared128 tonnes of weapon-grade HEU excess for weapons purposes but has placed it into a reserve for future use in naval-reactor fuel (see Figure 1). Russia presumably has a similar stockpile. (I have assumed 100 tons in Figure 1.) As the stockpiles of weapons materials are reduced, the naval stockpiles will become an increasingly large part of the HEU problem (see Figure 3). A simple way to eliminate this problem is to fuel future naval reactors with low-enriched uranium (uranium enriched to less than 20 percent U-235). France is already making this shift. Russia similarly has developed LEU fuel for the floating nuclear power plant that it has under construction. Since the reactor for this floating power plant is adapted from an icebreaker reactor, the icebreaker reactors could be converted – and perhaps Russia's nuclear submarines as well.

The situation is a little more difficult for the U.S. and U.K. Unlike France and Russia, which refuel their reactors every 5-10 years, the U.S. and U.K. have developed reactors that have "lifetime" cores. The U.S. Navy insists that, to convert to LEU cores, it would have to return to a refueling cycle of every 15 years or so. Future submarines and ships, however, could be designed around reactors that have lifetime LEU cores.

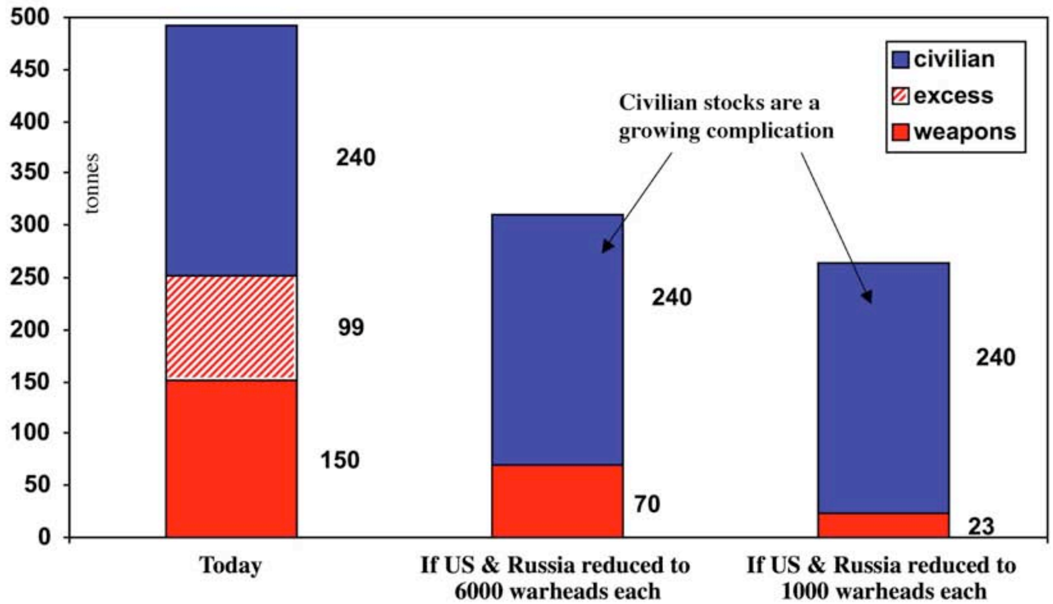


Figure 4. **Global Pu stocks**: **Potential for reductions**
(non-Russian/U.S. weapon stocks about 13 tonnes)

Discontinue civilian reprocessing. Reprocessing of power reactor fuel in most of the industrialized states was originally launched in the 1960s and 1970s in the expectation that plutonium breeder reactors would soon be built by the hundreds. Plutonium in the spent fuel of power reactors was therefore separated out to provide startup fuel for these breeder reactors.

In 1974, the proliferation dangers associated with this vision of plutonium fuel became obvious when India used the first plutonium that it separated out with U.S. assistance under the "Atoms for Peace" program to make a nuclear explosive. The U.S. cancelled its civilian plutonium program.

Other countries continued for some time, however. In some cases, as with Germany and Japan, exporting spent fuel to Britain and France to be reprocessed became a way to bypass their domestic anti-nuclear movements, which were making it impossible to establish central storage sites for spent fuel. This worked only for a decade or so, however, because Britain and France began to ship back to the countries of origin the solidified high-level waste that resulted from the reprocessing and central storage sites had to be found for this returning waste. The result is that Britain and France have lost virtually all of their reprocessing customers.

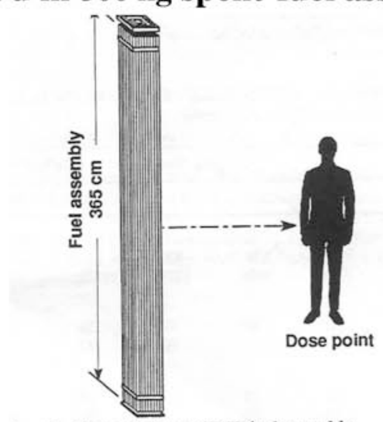
The U.K. has decided to abandon reprocessing but is faced with a costly legacy from its program, including about 80 tonnes of separated civilian plutonium for which it has no disposition plan. Russia has a dispositon plan for its 90 tonnes of separated civilian and excess weapons plutonium but that plan depends primarily on future plutonium breeder reactors. The U.S. has a disposition plan for much of its 45 tonnes of excess separated plutonium but the estimated cost of that plan has already climbed above $10 billion. France is recycling its separated plutonium into mixed-oxide fuel for irradiation in light-water reactors. The irradiated "mixed-oxide" fuel is being stored at France's reprocessing plant.

It makes little sense to separate more civilian plutonium until the huge stocks of already separated plutonium can be dealt with. For interim storage, plutonium is much more secure in spent fuel than in separated form (see Figure 5).

Separated plutonium

5 kg Pu in light-weight container. Three cans enough for Nagasaki bomb. Can be processed in a glove box.

6 kg Pu in 500 kg spent-fuel assembly



igure 1. Dose rate from a PWR fuel assembly.

Fifty years after discharge, gamma-ray dose still lethal in 20 minutes.
20-tonne transport container & remote handling behind thick walls required to recover plutonium.

Figure 5. **Separated plutonium is much less secure than plutonium in spent fuel.**

Convert or decommission HEU-fueled research reactors. There are currently more than 140 HEU-fueled research reactors in the world. The HEU at these reactor sites amounts to only a few percent of the total global stock of HEU but many of the sites are civilian and much less well protected than sites in the weapon complexes. Some critical assemblies and pulsed reactors contain hundreds of kilograms of barely irradiated HEU. This is a concern because converting HEU into a gun-type (Hiroshima-type) of nuclear explosive is well within the potential reach of terrorist groups. The material also could be diverted to weapons use by the host countries. Indeed, on the eve of the 1991 Gulf War, Saddam Hussein launched a crash program to convert into a weapon HEU in French and Russian supplied research-reactor fuel.

In 1978, out of concern about these dangers, an international Reduced Enrichment Research and Test Reactor program was launched with the objective of converting HEU-fueled reactors to LEU. There are plans to convert an additional 48 using existing LEU fuels and another 21 are to be converted with LEU fuels that are under development.

This leaves about 75 research reactors for which there are no current conversion plans. Ninety percent of these are in Russia. While Russia is cooperating in efforts to convert to LEU fuel Soviet exported research reactors in Eastern Europe and Central Asia, it has not yet decided to convert its own research reactors. Institutes that are interested in exploring the feasibility of converting their reactors are not being allowed to do so.

In any case, most of the world's HEU-fueled research reactors are no longer needed. In some cases, such as most critical assemblies and pulsed reactors, the experiments can be adequately simulated with computer codes. More generally, the era in which each nuclear research institute did experiments on its own research reactors is coming to an end. Increasingly, experiments are being done in a few well-equipped international centers and institute groups are becoming "user groups" that travel to those centers to do experiments. Most of the world's HEU-fueled reactors are therefore falling into disuse. They should be shut down and their HEU fuel removed to centralized secure storage.