Toward a Global Cleanout of Nuclear-weapon Materials (highly enriched uranium and plutonium):

A Report on Progress and the Challenges Ahead

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Colloquium: Plasma Physics Laboratory

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Global Fissile Material Report 2007

Toward a Global Cleanout of Nuclear Weapon Materials

IPFM
INTERNATIONAL PANEL
ON FISSILE MATERIALS

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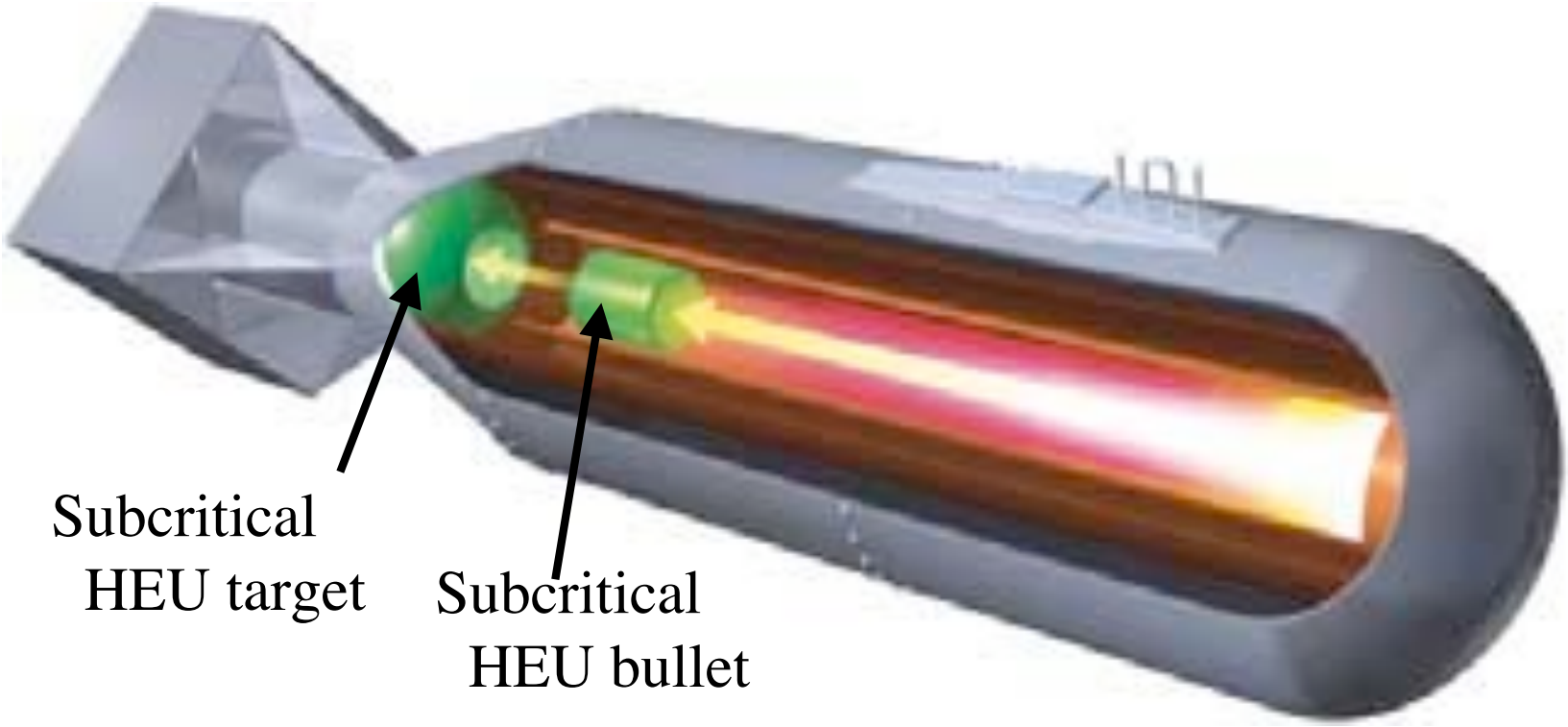
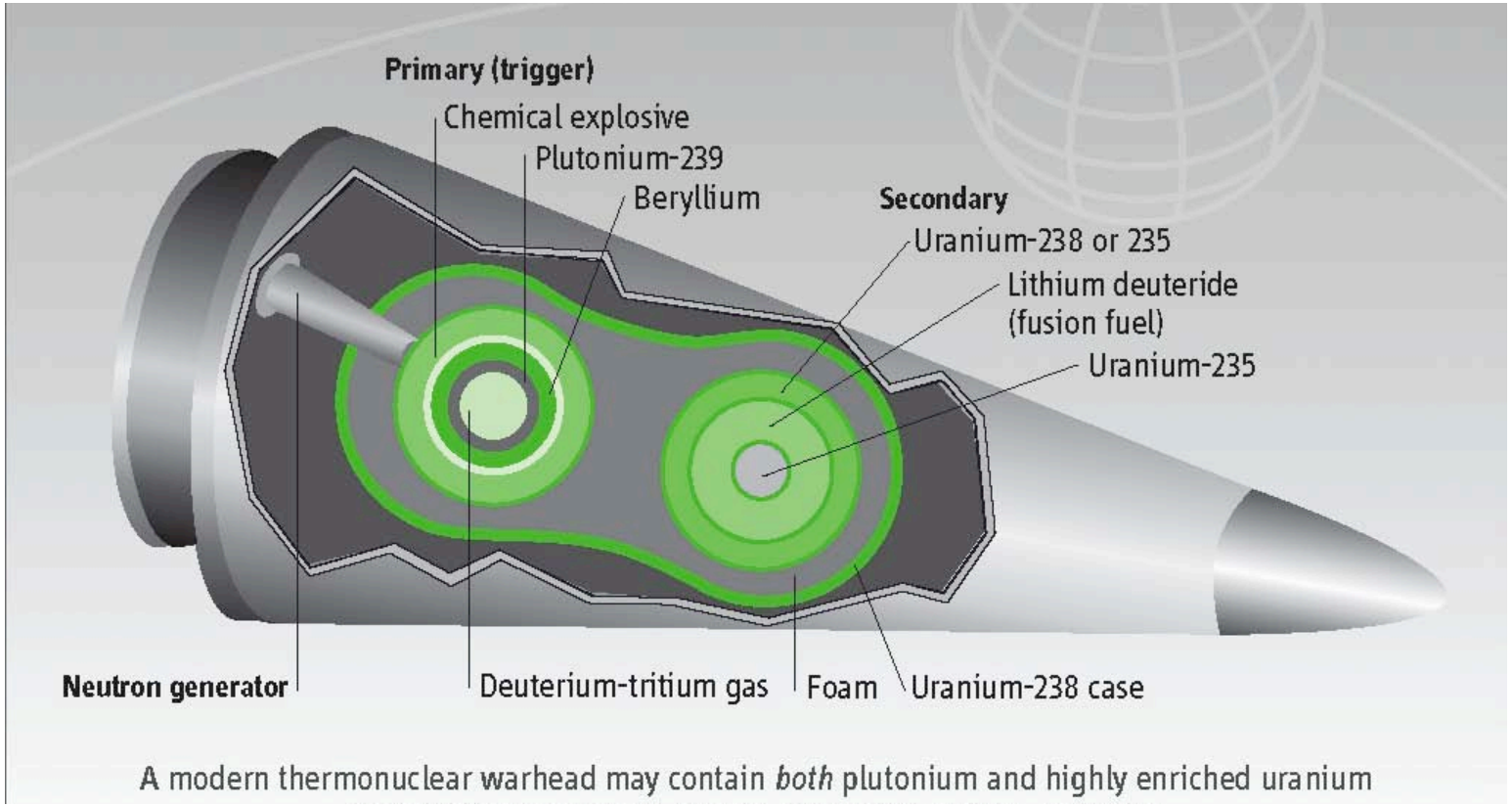
Hiroshima was destroyed by a supercritical mass made in a gun barrel (about 60 kilograms of 80% enriched HEU)



Terrorists could make a bomb with HEU

The average modern warhead contains about 25 kg of HEU *in the secondary*

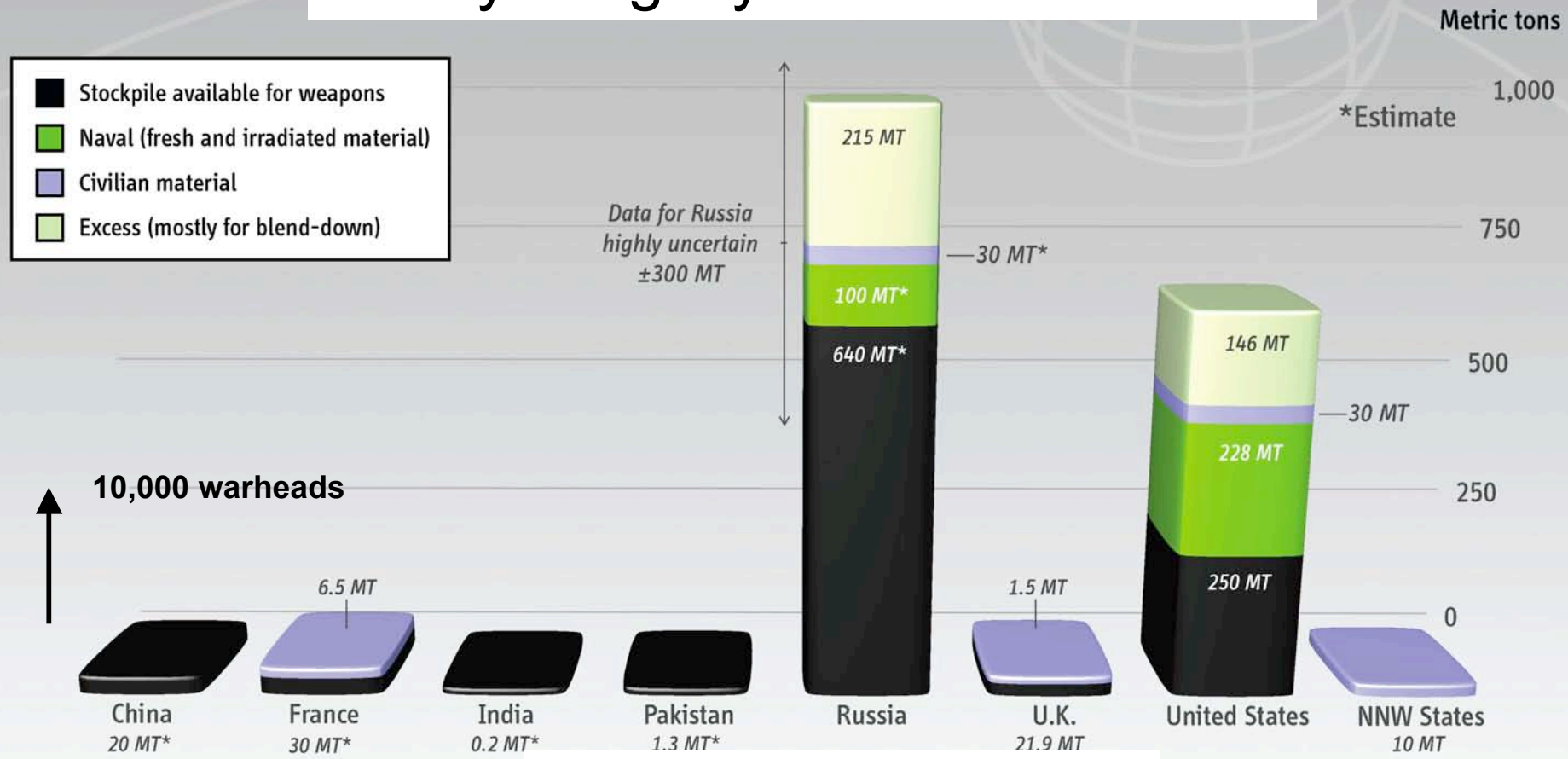


A modern thermonuclear warhead may contain *both* plutonium and highly enriched uranium

After *U.S. National Security and Military/Commercial Concerns with the People's Republic of China* [Report of a Select Committee of the U.S. House of Representatives (Cox Report) 1999] Vol. 1, p. 78.

Highly Enriched Uranium Stockpiles

Mostly a legacy of the Cold War

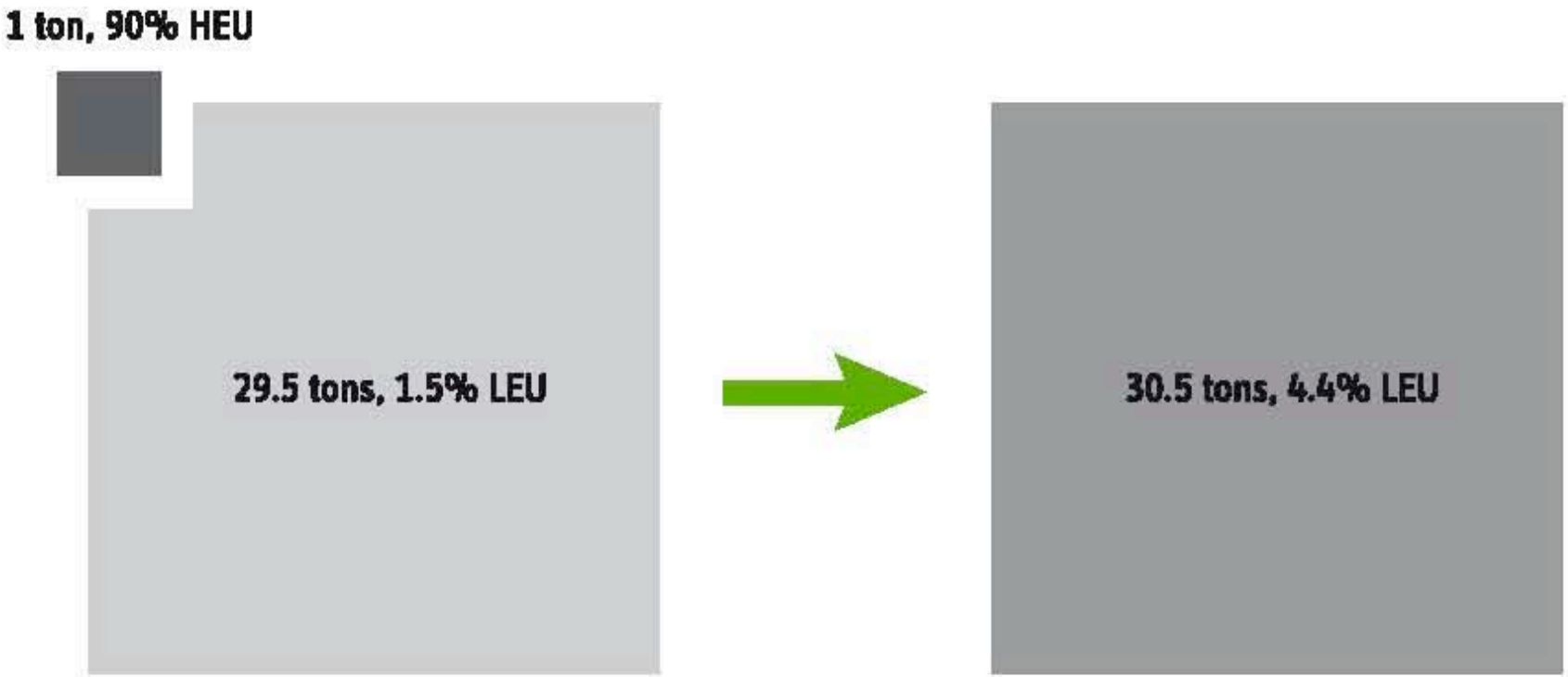


(It is not known whether Israel has made HEU)

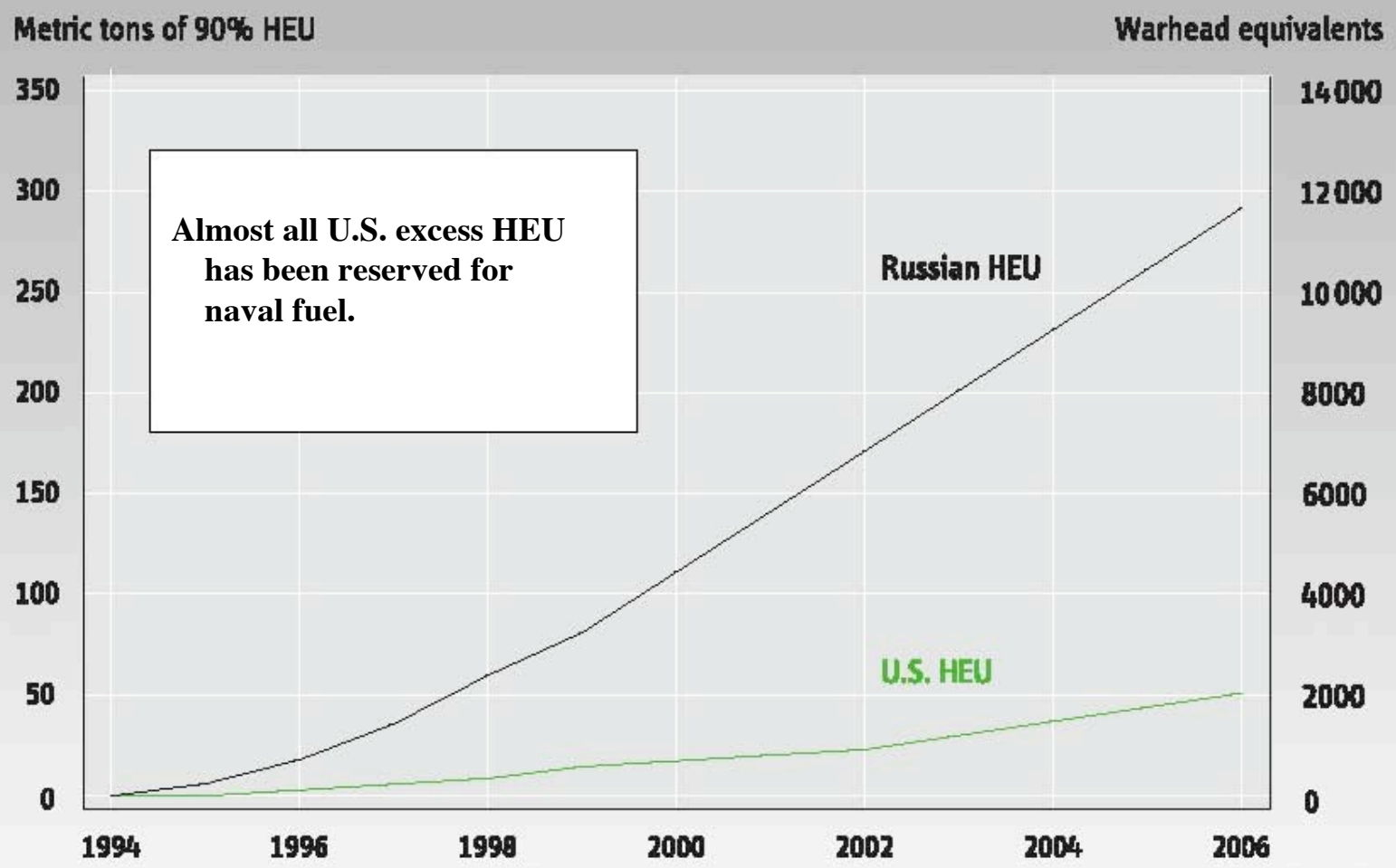
(250 MT of HEU are equivalent to 10,000 nuclear weapons)

Blending down Russian weapon-grade HEU: Making money by turning nuclear weapons into nuclear fuel

(1 GWe of capacity requires 20 tons/year)



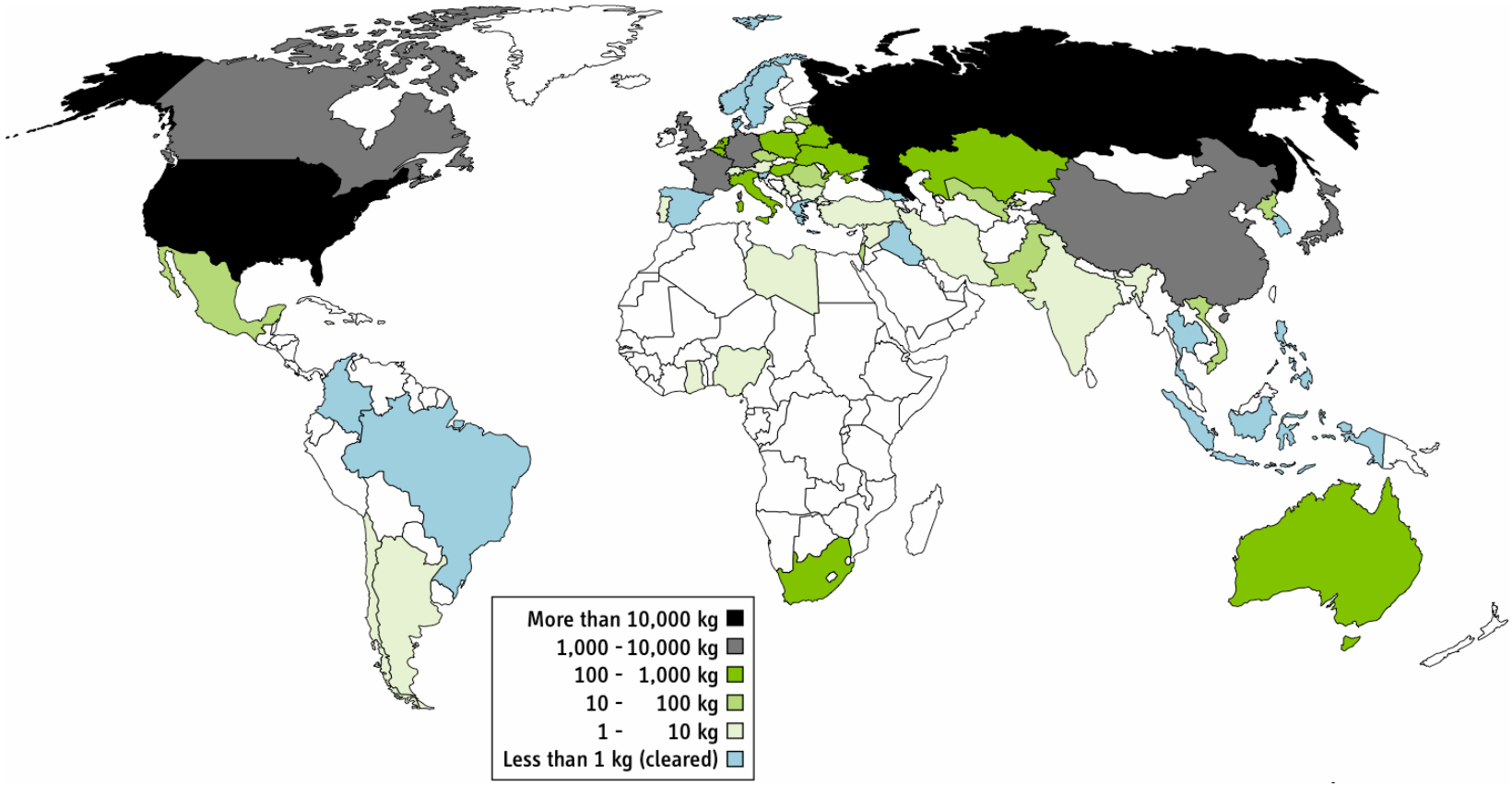
Progress of Excess HEU Disposition



Almost all U.S. excess HEU has been reserved for naval fuel.

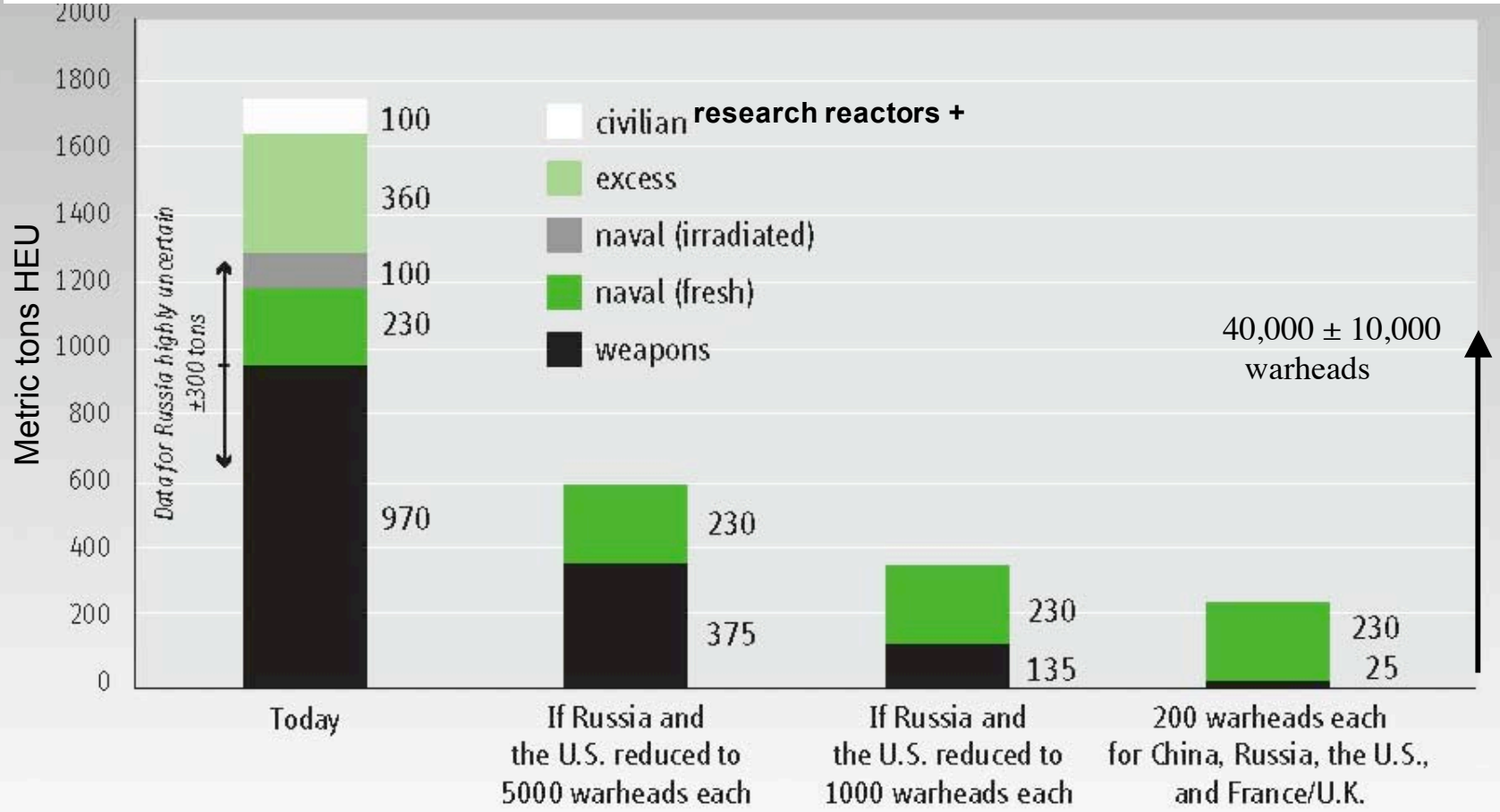
Civilian HEU -- A Legacy of Atoms for Peace

About 100 tons in research reactors and Russian icebreakers (enough for 2000 Hiroshima bombs) -- half in Russia and about ten tons in non-weapon states.
14 of 56 countries that had HEU-fueled reactors have had civilian HEU removed.



Scope for Warhead and HEU Stockpile Reductions

& the naval HEU problem **(France has converted its submarines to LEU)**



Implosion designed for plutonium (Nagasaki) bomb -- more efficient but more difficult

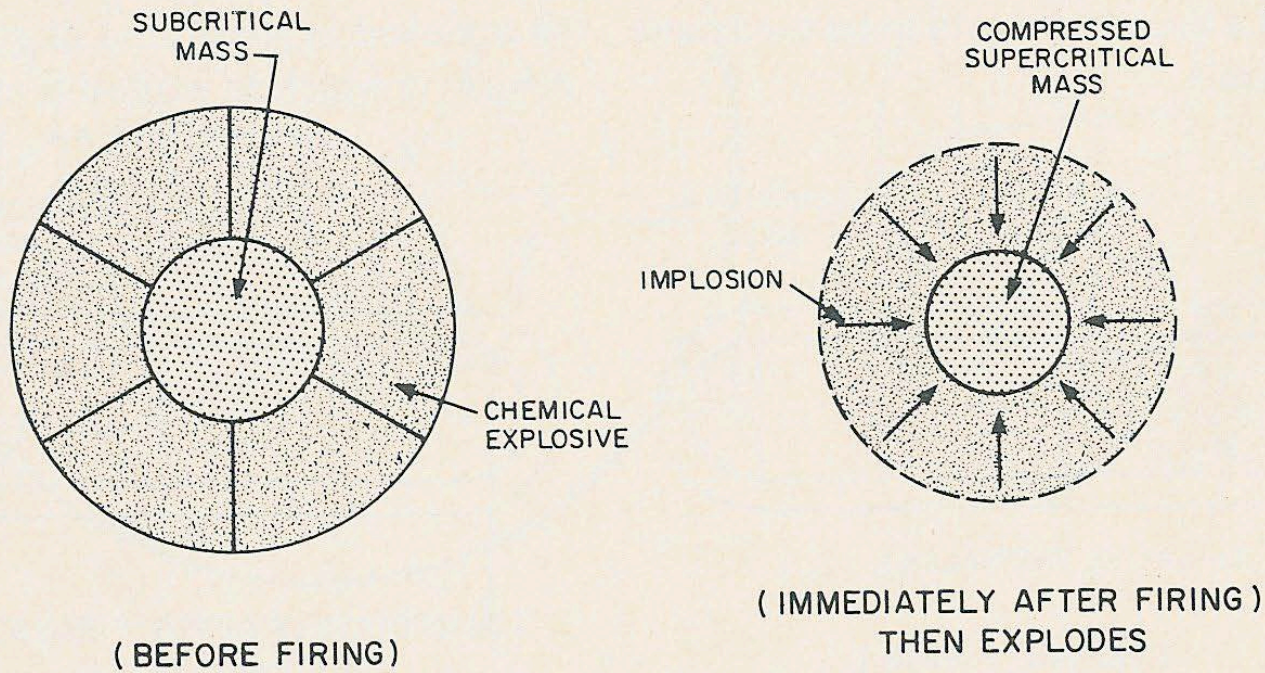
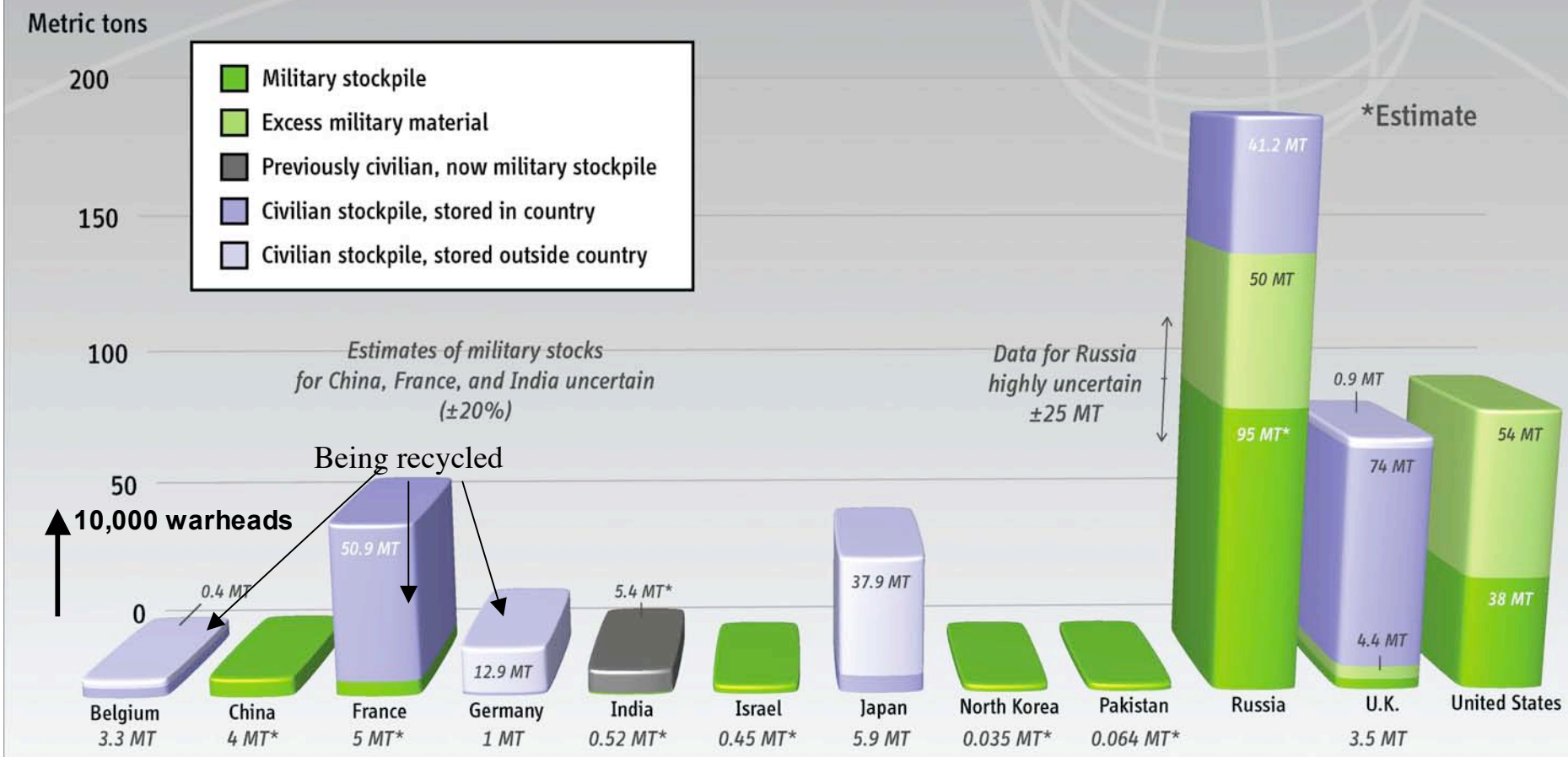


Figure 1.53. Principle of an implosion-type nuclear device.

The Nagasaki bomb contained 6 kilograms of plutonium. Modern nuclear weapons contain on average about 4 kg. Plutonium also could be used to make radiological weapons.

Global Stocks of Plutonium

(about half UK, French, Japanese, Russian civilian stocks)



(50 MT of plutonium are equivalent to more than 10,000 nuclear weapons)

Making plutonium into fuel: more expensive than the fuel is worth

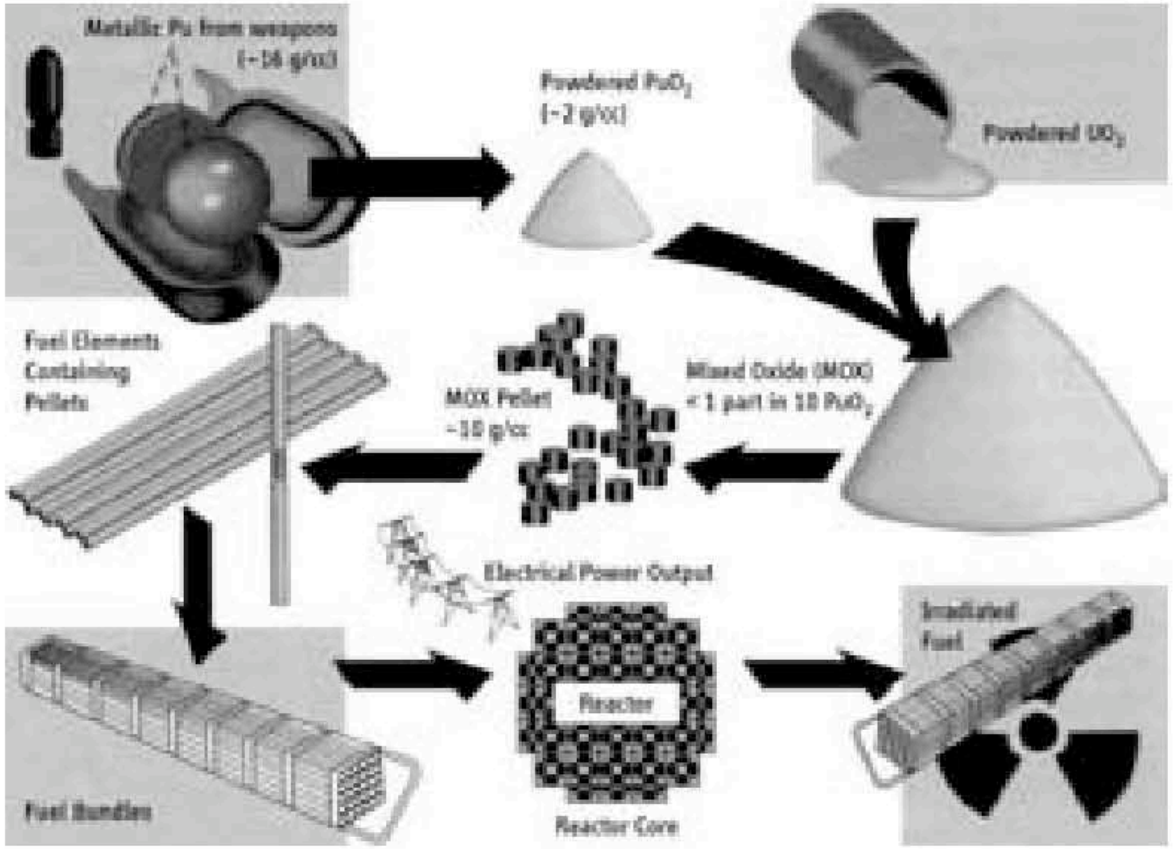


Figure 3.1. Diagram of plutonium pit being cut up, the plutonium made into MOX fuel and the fuel being irradiated in a nuclear-power reactor.[111]

The alternative: Immobilization of Pu with some of the radioactive waste from which it was originally separated

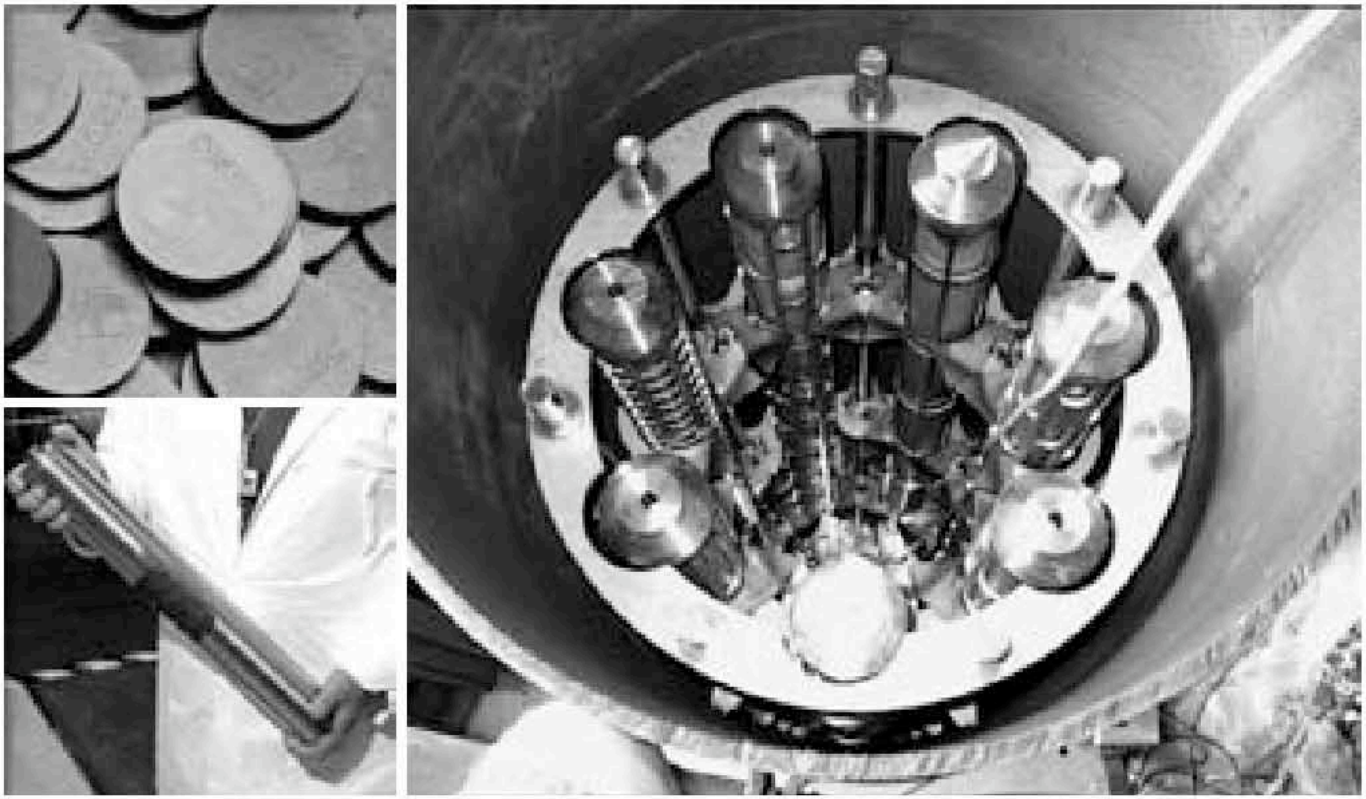
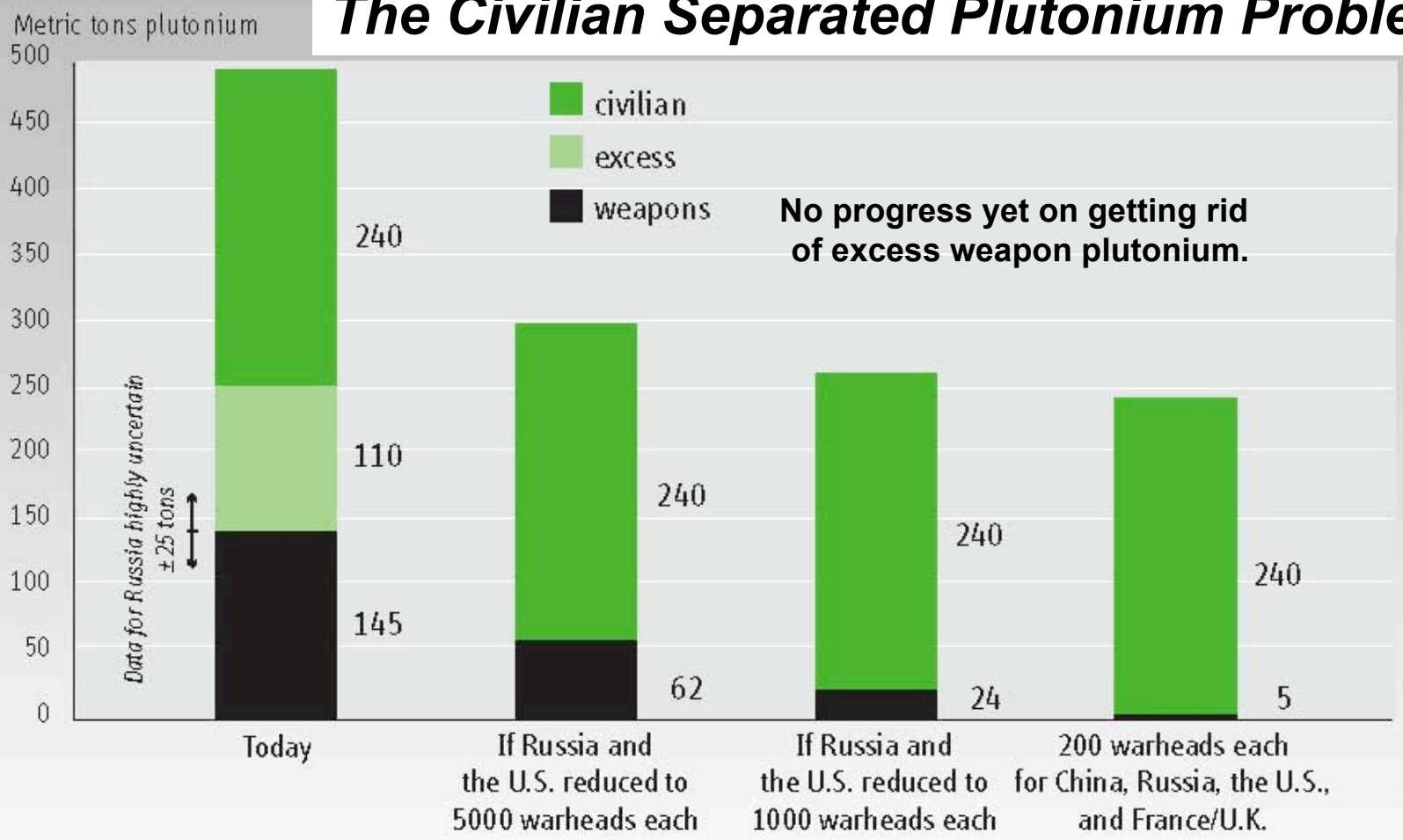


Figure 3.2. Plutonium immobilization with the can-in-canister approach. Left top: plutonium immobilized in ceramic pucks. Left bottom: pucks stacked in a can. Right: cans emplaced in a canister before molten glass containing radioactive waste is poured around them to provide the radiation barrier. [Source: U.S. DOE]

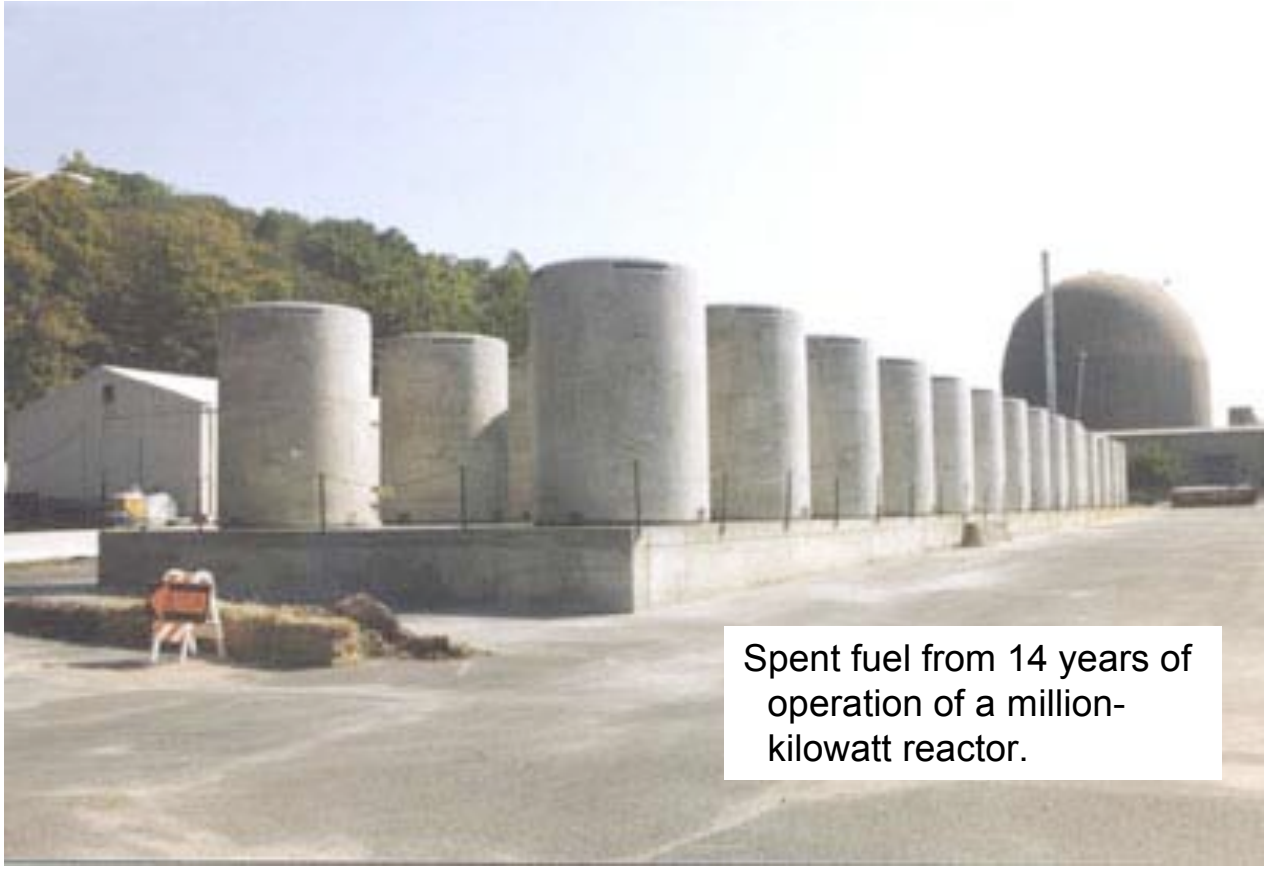
Scope for Warhead and Plutonium Stockpile Reductions

The Civilian Separated Plutonium Problem



No progress yet on getting rid of excess weapon plutonium.

The new debate in the U.S. over reprocessing started with US nuclear utilities pressing the Department of Energy (DOE) to start removing spent fuel from their reactor sites. DOE responded by proposing to reprocess it.



Spent fuel from 14 years of operation of a million-kilowatt reactor.

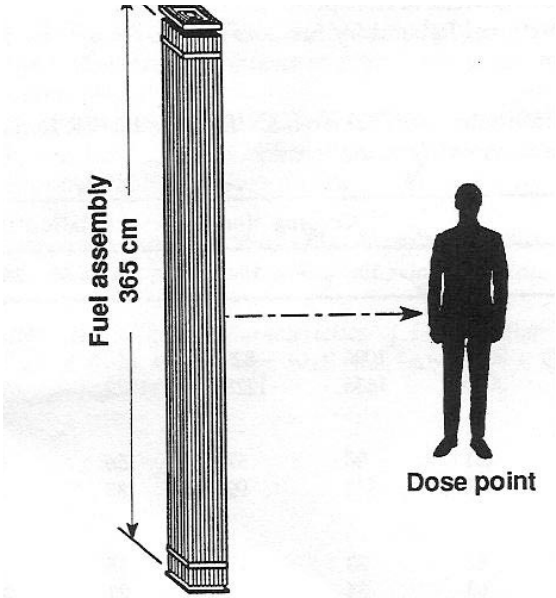
But separated plutonium can be carried away easily. Spent fuel is self-protecting for more than a century.

Separated plutonium

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

Spent fuel assembly

(1000 pounds and 12 feet long)



igure 1. Dose rate from a PWR fuel assembly.

12 pounds Pu. Lethal gamma dose in 20 minutes 50 years after discharge. 20-ton transport container & remote processing behind thick walls required to recover Pu.

Most other countries are stopping reprocessing

(Countries with separated civilian power-reactor plutonium in red.)

Countries that reprocess or plan to		**Customer Countries that have quit or plan to**		**Countries that have not reprocessed**	
(billions of Watts of nuclear capacity)					
China (incomplete plant)	6.4	Armenia (in Russia)	0.4	Argentina	0.9
France (67%)	63.4	**Belgium (home/France)**	5.8	Brazil	1.9
India (?)	3.6	Bulgaria (Russia)	2.7	Canada	12.9
Japan (90% planned)	44.3	Czech Repub (Russia)	2.6	Lithuania	1.3
Netherlands (in France)	0.5	Finland (Russia)	2.7	Mexico	1.4
Russia (15%)	21.7	**Germany** (home/Franc/UK)	20.3	Pakistan	0.4
UK (quitting)	11.8	Hungary (Russia)	1.7	Romania	0.6
		Japan (France/UK)	44.3	Slovenia	0.7
		Slovak Repub (Russia)	2.5	South Africa	1.8
		Spain (France, UK)	7.6	South Korea	16.8
		Sweden (France/UK)	8.9	Taiwan	4.9
		Switzerland (France/UK)	3.2	U.S. (since 1972)	97
		Ukraine (Russia)	13.1		
Total (70%)	**151.8**	**Total**	**116.1**	**Total**	**141.4**

Reprocessing is a panic "solution."
Spent fuel will have to be removed from reactor sites eventually. But there is no reason to panic and turn a waste-management problem into a terrorist and proliferation problem.

- 95 % of U.S. spent fuel is at operating power reactor sites
- Accident/terrorism risk from dry-cask storage negligible in comparison to that from fuel in reactors or storage pools.
- All U.S. nuclear power plant sites can accommodate spent fuel from 60 years of operation.
- U.S. anti-nuclear groups no longer oppose interim on-site dry-cask storage if it is "hardened" as in Germany and Japan

Designing a verifiable ban on the production of fissile materials for weapons is a current focus for IPFM

China, France, North Korea, Russia, U.K. and U.S. have all stopped.

India, Pakistan, and (probably) Israel have not.

Originally proposed by Eisenhower finally supported by both Soviet Union (Gorbachev) and U.S. (Clinton). UN General Assembly consensus to start negotiations at Conference on Disarmament in Geneva.

Negotiations have not yet begun because of disagreements over linkages to other negotiations.

Bush Administration has decided that an FMCT would not be verifiable

(but would like more stringent verification of the same commitment in the non-weapon states that are Parties to the Nonproliferation Treaty).