Reducing fissile-material stocks for nuclear disarmament and to reduce the dangers of proliferation and nuclear terrorism

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Outline

- Fissile material and nuclear weapons
- Fissile material stocks
- Fissile Material Cutoff Treaty
- Elimination of excess weapons materials
- Reducing the danger of nuclear terrorism
- Minimizing stocks of civilian plutonium
- Multilateral as well as IAEA oversight of enrichment and reprocessing facilities
- Regional spent-fuel storage arrangements

Fissile materials and nuclear weapons

Hiroshima: 60 kg of 80%-enriched HEU (gun-type design)

Nagasaki: 6 kg of 98%-Pu-239 (solid-core, unboosted implosion)

IAEA (first generation implosion bomb, including production losses):

8 kg Pu with < 80% Pu-238 or

25 kg U-235 in HEU

U.S.: 4 kg Pu (U.S. weapons "for planning purposes")

Stockpiles of fissile material (1000 kg)

(*not including weapon materials declared excess*)

	Weapon HEU (93% ^{235}U equiv.)	**Weapon Pu**	**Civil Pu-**2002 **In-country (own)**
Russia	600 ± 300	120 ± 25	37
USA	525 ± 70	47	14.5
China	25 ± 6	3.5±1.5	-
France	25 ± 8	5 ± 1.4	81 (47)
U.K.	8 ± 2	3.1	91 (70)
Japan	-	-	5 (38)
Germany	-	-	11 (31)
TOTAL	1200 ±350	180 ±25	240

Stockpiles of fissile material (weapon equiv.)

(*not including weapon materials declared excess*)

	Weapon HEU (25 kg/weapon)	**Weapon Pu** (4 kg/weapon)	**Civil Pu** (2002, ***including abroad***, 8 kg/weapon)
	← **same weapons** →		
Russia	24,000±12,000	30,000 ±6,000	5,000
USA	21,000 ± 3,000	12,000	2,000
China	1,000 ± 240	900±400	-
France	1,000 ± 320	1250 ± 350	6,000
U.K.	320 ± 80	800	9,000
Japan	-	-	5,000
Germany	-		4,000
TOTALS	50,000±13,000	45,000±7,000	30,000

Fissile Material Cutoff Treaty (FMCT)

Non-weapon-state Parties to the NPT have already agreed not to produce fissile material for weapons.

U.S., Russia, U.K., France, China have all stopped producing fissile material for weapons.

India, Israel, North Korea and Pakistan still producing?

Verified FMCT would make the production halt universal and permanent.

Cases of Iraq, Iran, Libya, N. Korea, S. Korea show FMCT could be verified with IAEA inspections under Additional Protocol clued by informants and satellite images.

Weapon material declared excess (disposed as of 6/30/04)

(tonnes)

	HEU (90% ^{235}U equivalent)	**Plutonium** (weapon grade)
Russia	500 (217)	34 (0)
U.S.	125 (29)	34(0)
U.K.	0	0.4(0)

Further reductions and declarations

If Russia and the U.S. reduced to 5,000 warheads each, each could declare much more fissile material excess:

Russia: 500 ±300 tons HEU, 100 ±25 tons Pu

U.S.: 400± 70 tons HEU, 27 tons Pu

Uncertainty in these numbers is a major problem

Total fissile-material stocks should be declared.
(***U.S. has declared its plutonium stocks.***)

Problems with disposition of excess weapon HEU

U.S. and U.K. naval reactors fueled with 93% enriched uranium.

--U.S. therefore stockpiling virtually all excess 93% enriched weapon uranium.

Russian reactors fueled with 21-45% enriched uranium.

Future naval reactors should be fueled with LEU *(<20% U-235)*

Problems with disposition of excess weapon plutonium

Partners not enthusiastic about paying for Russian Pu disp.

-- Russian nuclear establishment still wants breeder plutonium economy

-- U.S. NGOs and German government would prefer immobilization

U.S.-Russian disagreement over liability in case of incident

Pu should be in secure, monitored storage.

U.S. has funded secure storage facility for excess weapon material at Mayak in Urals.

But no agreement on reciprocal or IAEA monitoring

--U.S. will store in pit form.

--Russia will store in 2-kg spheres but classifies isotopic makeup.

The danger of nuclear terrorism

Very difficult to protect fissile material from theft

Attack. In exercises, heavily-armed attackers succeed about half the time -- even at U.S. nuclear-weapon facilities where the guards are also heavily armed.

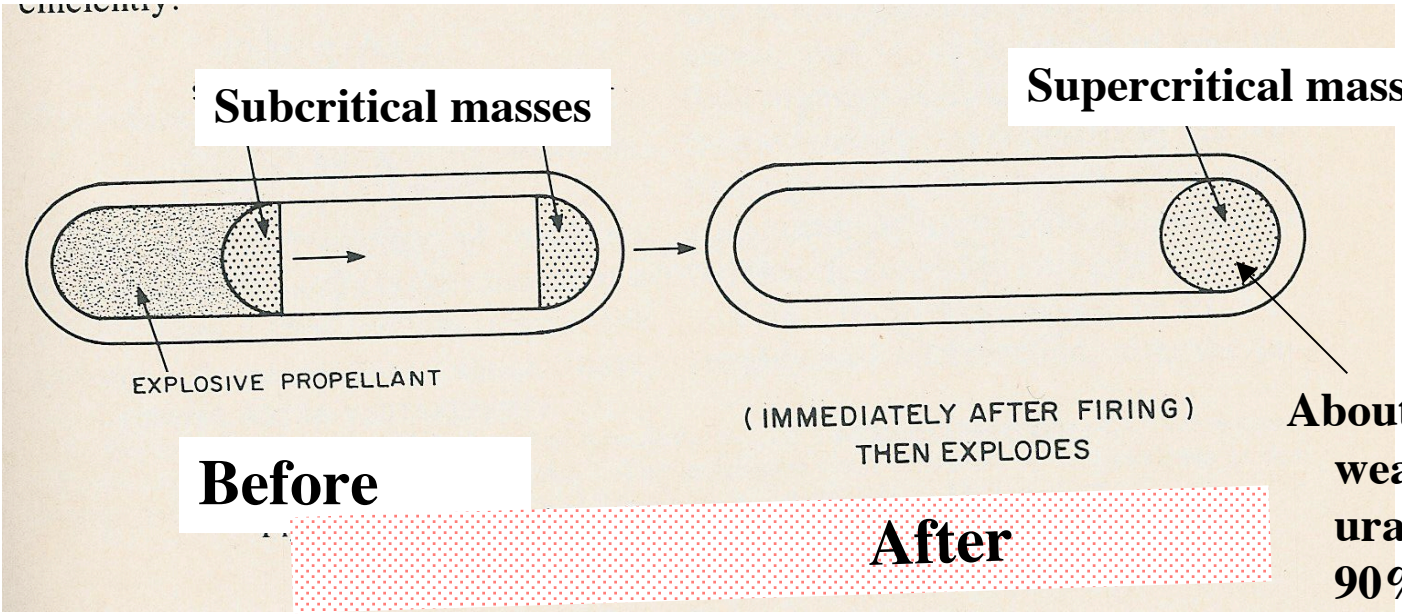
Diversion. A series of small but cumulatively significant insider thefts at a reprocessing or HEU or MOX fuel-fabrication plant could be undetectable.

Possible consequences of theft/explosion or Pu dispersion

-- Loss of civil liberties

-- If civilian plutonium, huge blow to nuclear industry

THREAT FROM HEU: *Gun-type design works for HEU and is feasible for terrorists*



About 60 kg of weapon-grade uranium (80-90% U^{235})

Need to reduce the use of HEU fuel

128 research-reactor sites with at least 20 kg of HEU.

Since 1978, international "Reduced Enrichment Research and Test Reactor" program has converted 38 research reactors to LEU (2 in Japan).

Still 129 HEU-fueled operating reactors (3 in Japan*) plus many shut-down HEU-fueled reactors.

*Fast critical assembly, Tokai Mura,
KUCA critical assembly, Kyoto University
UTR Kinki Argonaut, Kinki University
(KUR at Kyoto, to be shut down in 2006).

HEU-fueled reactors *not* currently targeted for conversion or shutdown

Critical assemblies

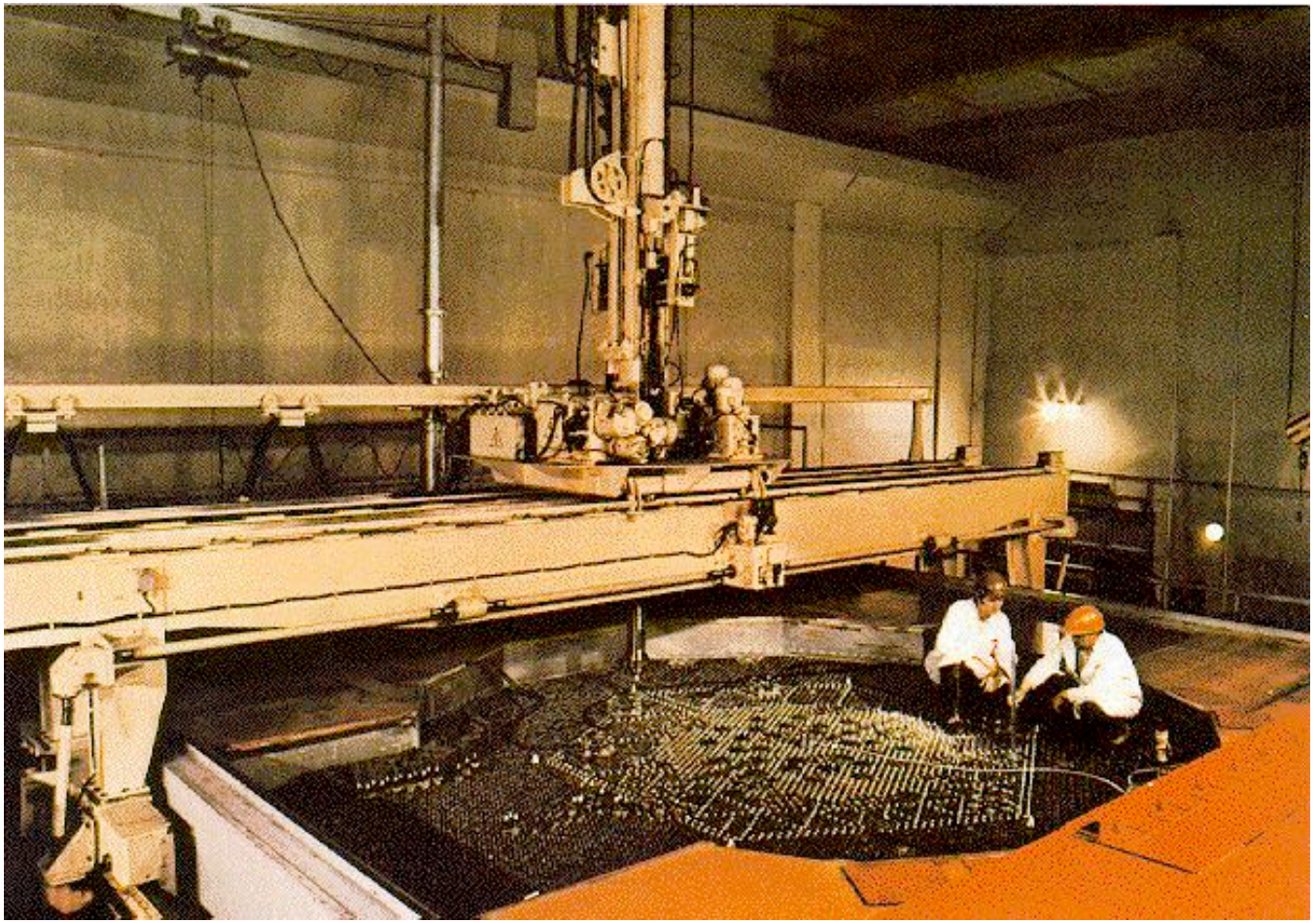
Pulsed reactors

Ice-breaker reactors

Naval reactors

BFS2 *critical assembly* mockup for breeder-reactors, Institute of Physics & Power Engineering, Obninsk Russia

(8700 kg HEU and 800 kg Pu in 90,000 disks +)



BIGR pulsed reactor contains 833 kg of barely irradiated weapon-grade uranium -- enough for 15 Hiroshimas

Russian Institute of Experimental Physics has submitted proposal for feasibility study on BIGR conversion to LEU to the ISTC

Russian Nuclear-powered Icebreakers

11 reactors on 7 ships. 400 kg ^{235}U/yr.

Deputy Director of base arrested in 2003 for nuclear-material theft.

Bochvar Institute proposal to develop LEU fuel for KLT-40 reactor approved by ISTC in 2001 "without funding"

Plutonium and nuclear terrorism

Could terrorists make a Nagasaki bomb with stolen plutonium?

- Opinions differ

Terrorists could certainly make a radiological weapon with plutonium.

- ≈ 1,000 cancer deaths per kg dispersed in a city

Civilian plutonium stocks

"the chance that [Britain's] stocks of [civilian] plutonium might, at some stage, be accessed for illicit weapons production is of extreme concern."

--U.K. Royal Society, *Management of Separated Plutonium* (1998)

BNFL plans to end reprocessing in the U.K. (no more German or Japanese spent fuel to reprocess)

French government has concluded that reprocessing is not economic

What if Japan had a no-surplus-plutonium policy? (including plutonium held abroad)

38 tons of stored separated plutonium at end of 2002

If 3 GWe of capacity fueled with 25% MOX fuel in 2012, 12 GWe in 2015, and 24 GWe in 2020, *no need to operate Rokkasho for about 15 years*.*

*0.35 tons/Gwe-yr

Implications of delay in operating Rokkasho

Need to store more spent fuel (800 tons/yr)

Dry cask storage at $100-200/kgU would cost $80-160 million/yr

-- much less than the $2 billion/yr (¥230 billion/yr) government subsidy that has reportedly been requested for the operation of Rokkasho

-- *dry storage much safer than pool storage*

Environmental benefits and costs from reprocessing in the long term

Benefits: Total plutonium in spent fuel reduced by about half per recycle in MOX

Costs: Each recycle creates large volume of transuranic waste from operations and decommissioning.

More plutonium left on surface than likely to leak out of spent-fuel repository.

Replacing LEU with fuel made of thorium and $LEU_{(20\%)}$ would reduce plutonium in spent fuel by 80% and actinides by half without reprocessing or recycle.

Interim storage would give us time to debate such alternatives.

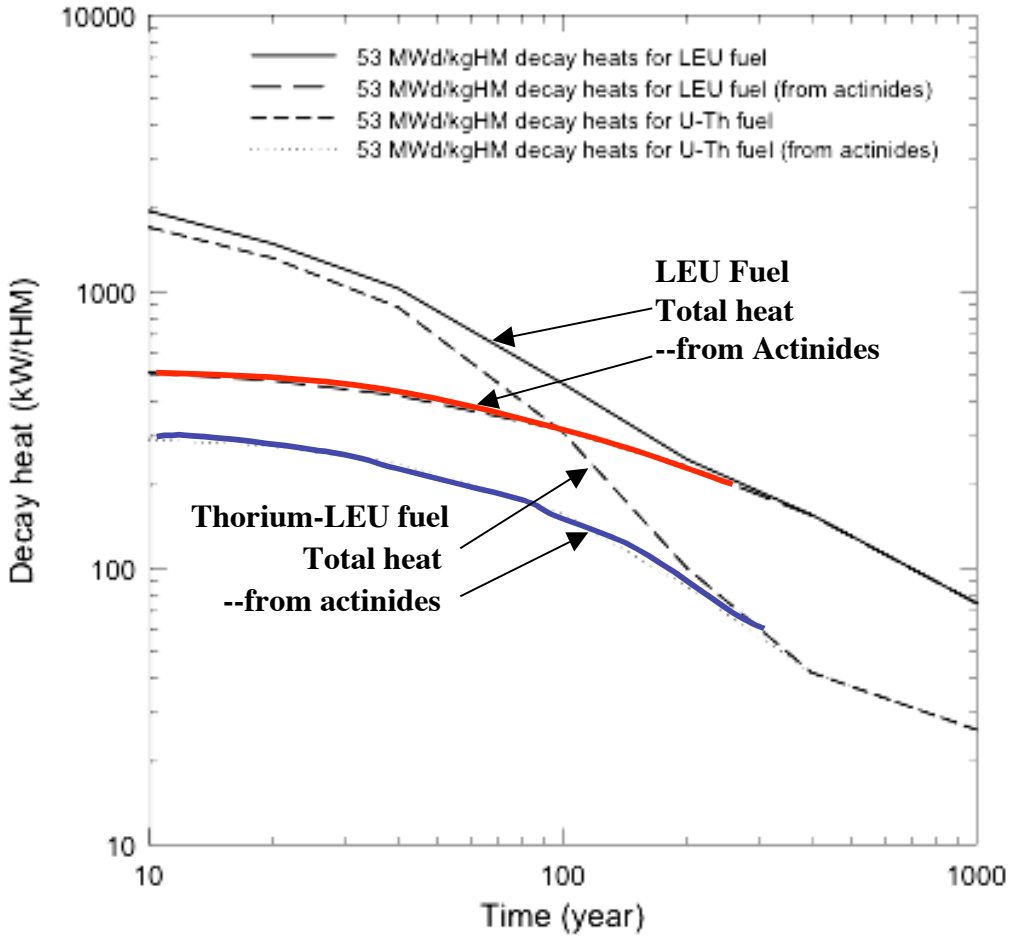


Fig. 1. Comparison of decay heat of a ton of 53 MWd/kgHM of spent LEU and U-Th fuels as a function of cooling time

Switching to Thorium-LEU fuel would reduce actinides in spent fuel by about half and plutonium by 80% without reprocessing or recycle

In addition to IAEA inspections: regional transparency for enrichment & reprocessing plants

One model could be the Argentine-Brazilian Agency for Accounting and Control of Nuclear Material

Another is EurAtom

Could Japan and China have regular reciprocal visits to discuss materials protection, control and accounting at their:

- ***centrifuge enrichment plants,***
- ***civilian reprocessing facilities, and***
- ***prototype breeder reactors?***

Regional spent-fuel storage

Russia only country interested in being host.

-- But Russia's environment & democracy movement opposes import of foreign radioactive waste and

-- Russia's nuclear establishment is interested in reprocessing the spent fuel.

What about interim (30-year?) storage in dry casks, after which spent fuel would be returned if no agreement on a long-term regional solution?