Global Phase-Out of Bomb-Grade Uranium

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The NPPP engages in research, debate, and public education to ensure that civilian applications of nuclear technology do not foster the spread of nuclear weapons to states or terrorist groups.

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Civilian HEU = Bomb-Grade Uranium

Type of Uranium	*Enrichment*
Natural	0.7%
LEU fuel for nuclear powerplants	3.5%
Military HEU in nuclear weapons	93.3%
Civilian HEU fuel for research reactors	93.3%
Civilian HEU targets for medical isotope production	93.3%

Easy to Make a Hiroshima-type Atomic Bomb from HEU

"With modern weapons-grade uranium . . . terrorists, if they had such material, would have a good chance of setting off a high-yield explosion simply by dropping one half of the material onto the other half. . . . Even a high school student could make a bomb in short order."

-- Luis Alvarez, Manhattan Project Scientist
Adventures of a Physicist (Basic Books, 1987), p. 125

Table 1. Critical Specifications for HEU/Natural-Uranium-Reflected Spheres.

Case Number	Ref. Number	Reflector Thickness (in)	Maximum Measured Multiplicatio n	Extrapolated Critical Mass (kg U)	Extrapolated Critical Mass (kg ^{235}U)
1	1	3.925	0.0060[(a)]	19.74	na
	2	3.925	167	19.83±0.5%	na
	3	3.93	na	19.82±0.5%	na
	4	3.93	167	na	18.61 ± 0.09
2	1	3.525	0.0188 [(a)]	20.47	na
	2	3.525	53	20.6±1%	na
	3	na	na	na	na
	4	3.52	53	na	19.2 ± 0.2
3	1	1.761	0.0071 [(a)]	26.45	na
	2	1.76	141	26.6±0.5%	na
	3	1.742	na	26.56±0.5%	na
	4	1.742	141	na	24.96±0.12
4	1	0.695	0.0064 [(a)]	36.41	na
	2	0.695	156	36.3±0.5%	na
	3	0.683	na	36.53±0.5%	na
	4	0.683	156	na	34.31 ± 0.17

HEU Exports: 1950s-1970s

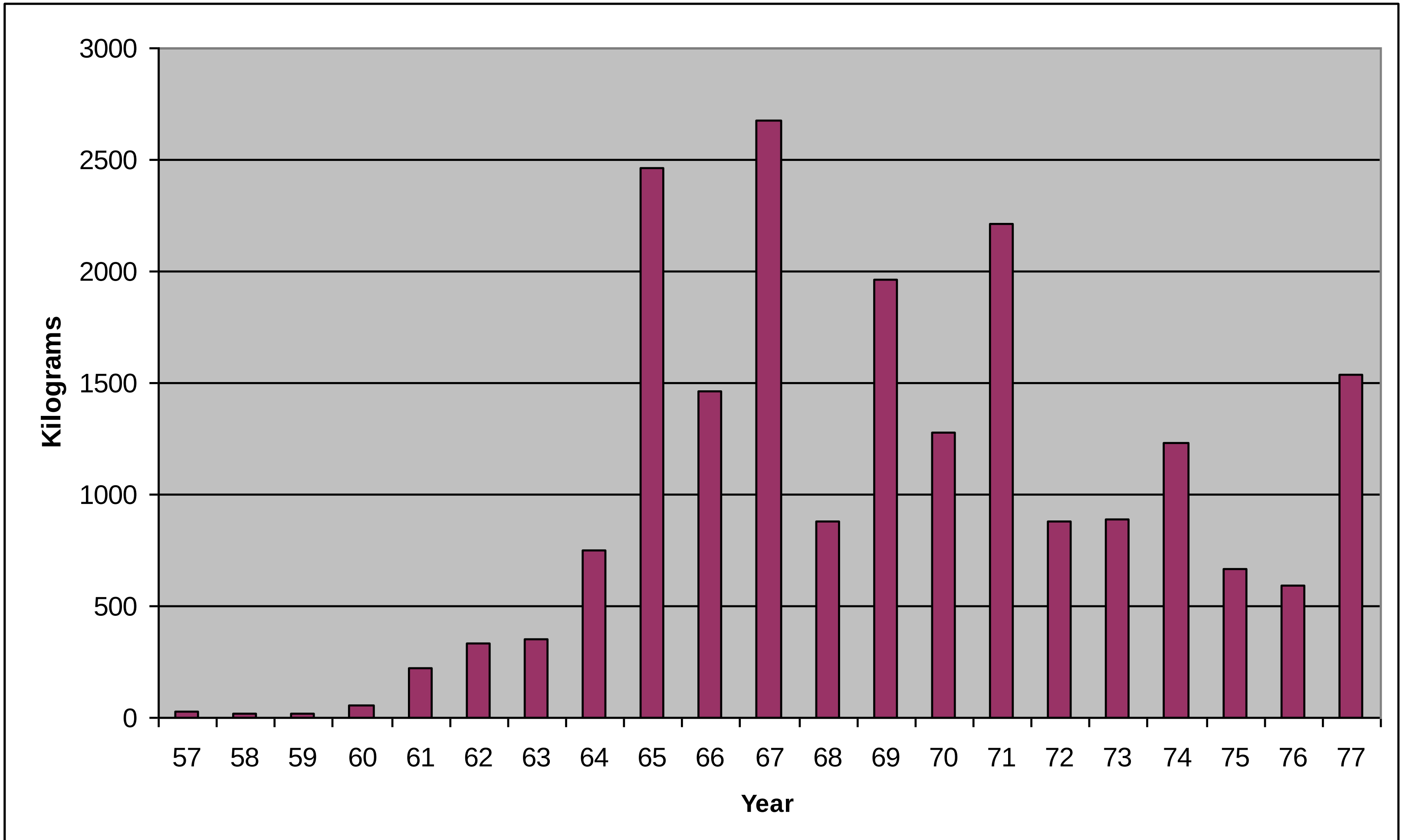
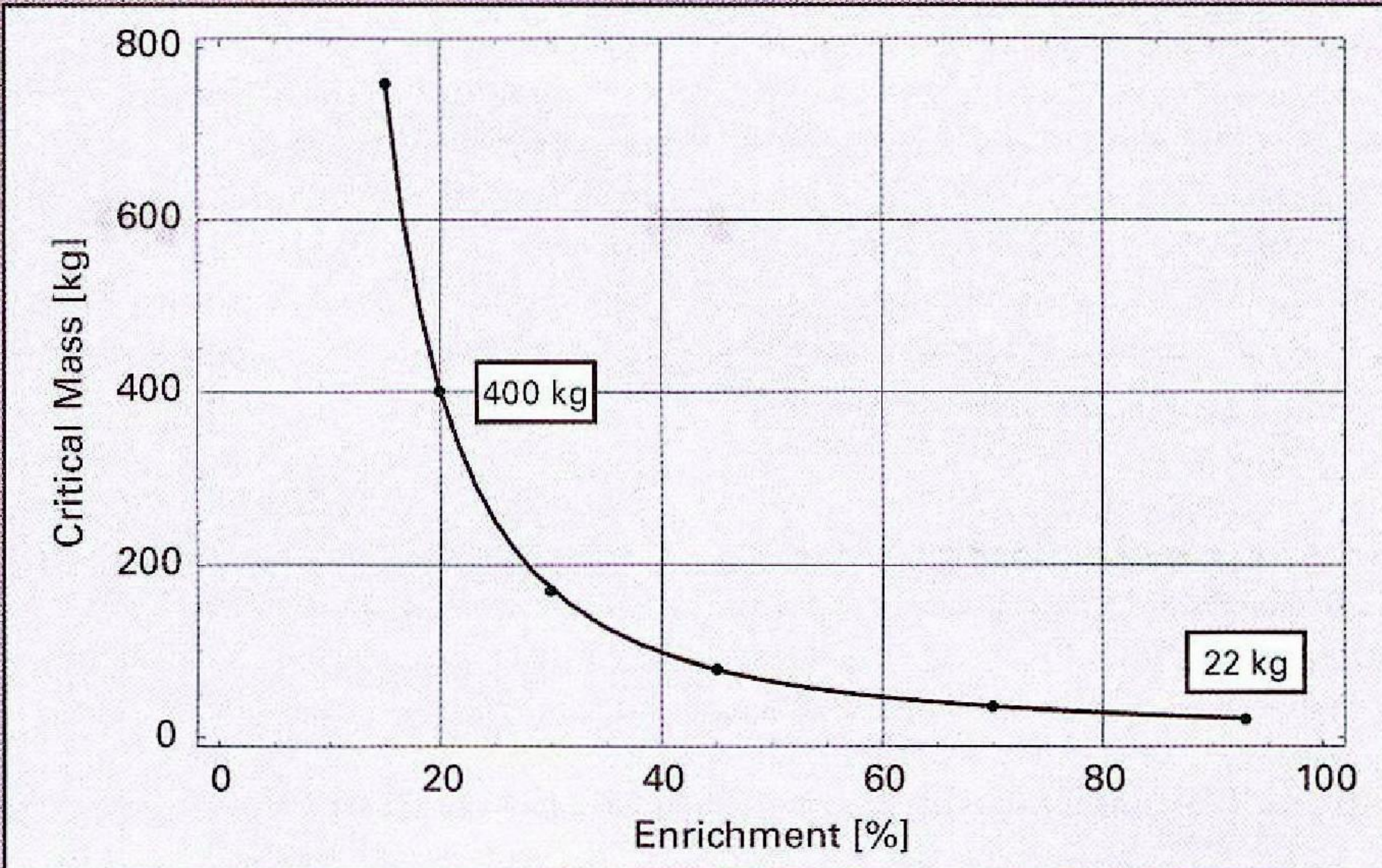
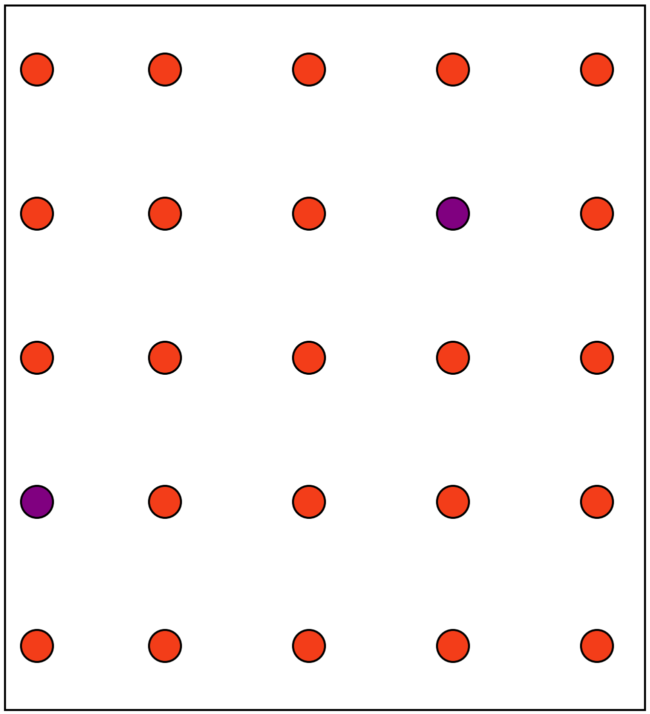


Figure 1 Critical mass of a uranium sphere surrounded by a 5-cm beryllium "neutron reflector" as a function of uranium-235 enrichment.

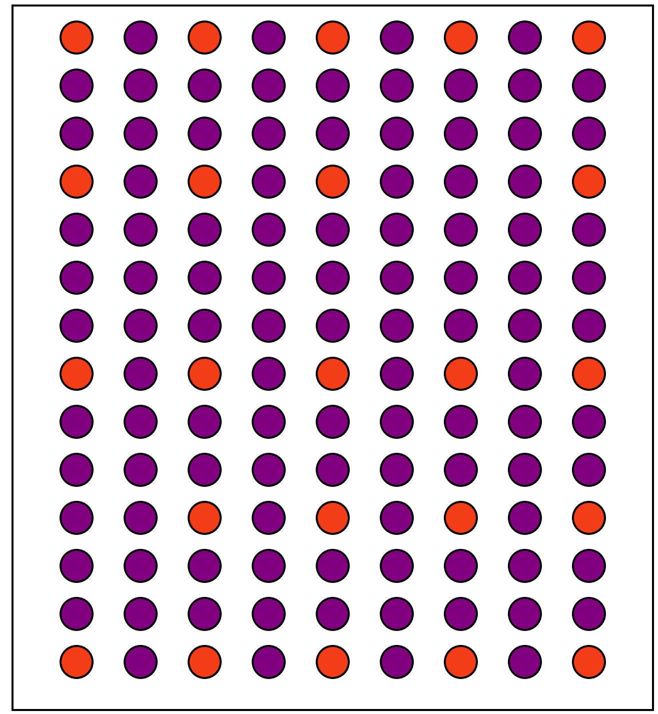


RERTR Converts Fuel and Targets from HEU to LEU:

Higher Uranium Density Enables Lower Enrichment



HEU: 93.3%-enriched



LEU: 19.9%-enriched

Key:
= U-235
= U-238

Progress on HEU Phase-Out

- 1978: RERTR for LEU fuel (later expanded to LEU targets for medical isotope production).
- 1980s: Russian copycat program for exported reactors.
- 1986: U.S. NRC orders conversion of domestic reactors.
- **Almost all research reactors built since 1980 use LEU.**
- **74 research reactors worldwide have converted to LEU or shut down,** of 200 now within GTRI scope.
- **Medical isotopes (Mo-99) are made w/o HEU in** Australia, Argentina, and – **as of this year – South Africa (the first large-scale production).**

Problem #1: HEU Still Used at Facilities <u>Within</u> Scope of RERTR

- Research reactors that use the most HEU have not yet converted:

	USA	Europe	Russia et al.
	ATR	HFR-ILL	SM-3
	HFIR	FRM-II	MIR.M1
	MURR	BR-2	WWR-M
	NBSR	Orphee	IVV-2M
	MIT		Etc.
HEU (kgs/yr)	***250***	***130***	***300+***

- 90% of medical isotopes still made with HEU.

Problem #2: HEU in Non-Weapons Activities <u>Outside</u> Scope of RERTR

- Critical assemblies
- Pulsed reactors
- Naval propulsion
- Ice-breaking ship propulsion
- Floating reactors (potential)
- Space reactors (potential)

Most HEU Commerce Continues

Nuclear Activity	**Kgs Used per Year**	**Kgs in Lifetime Cores**
Research Reactors	750	
Medical Isotope Targets	50	
Naval Propulsion	3,000	
Ice-Breaking Ship Propulsion	~250	
Critical Assemblies		~10,000
Pulsed Reactors		~2,000
TOTAL	**~4,000**	**~12,000**
	(Of which, only 800 in RERTR scope)	
Reduced by Conversion to Date	**280**	
Reduced by Shutdown to Date	**450**	**~1000s**

HEUphaseout.org

Global HEU Phaseout

NPPP POLICY RESEARCH PROJECT - UNIVERSITY OF TEXAS AT AUSTIN

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This year-long Nuclear Proliferation Prevention Project research project — led by Prof. Alan J. Kuperman and involving 14 University of Texas at Austin graduate students in nuclear engineering and global policy studies explores the technical and political prospects and challenges of reducing worldwide non-weapons usage of highly enriched uranium (HEU). Most previous research and policy initiatives in this area have focused on the use of HEU as fuel for nuclear research reactors and as targets for production of medical isotopes. Our project updates and broadens the scope of past research to cover all remaining non-weapons usage of HEU, including the following: naval propulsion, ice-breaking ship reactors, floating reactors, critical assemblies, pulsed reactors, research reactors, and isotope production.

The research project is funded by the Nuclear Threat Initiative

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Field Research in 11 Countries

- Argentina
- Belgium
- Canada
- China
- France
- Germany
- Netherlands
- Norway
- Russia
- South Africa
- USA

13 Research Projects

Past Successes

- Medical Isotope Production in Argentina
- Reactor Fuel and Isotope Production in South Africa

Continued Progress

- High-Powered Research Reactors in the United States and Europe
- FRM-II in Germany
- *Icebreakers and Floating Reactors in Russia*
- Civilian HEU Use in China

Ongoing Civilian HEU Use

- Medical Isotope Production in Canada/Russia
- *Medical Isotope Production in Belgium and Netherlands*
- Research Reactors in Russia
- Critical Assemblies in Russia

Ongoing Military HEU Use (non-weapons)

- *Naval Propulsion in the United States*
- Naval Propulsion in Russia

Future Applications

- Space Reactors

Today's Presentations

Medical Isotope Production in Europe
Alex Fay

Icebreakers and Floating Reactors in Russia
Christine Egnatuk

Naval Propulsion in the United States
Rebecca Ward