Nuclear Choices

Current Technical and Policy Challenges For Managing Nuclear Technologies

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Revision 24

Remarks of U.S. President Obama

Hradcany Square, Prague, Czech Republic, April 5, 2009

"Today, I am announcing a new international effort to secure all vulnerable nuclear material around the world within four years."

"We should build a new framework for civil nuclear cooperation, including an international fuel bank, so that countries can access peaceful power without increasing the risks of proliferation."

Two Case Studies

Global Cleanout of Highly Enriched Uranium
from the Civilian Nuclear Fuel Cycle

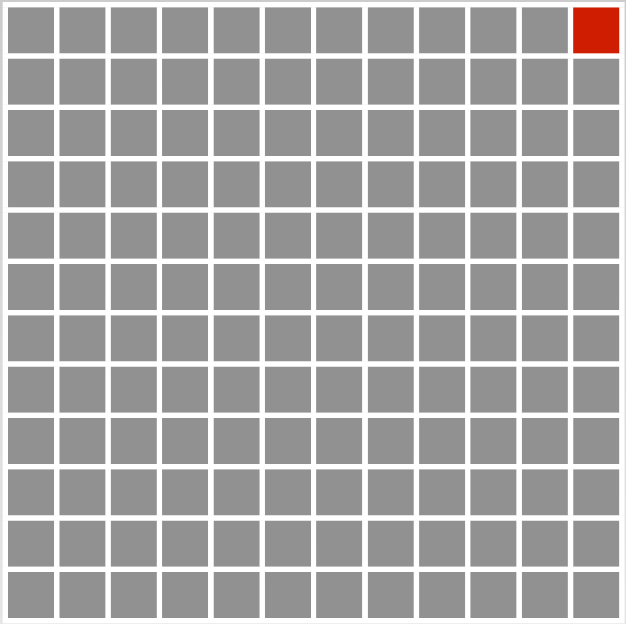
Uranium Enrichment and
the Proliferation of Centrifuge Technology

Highly Enriched Uranium

and Nuclear Weapons

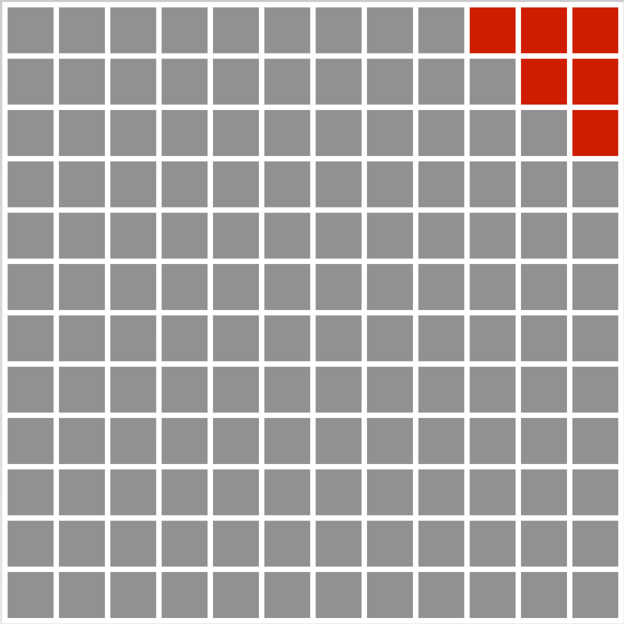
Enriched Uranium

(visually)



Natural uranium

0.7% U-235



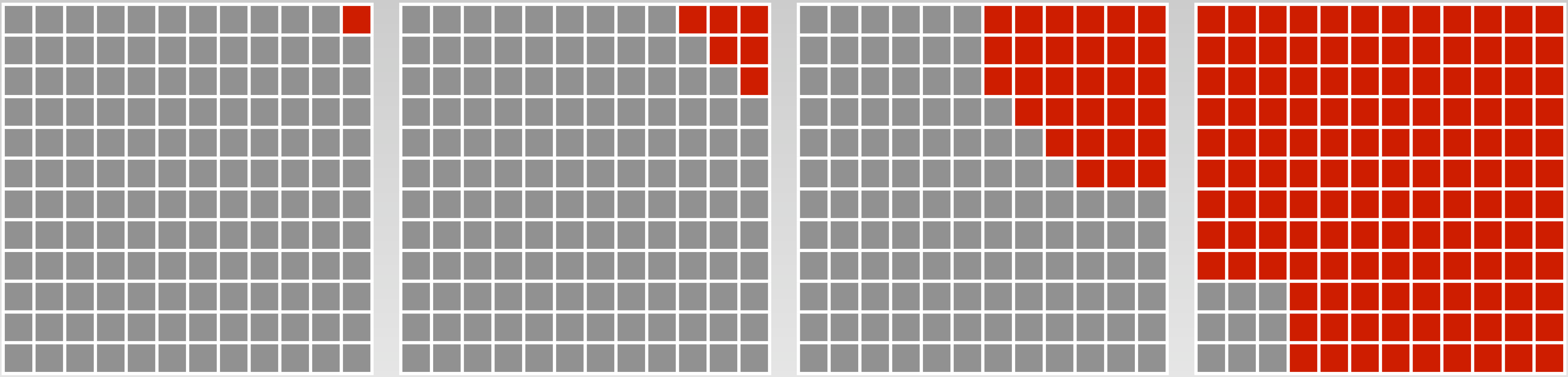
Low-enriched uranium

typically 3-5%,
but less than 20% U-235

Enriched Uranium

(visually)

HEU
(weapon-usable)



Natural uranium
0.7% U-235

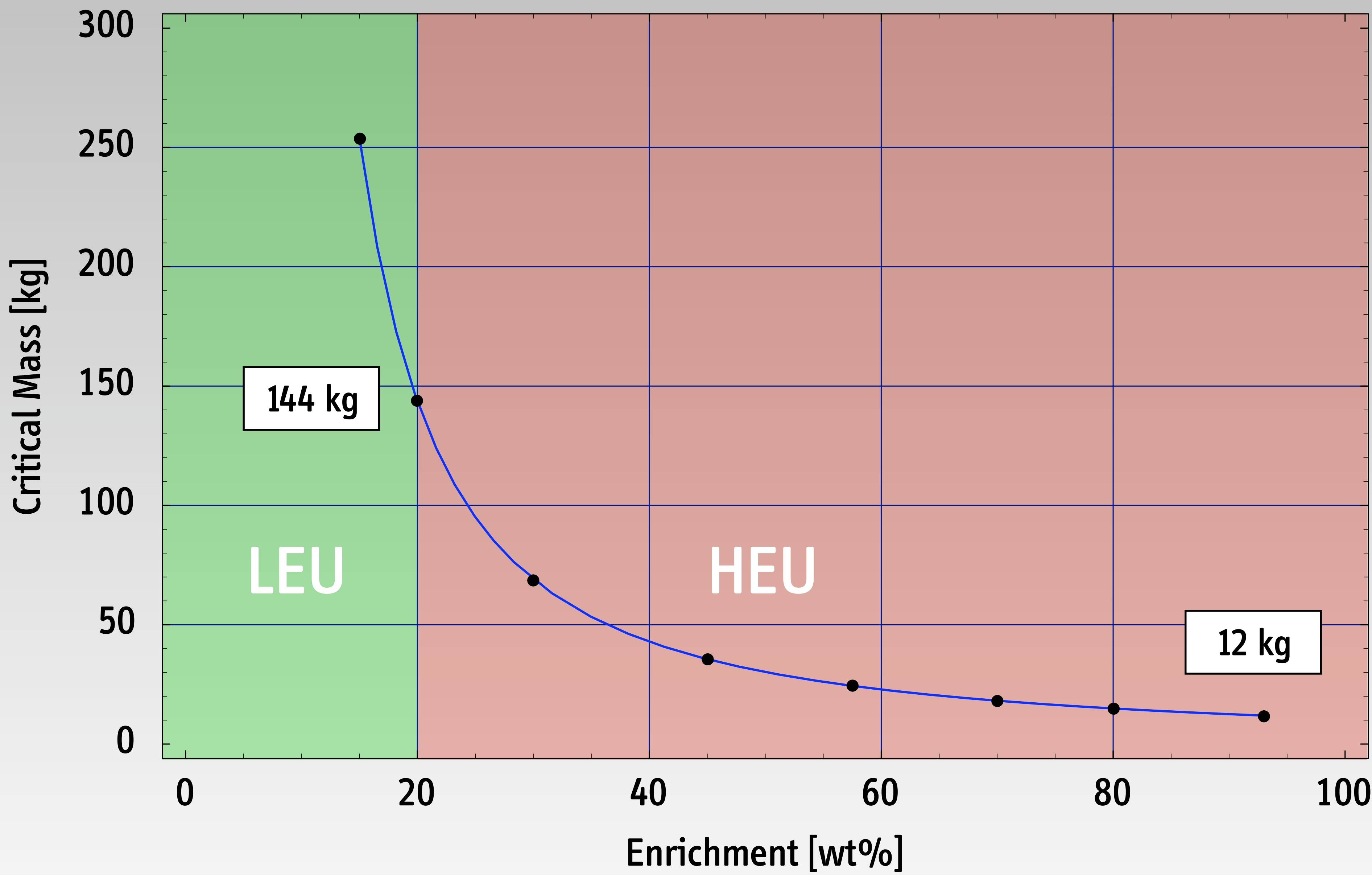
Low-enriched uranium
typically 3-5%,
but less than 20% U-235

Highly enriched uranium
20% U-235 and above

Weapon-grade uranium
more than 90% U-235

Critical Mass of Uranium

(for a beryllium-reflected metallic sphere)



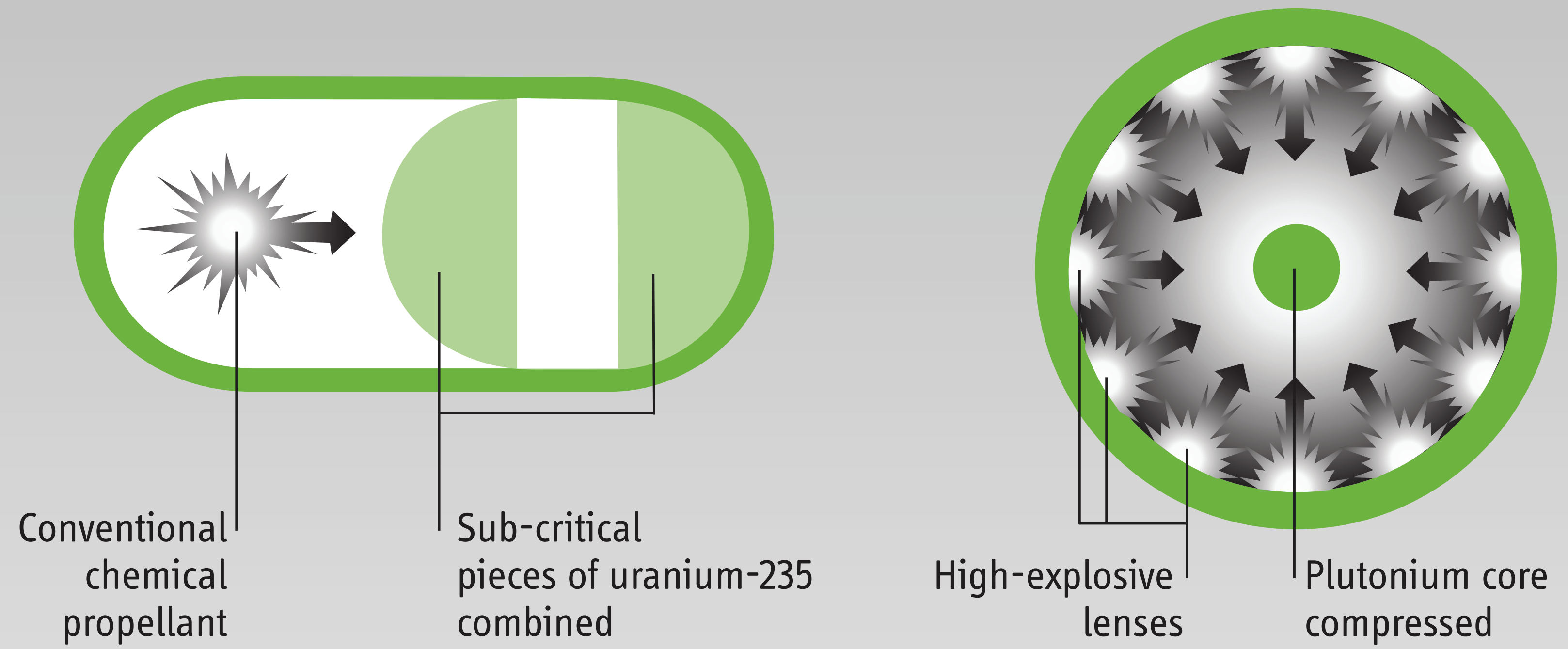
A. Glaser, *Neutronics Calculations Relevant to the Conversion of Research Reactors to Low-Enriched Fuel*
Ph.D. Thesis, Department of Physics, Darmstadt University of Technology, April 2005

Characteristics of Highly Enriched Uranium

Easy to handle

Easy to use in nuclear weapon or nuclear explosive device

Difficult/Impossible to detect



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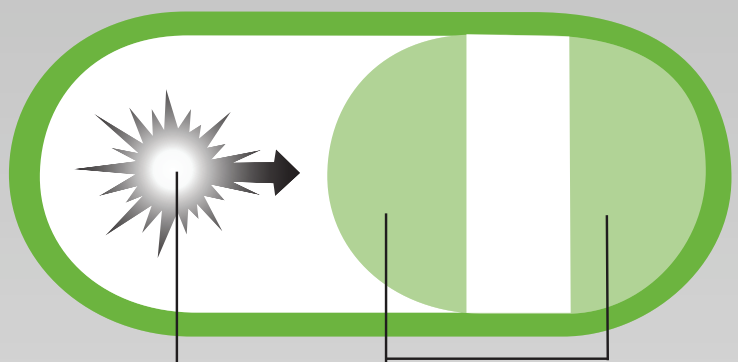
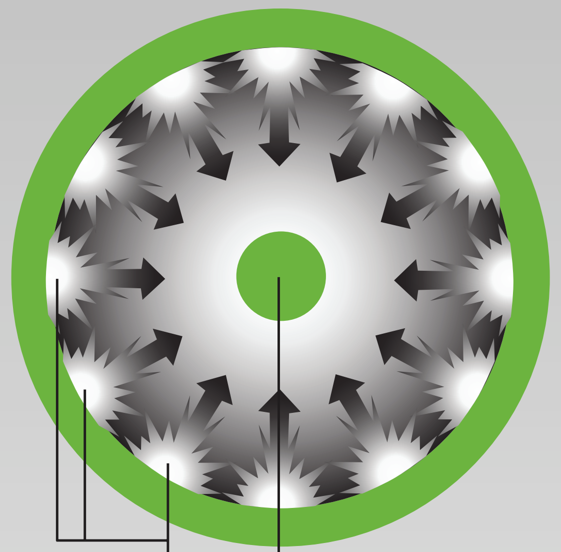




Difficult to produce

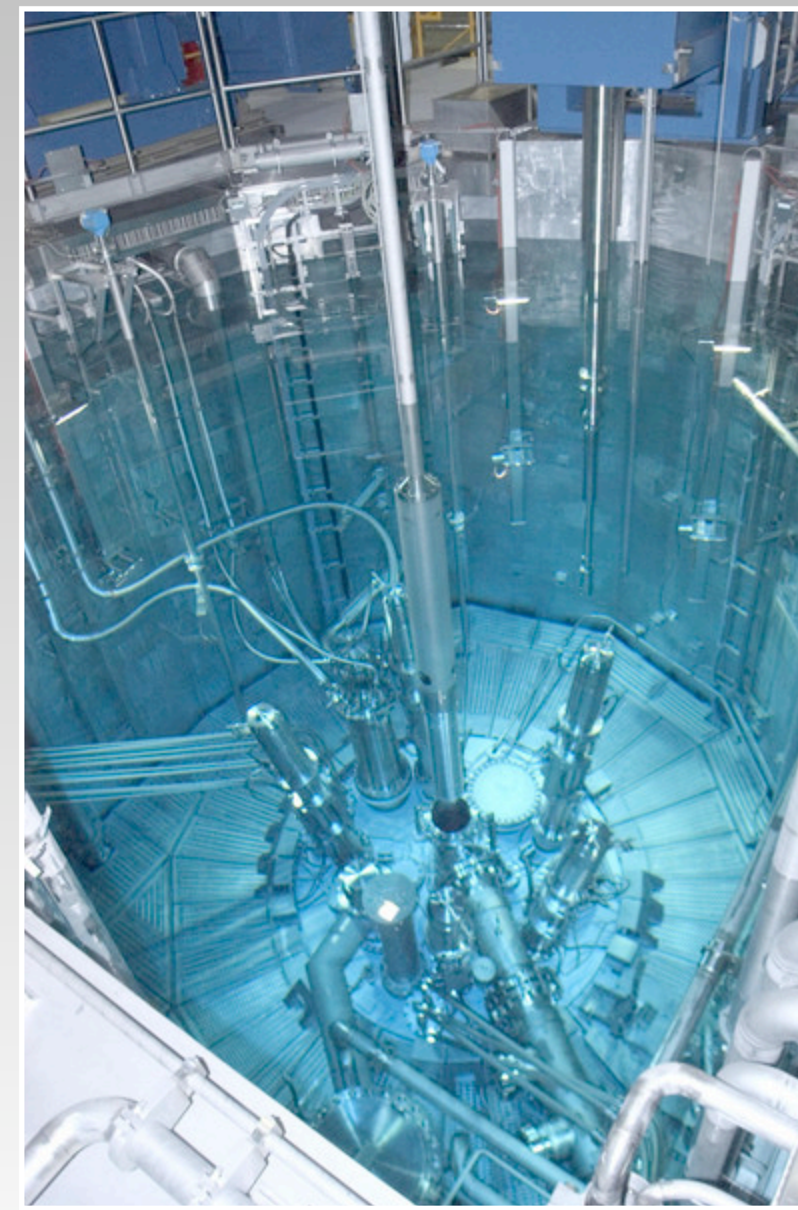
EXAMPLE 1

Global Cleanout of Civilian Highly Enriched Uranium

(Ending the Use of Highly Enriched Uranium in Research Reactors)

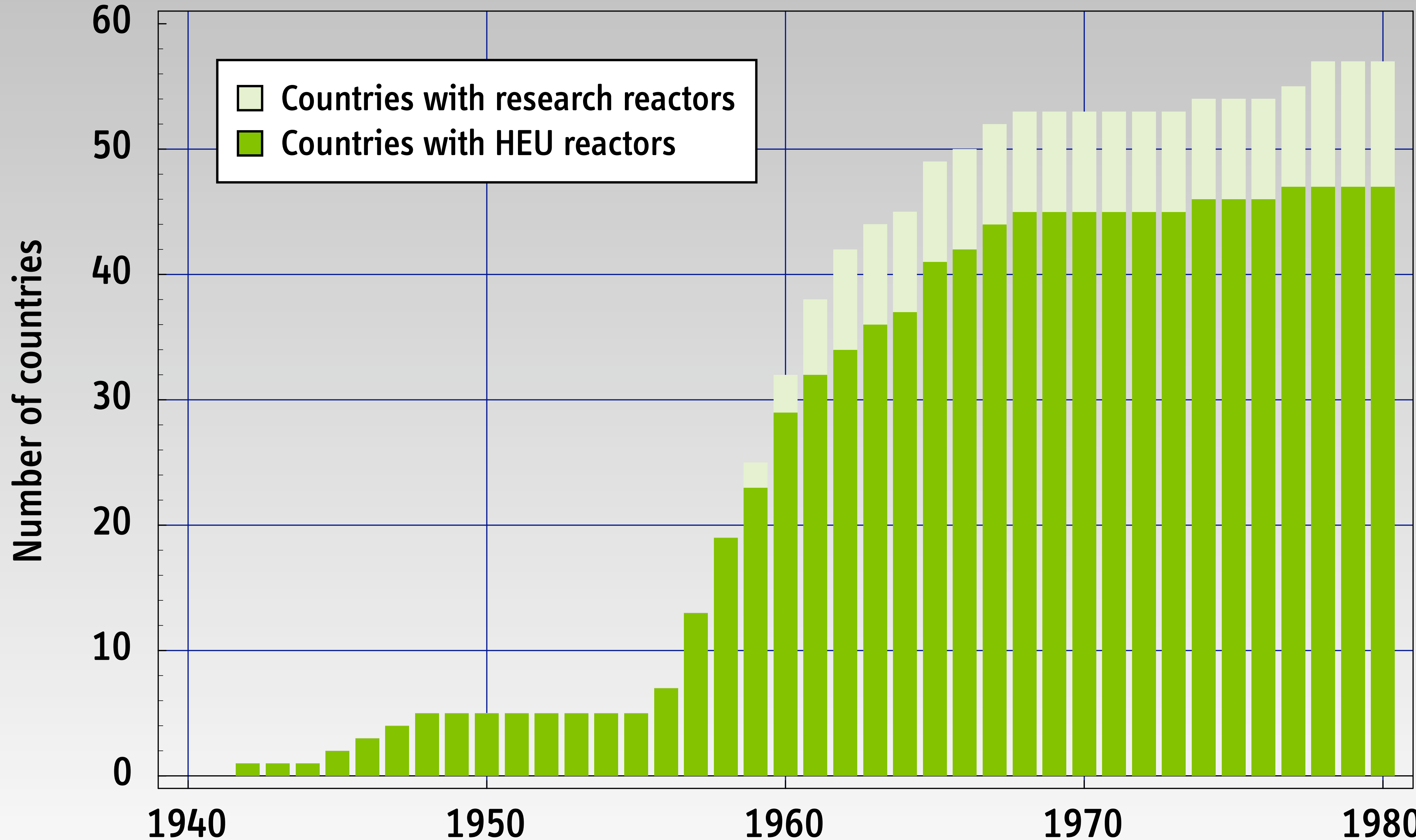
What Are Research Reactors?

And What Are They Good For?



Research Reactor FRM-II, Munich, Germany (www.frm2.tum.de)

Countries with Research Reactors



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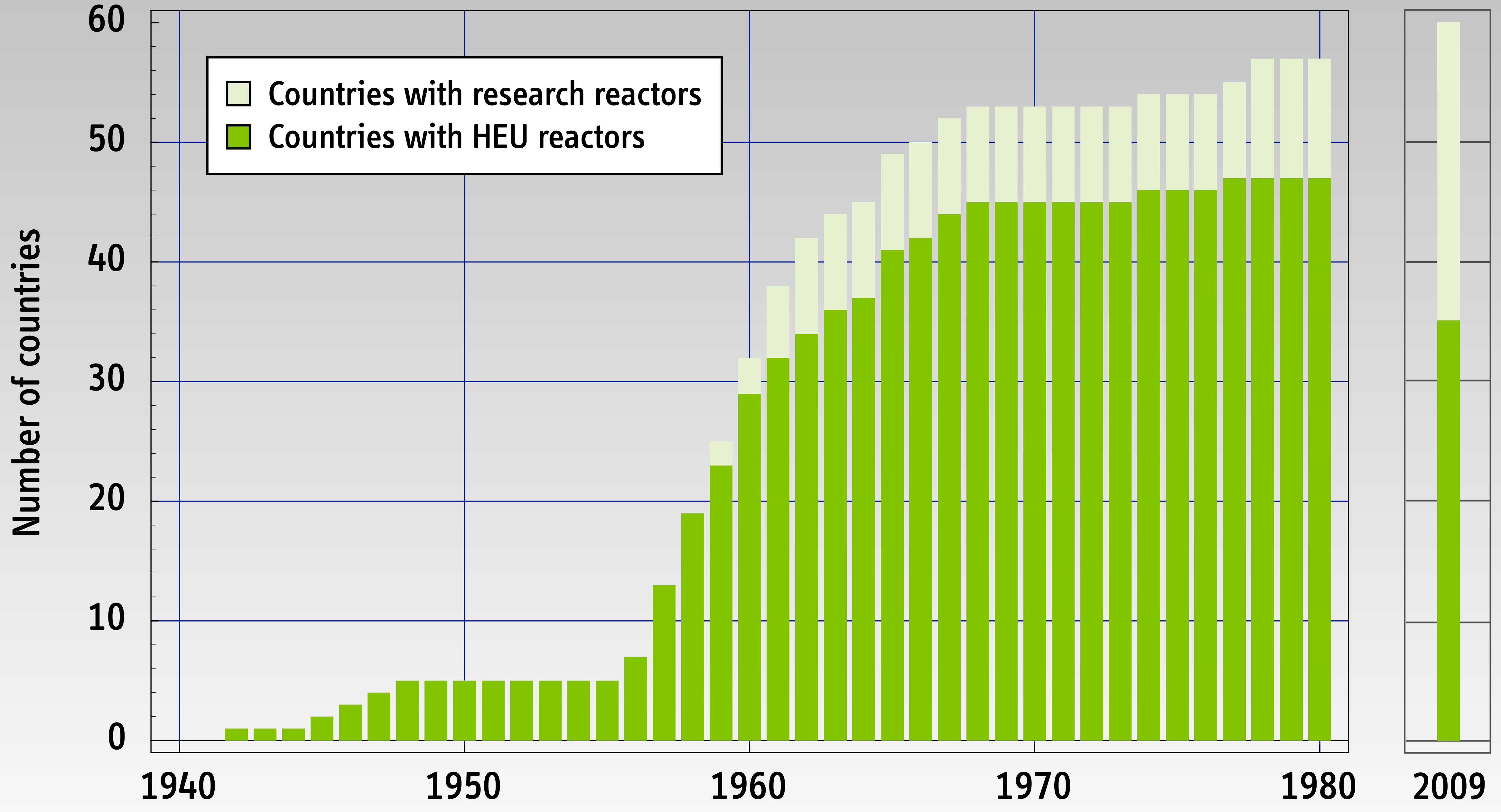

Why Has it Been So Difficult to Convert Research Reactors in the Past?

Little high-level governmental attention and support

(U.S. RERTR budget: less than $2 million per year throughout the 1990s)

Resistance on the part of reactor operators

(performance loss, cost, relicensing and shutdown concerns)

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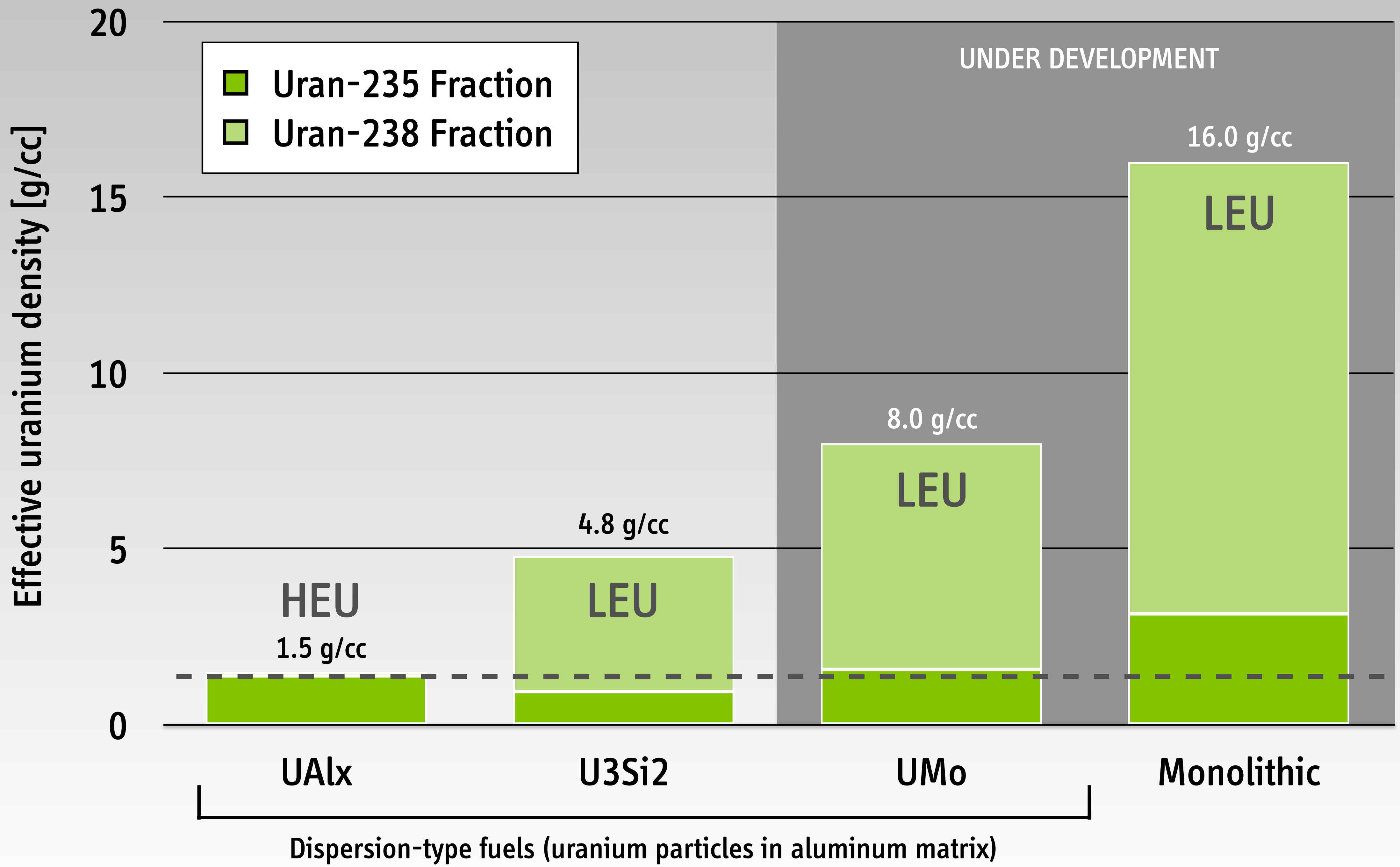
Global Threat Reduction Initiative (GTRI), since 2004

FY 2009 budget: $395 million

(including more than $50 million for HEU reactor conversion (+50% vs FY 2008)

Discovery of advanced high-density fuels

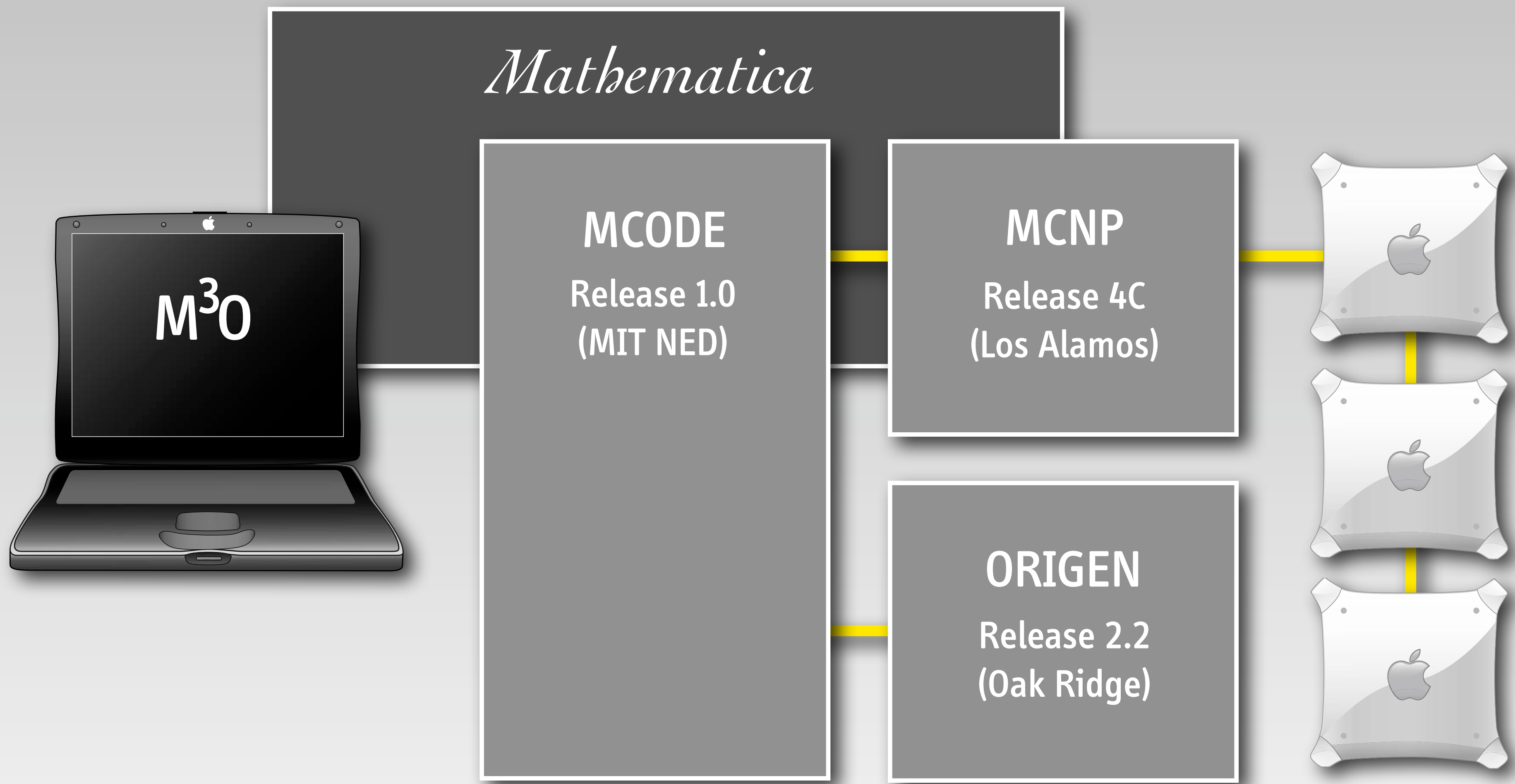
Effective Uranium Density in Advanced Research-Reactor Fuels



Reactor Modeling

Determining the Potential of New High-density Fuels for the Conversion of Research Reactors to Low-enriched Uranium

System for Neutronics Calculations



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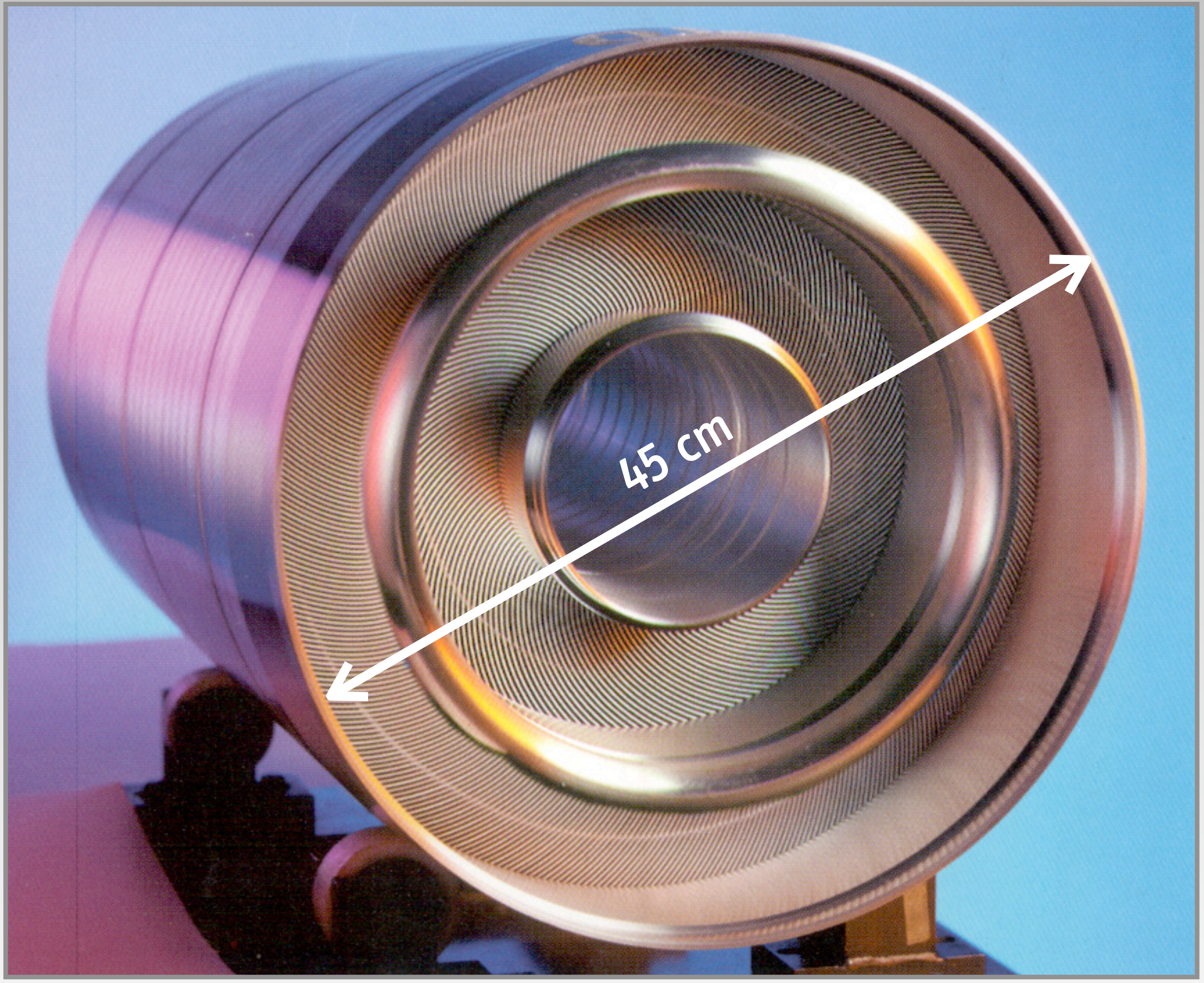
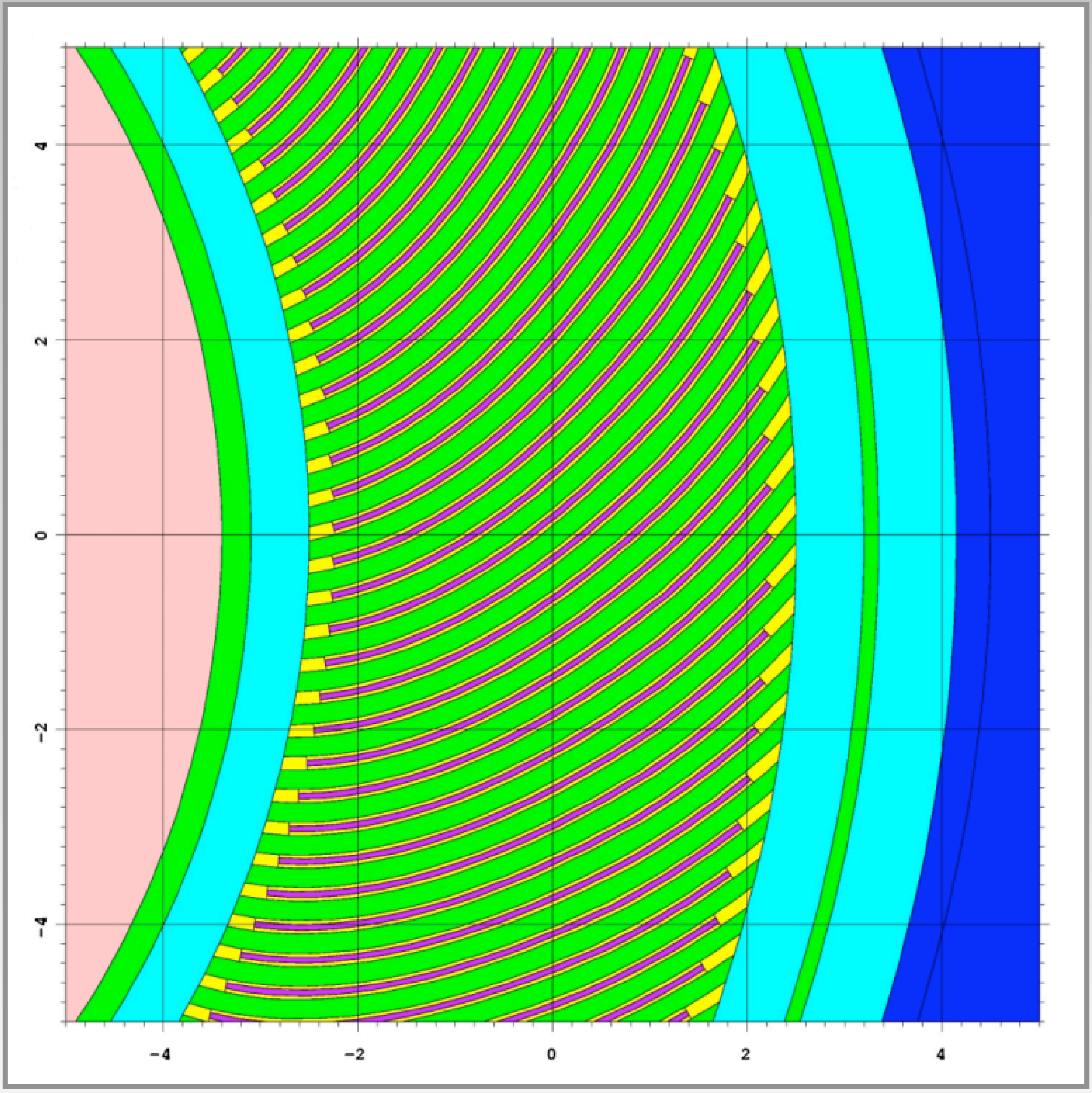
Fuel Element of a High-Flux Reactor



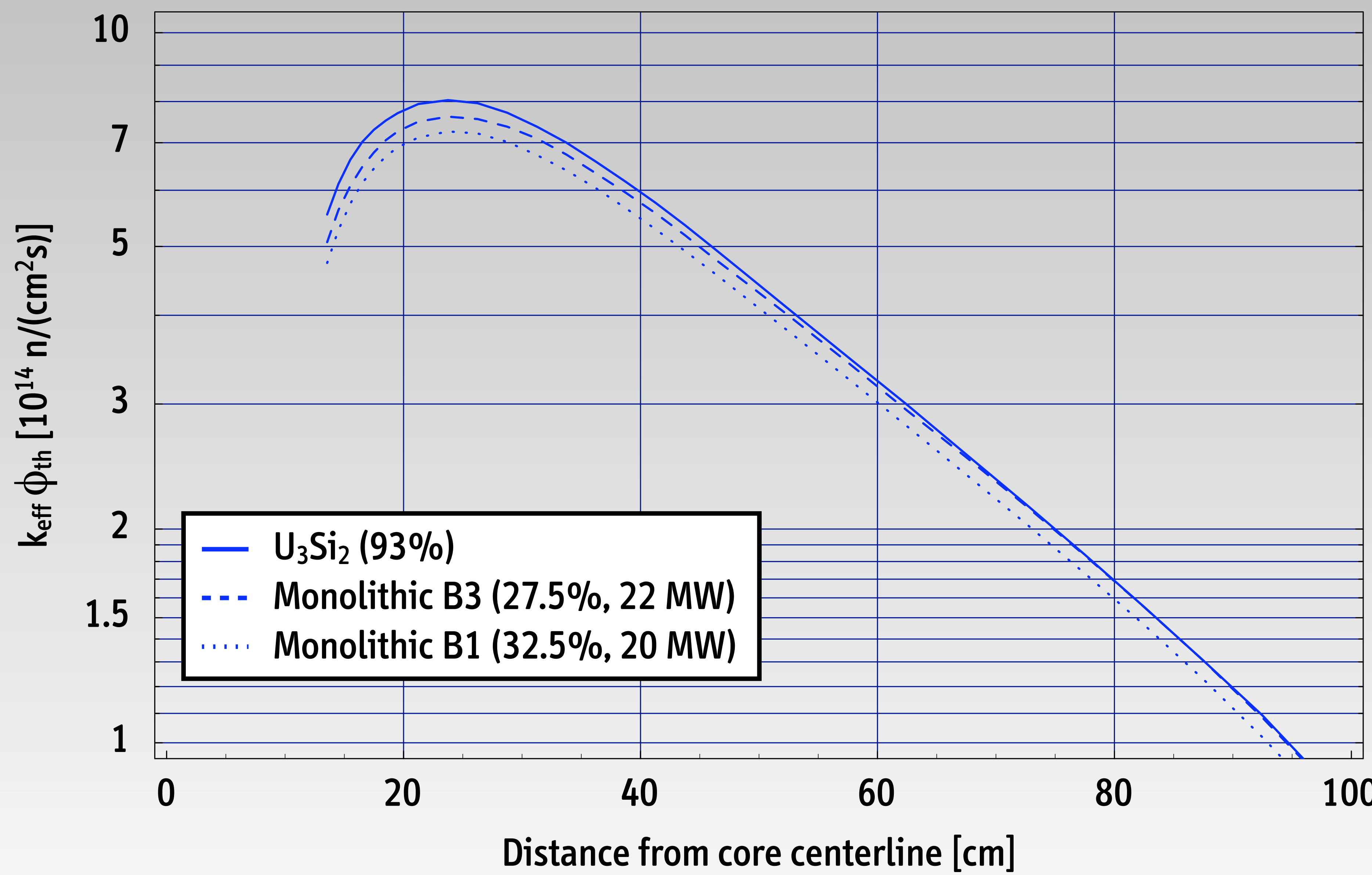
HFIR fuel element (Source: BWXT)



MCNP model of FRM-II core

Thermal Neutron Flux Near the Core

(FRM-II before and after conversion to fuel with reduced rnrichment)



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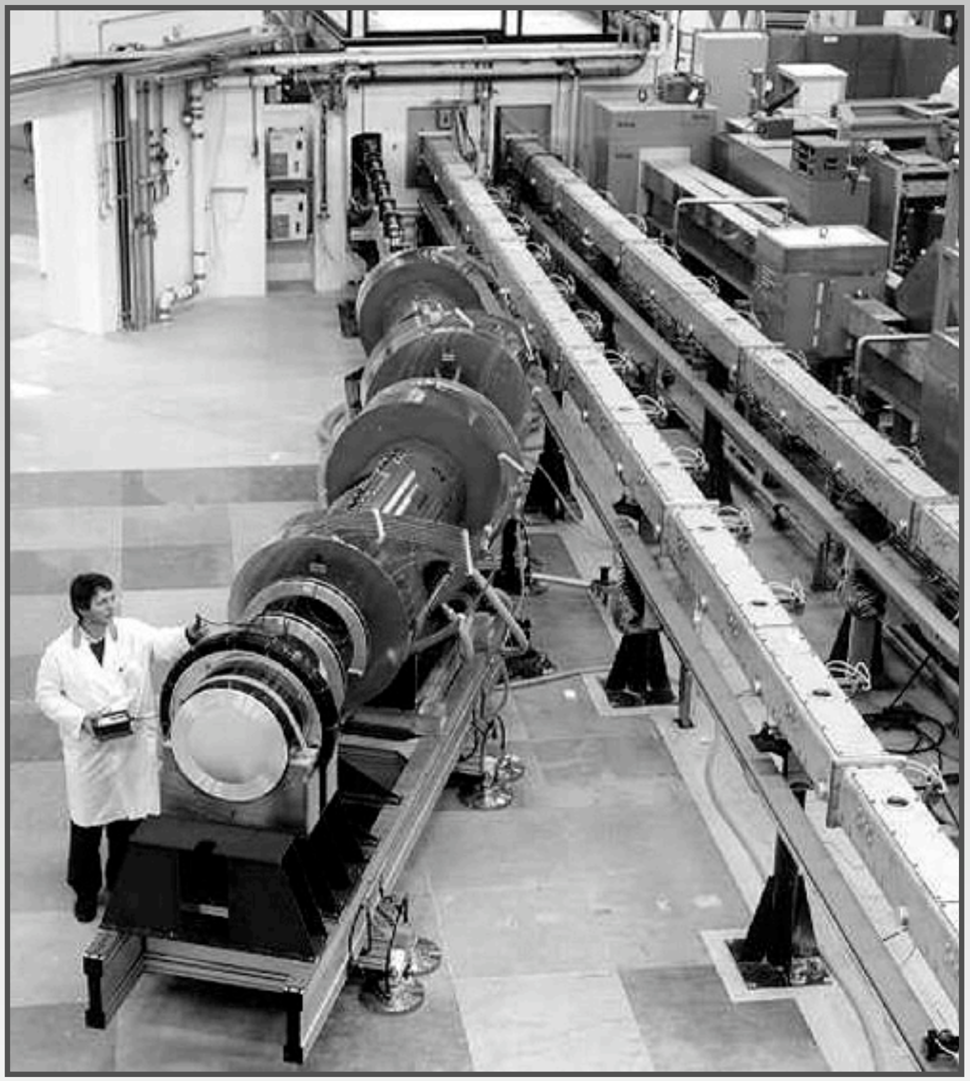
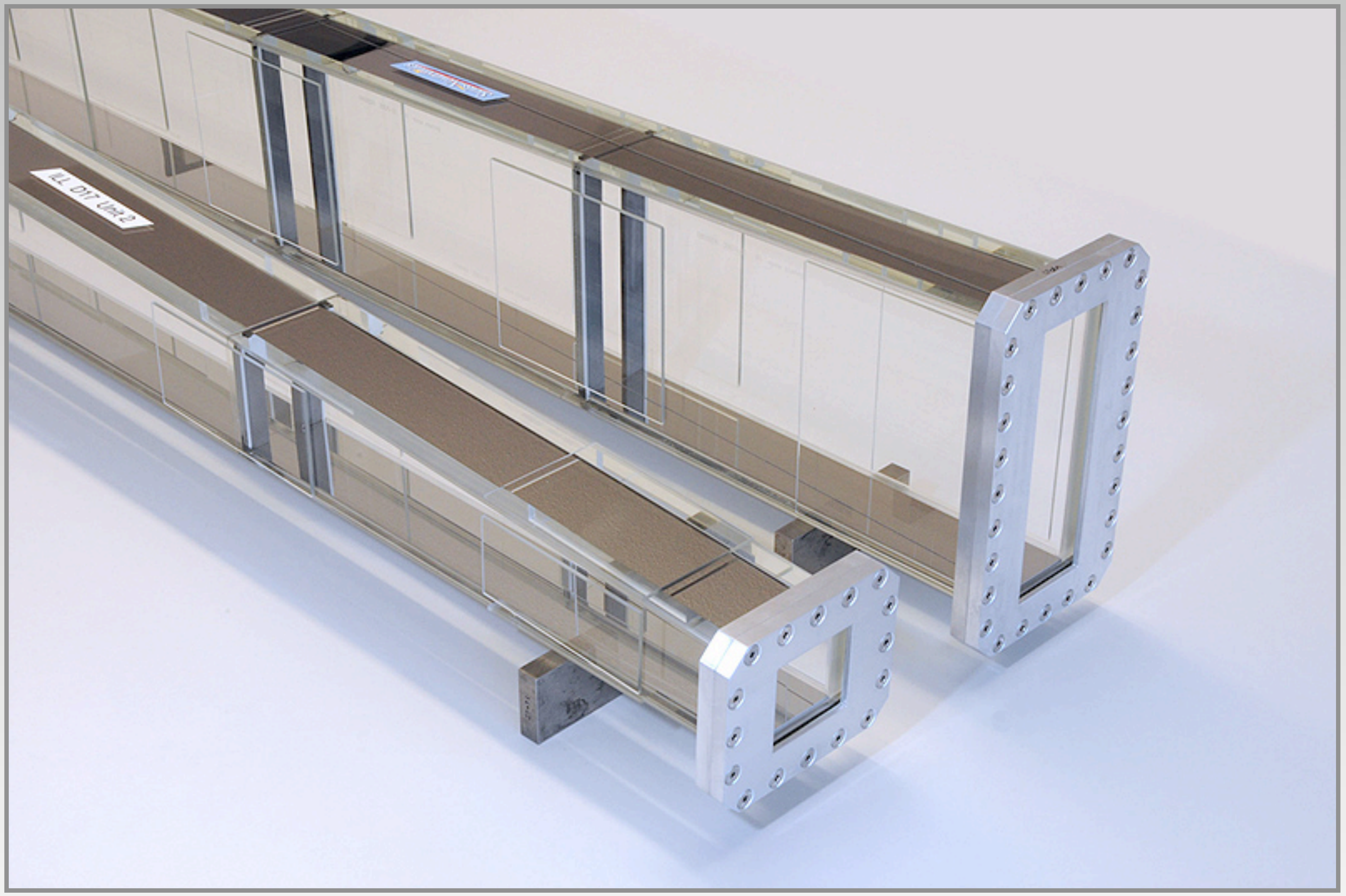
Supermirrors for Neutron Guides

(Most Neutrons are Used Far Away From the Reactor Core)



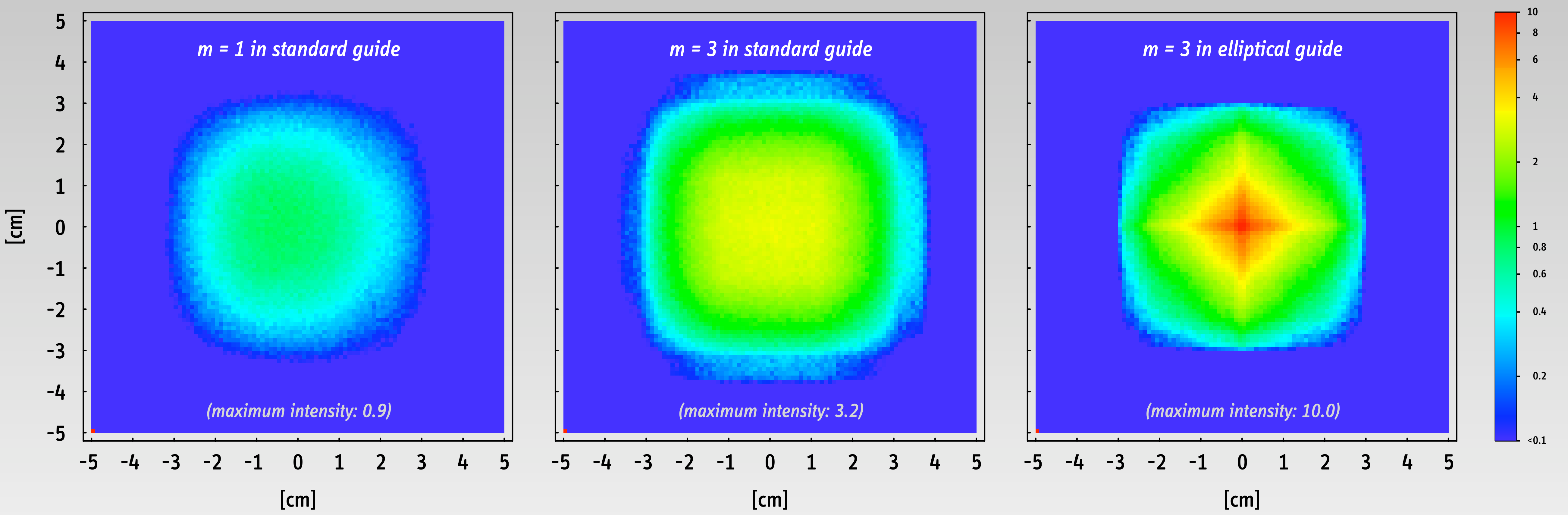
Neutron guide hall of HFR/ILL



Courtesy: Swissneutronics

Spatial Intensity Distribution

for various supermirror coatings and two guide geometries



Shown are the planes of best focus behind the exit of a neutron guide with a total length of 35m
Each simulation is based on 10 million neutron tracks

Source: A. Glaser and U. Filges, "Neutron-Use Optimization with Virtual Experiments to Facilitate Research-Reactor Conversion to Low-Enriched Fuel," under review.

What Do We Have to Lose From Giving Up the Use of HEU?

In the past, some research reactors have experienced a small reduction (10–15%) in neutron flux as a result of conversion to LEU

"Convert & Upgrade"

A Strategy to Enable the Global Cleanout of Highly Enriched Uranium

Consolidate research reactor fleet and create regional "centers of excellence"

(Shutdown other facilities where HEU remains today)

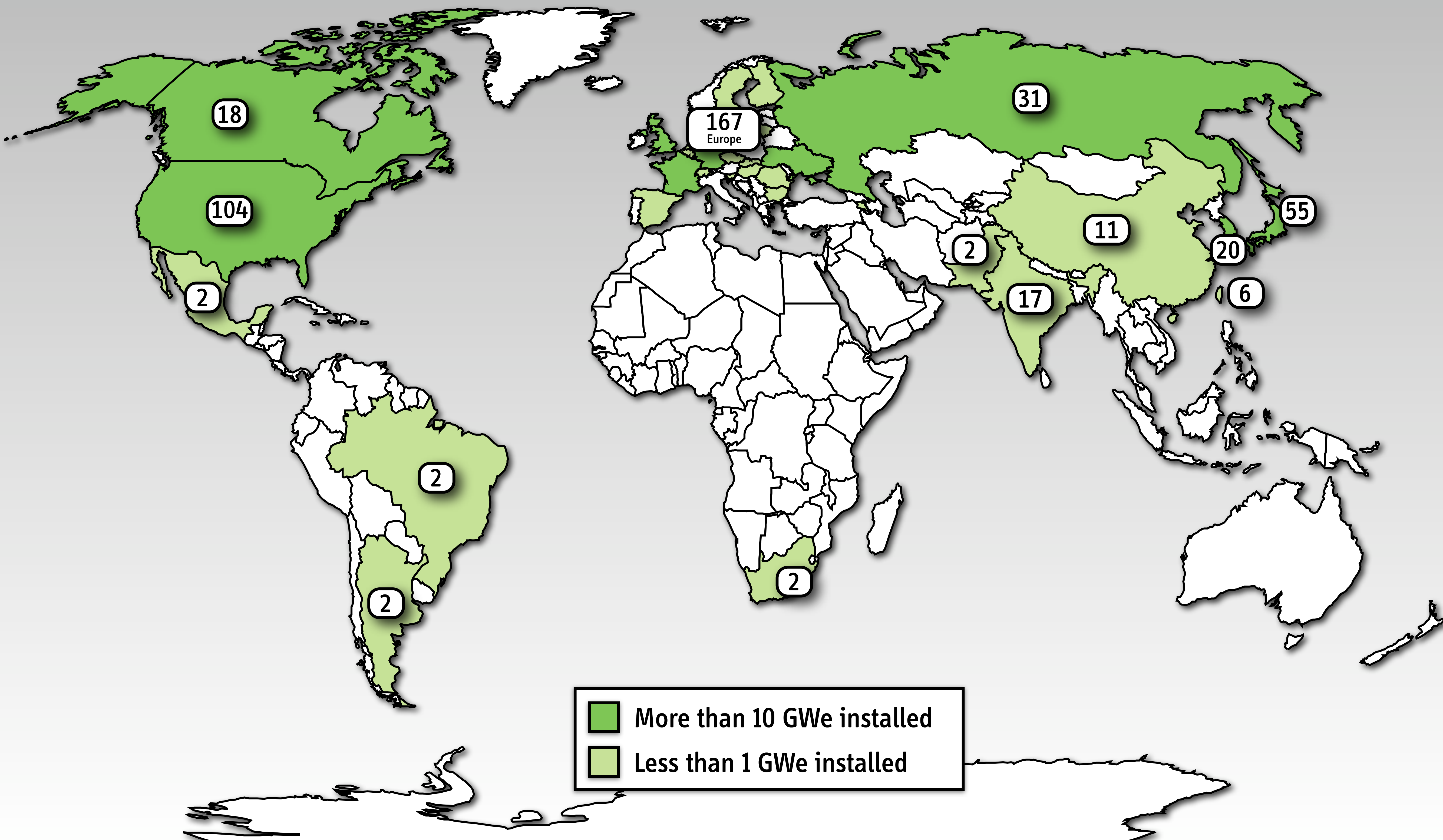
EXAMPLE 2

Uranium Enrichment

Centrifuge Proliferation and the Future of Nuclear Energy

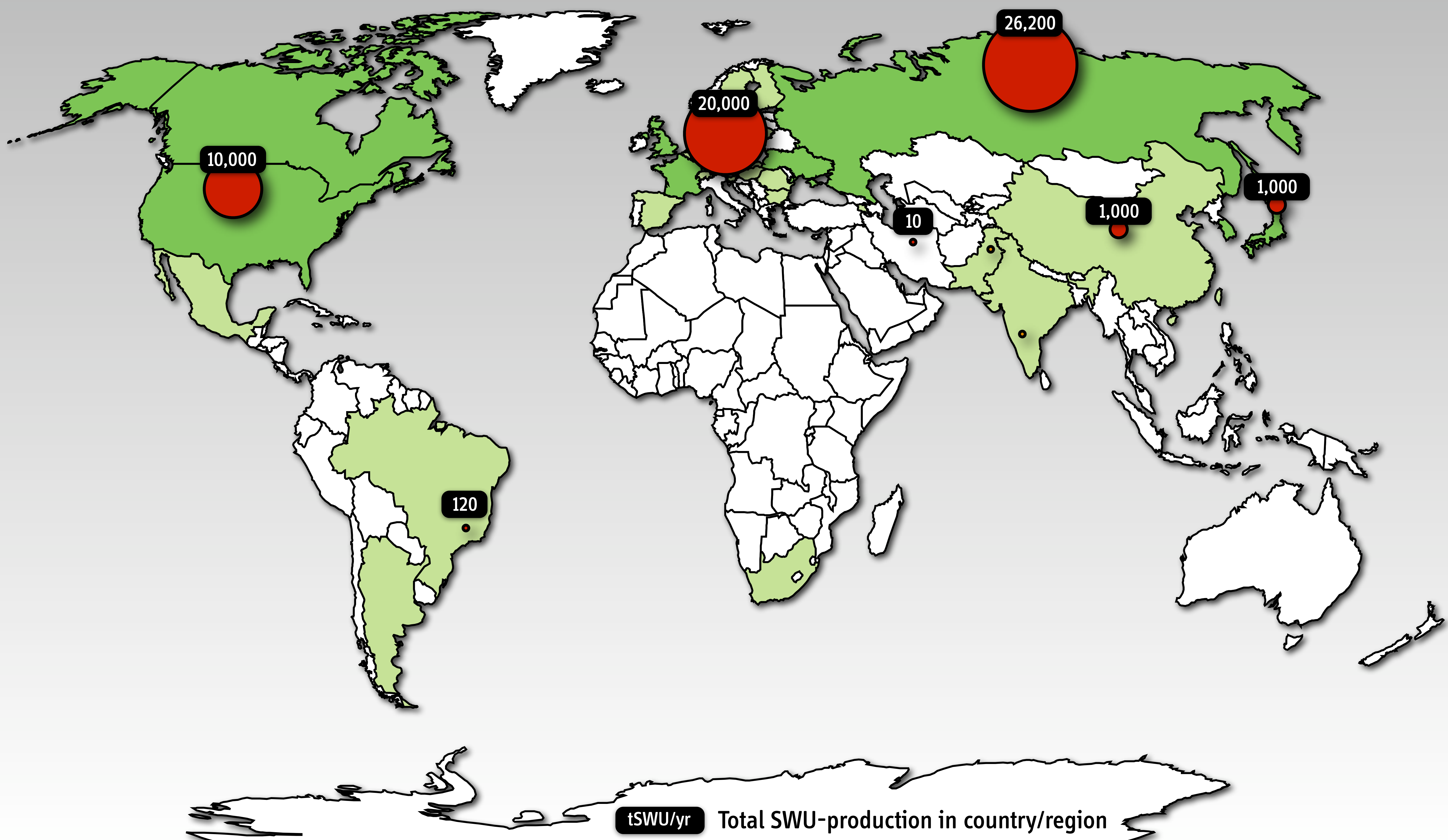
Nuclear Power Reactors in the World, 2008

(439 reactors in 31 countries)



Global Enrichment Capacities, 2008

(14 operational plants in 10 countries, not including two military plants)



The Natanz Site in Iran (2007)

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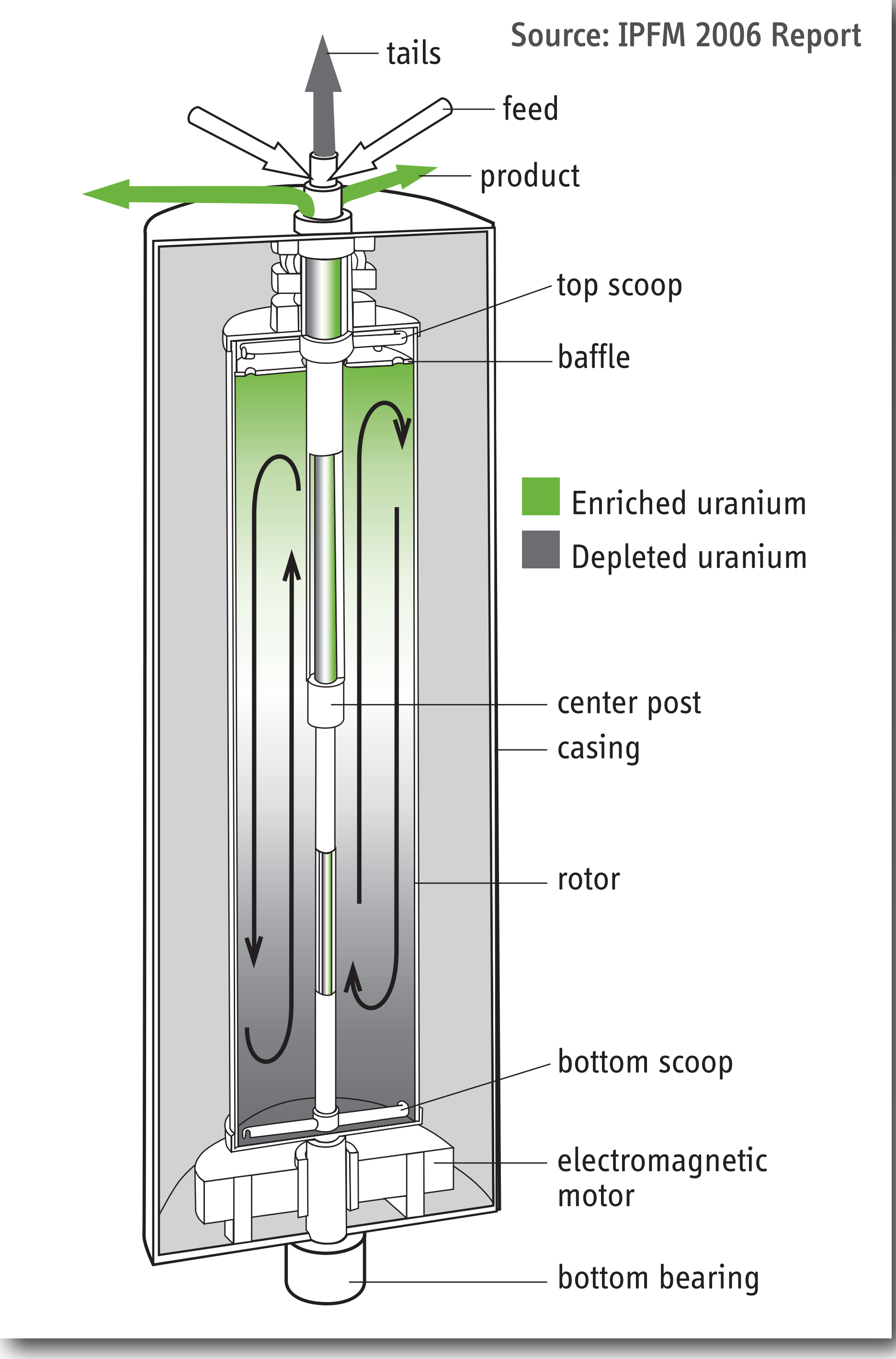
Why Centrifuges Are Different

(Centrifuge Modeling)

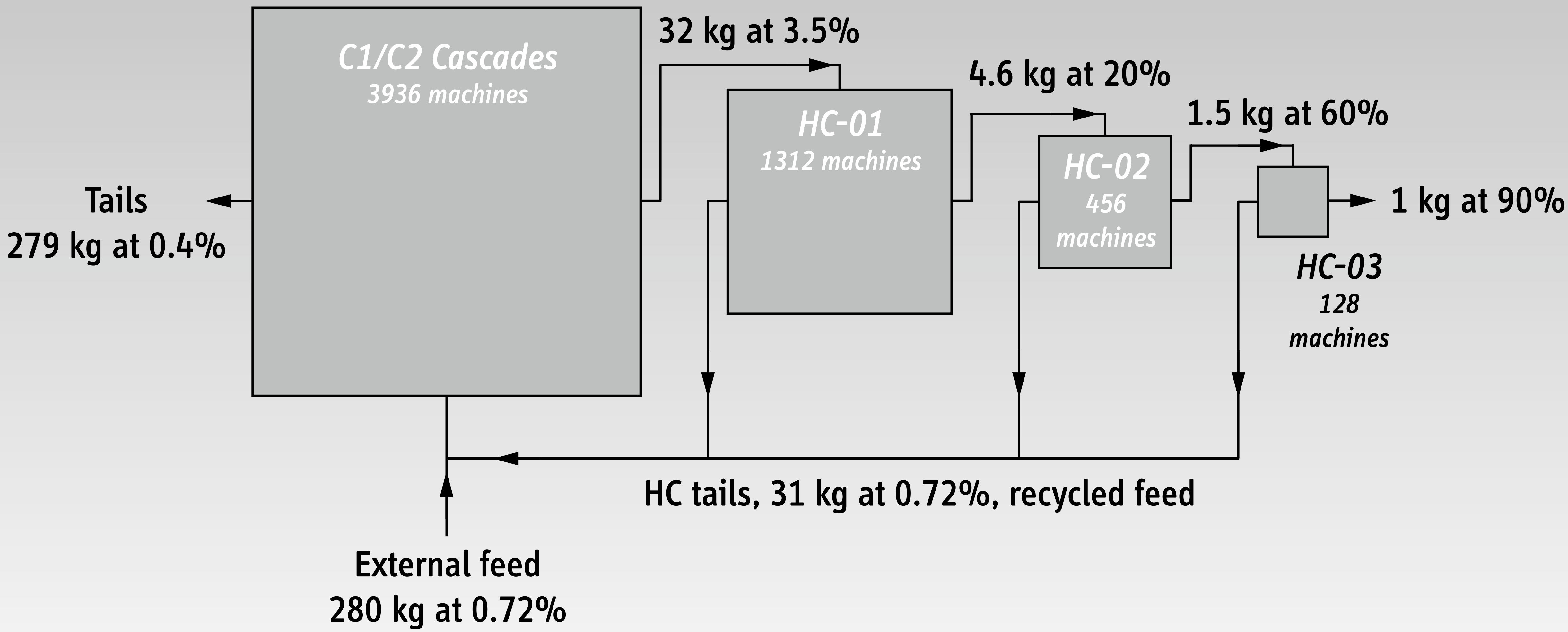
Centrifuges for Uranium Enrichment

Source: Presentation by Mohammad Saeidi (AEOI), 2005



Cascade Interconnection

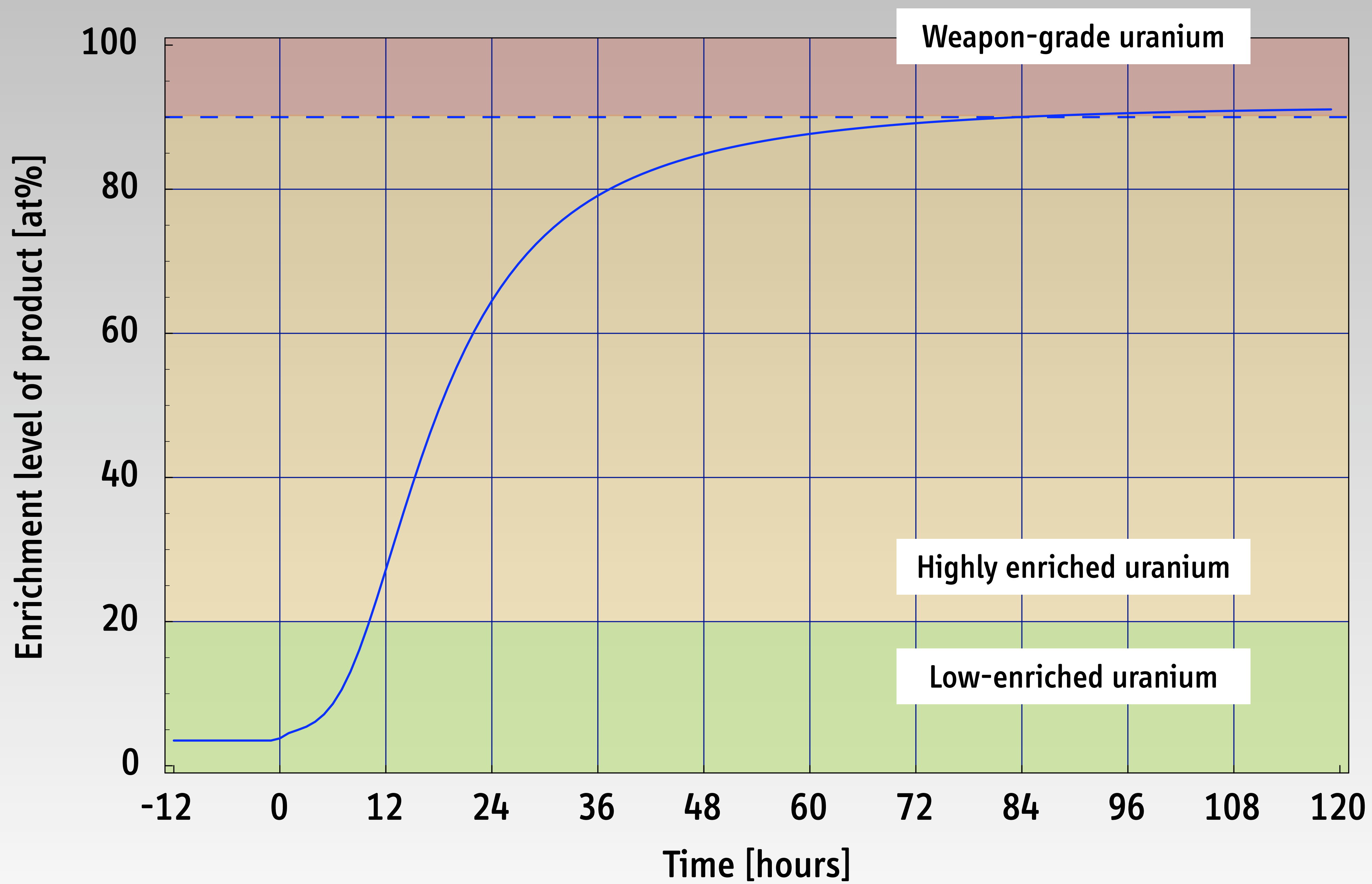
with Partial Reconfiguration for Production of Highly Enriched Uranium



A. Glaser, "Characteristics of the Gas Centrifuge for Uranium Enrichment and Their Relevance for Nuclear Weapon Proliferation"
Science & Global Security, 16(1–2), 2008, pp. 1–25

Rapid Breakout

using batch recycling, avoiding cascade reconfiguration



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Courtesy: Urenco

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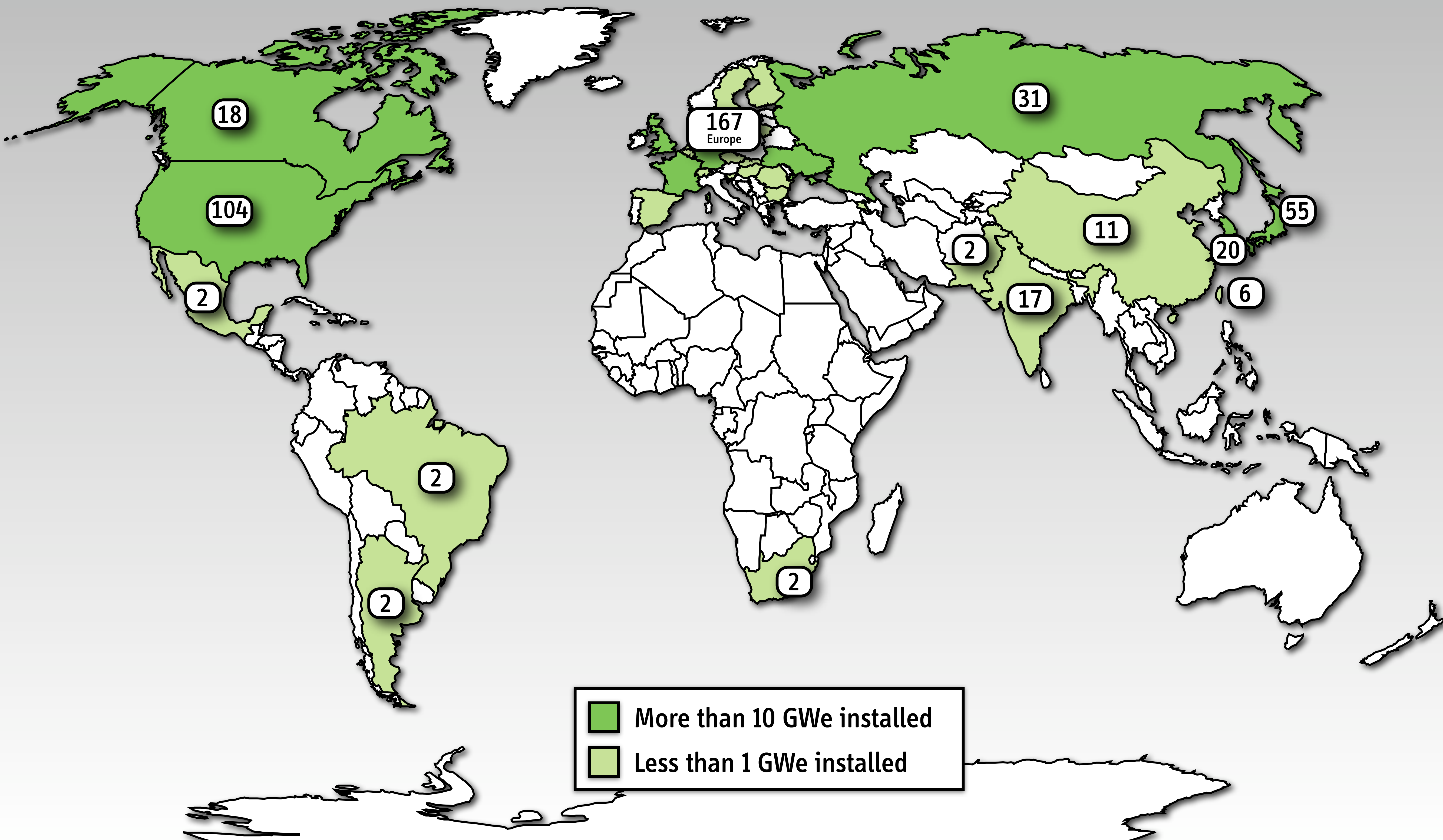
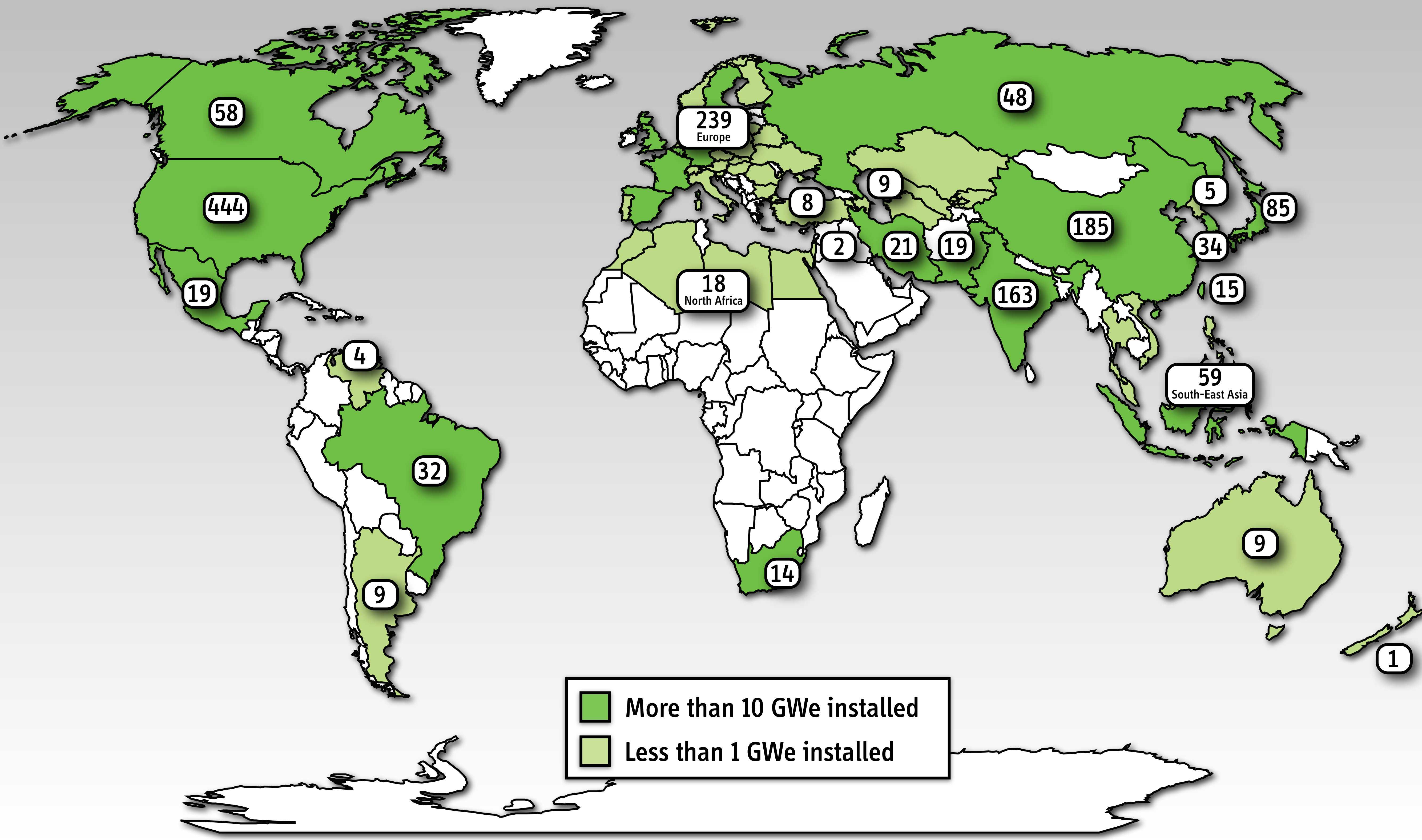


Global Nuclear Expansion Scenario

(1500 GWe in 58 countries, based on 2003 MIT study)



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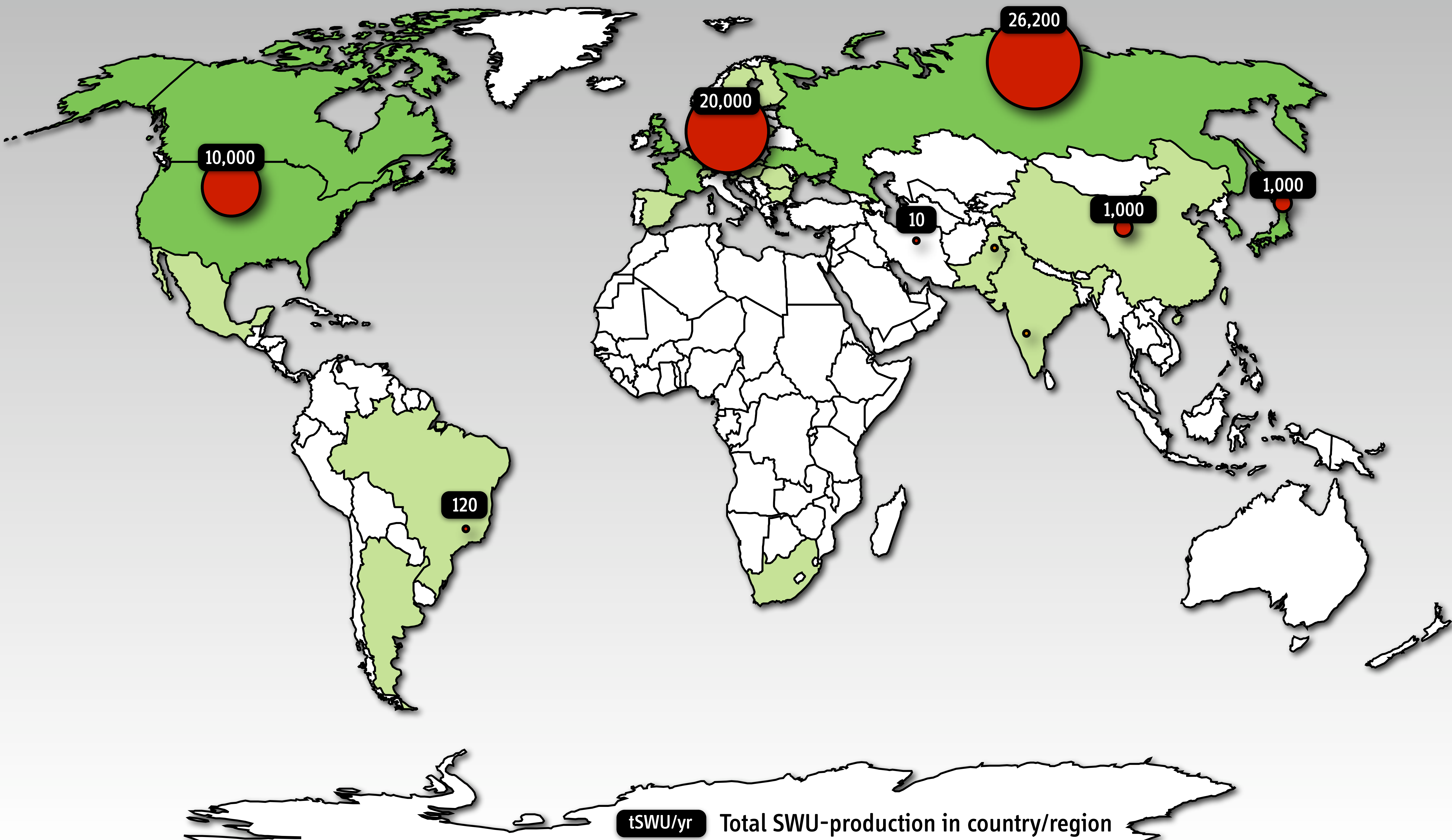
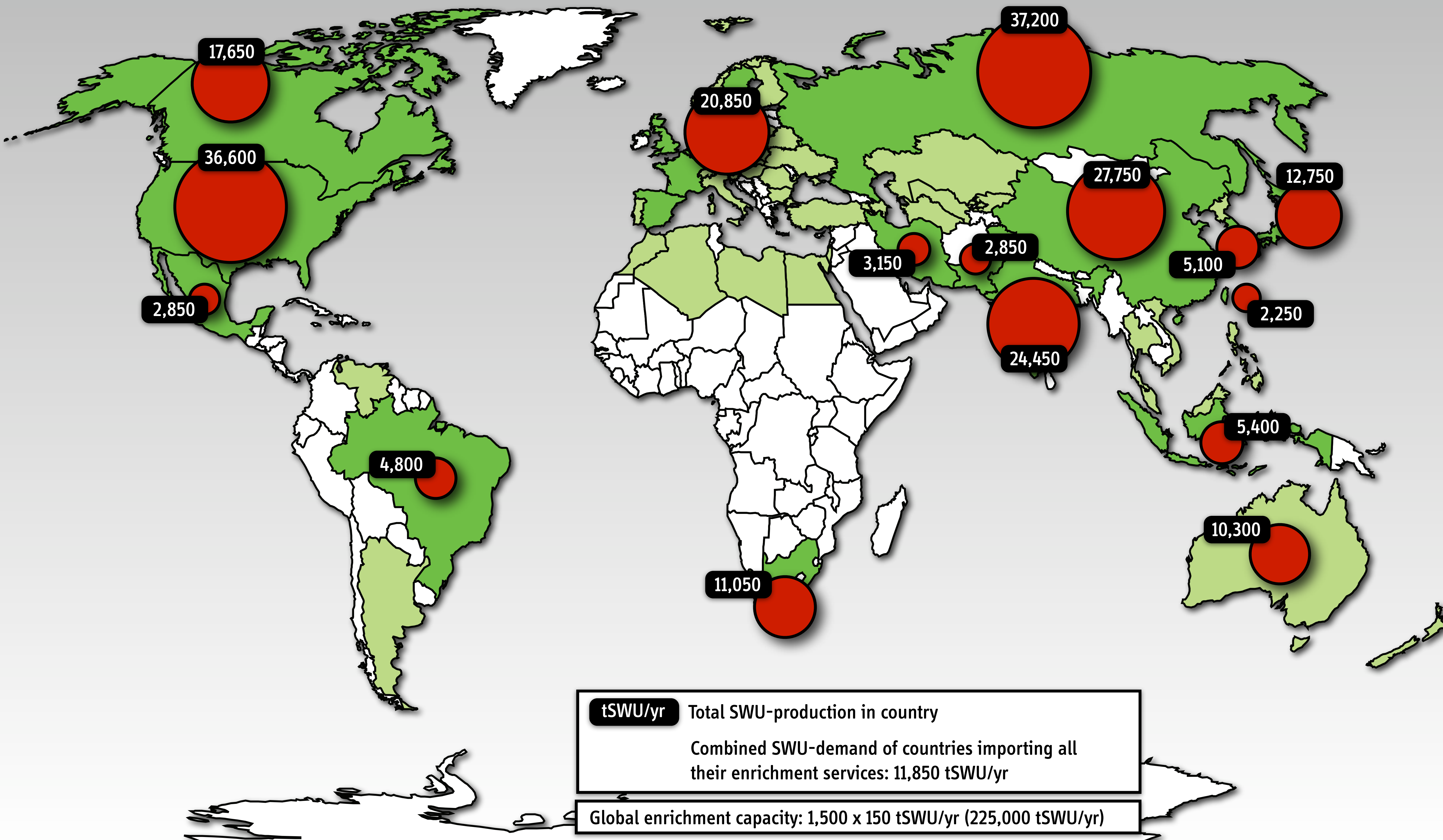


Enrichment Demand and Distribution

(for 1500 GWe Global Nuclear Expansion Scenario)



What Can Be Done About It?

Preventing the Further Spread and Assuring Peaceful Use

Preventing Further Spread

Assuring Peaceful Use

- Tighten export controls (further)
- Delegitimize enrichment in today's "non-enrichment" states
- Increase the ability to detect undeclared facilities
- Encourage multilateral approaches to the nuclear fuel cycle
- Increase the effectiveness of IAEA safeguards
- Revisit alternative "proliferation-resistant" technologies

“Twelve Proposals”

		Original reference	Option	Fundamental Mechanism and Conditions
1	U.S reserve of nuclear fuel	INFCIRC/659 (Sep 2005)	2	Fuel assurances (fuel reserve) Initially, only for states that forego enrichment and reprocessing
2	Peaceful use of nuclear energy, Russia	INFCIRC/667 (Feb 2006)	(3)	Create system of international centers providing nuclear fuel cycle services IUEC Angarsk (see below) as an example
3	Global Nuclear Energy Partnership (GNEP)	USA, Feb 2006	(1)	Fuel supply, possibly spent fuel take-back Existing supplier states provide services for recipient states
4	Ensuring Security of Supply	WNA Report (May 2006)	2	Fuel assurances (enrichment services, fuel reserve)
5	Six Country Proposal (RANF)	GOV/INF/2006/10 (June 2006, restr.)	2	Fuel assurances (enrichment services)
6	IAEA Standby Arrangements, Japan	INFCIRC/683 (Sep 2006)	2	Fuel assurances provided by existing supplies Reduce incentives for additional states to develop national capabilities
7	NTI fuel reserve	NTI Letter (Sep 2006)	2	Fuel assurances (fuel reserve for at least one full core, under IAEA auspices) States retain right to establish fuel cycle facilities under national control
8	Enrichment bonds, United Kingdom	INFCIRC/707 (June 2007)	2	Fuel assurances (enrichment services)
9	International enrichment center (IUEC), Angarsk	INFCIRC/708 (June 2007)	(3)	Share in multinational enrichment plant (in Russia, no technology transfer) Oriented chiefly to states not developing indigenous capabilities
10	Multilateral Enrichment Sanctuary Project (MESP), Germany	INFCIRC/704 (May 2007)	4	Establish multilateral extraterritorial enrichment plant States retain right to establish fuel cycle facilities under national control
11	Multilateralization of the fuel cycle, Austria	INFCIRC/706 (May 2007)	(5)	Establish a new authority to ensure “fair” distribution of nuclear fuels Eventually all facilities multinational and operated through this authority
12	Nuclear Fuel Cycle, European Union	EU non-paper (June 2006)	n/a	Criteria to evaluate multilateral arrangements and fuel assurances Not meant to “impinge on national choices and arrangements”

A. Glaser, *Internationalization of the Nuclear Fuel Cycle*, Report for the International Commission on Nuclear Non-proliferation and Disarmament, ICNND Research Paper No. 9, February 2009

Multilateral Approaches to the Nuclear Fuel Cycle

Fuel Assurances

Multilateral Approaches to the Nuclear Fuel Cycle

Fuel Assurances

Joint Ownership of Enrichment Plants

Construction of new facilities exclusively under multilateral control
Conversion of existing facilities

Dilemmas of Fuel Assurances

Energy Security

Fuel banks too small to be relevant for countries with large nuclear programs

Those who are most worried about fuel disruptions today
may not trust the concept of a fuel bank either

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"Entitlement"

Article IV of the NPT and the "inalienable right" to use nuclear
energy for peaceful purposes "without discrimination"

Fuel assurance tend to increase this tension

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Multinational Fuel Bank Proposal Reaches Key Milestone

Kuwait Pledge of US $10 Million Secures International Funding for Next Steps

Staff Report

6 March 2009


The IAEA Board is considering proposals for developing a framework for a multinational nuclear fuel reserve under the IAEA´s auspices. (Photo: D. Calma/IAEA)

A proposed multinational fuel bank under IAEA control reached a milestone this week when Kuwait pledged a financial contribution of US$10 million. The pledge - announced at the IAEA Board of Governors meeting in Vienna - means that the international financial target for the fuel bank has been reached, putting into motion the efforts for a future decision by the Agency´s Board to actually create it.

In welcoming the achievement, IAEA Director General Mohamed ElBaradei said that the next steps are to develop a proposed framework for the fuel reserve for the consideration of the Board hopefully at its mid-year meeting in June.

"The proposed fuel bank is a bold agenda and it is clearly not going to happen overnight. But bold measures, including assurances of nuclear fuel supply and multinationalizing sensitive parts of the

Story Resources

- NTI/IAEA Fuel Bank Hits $100 Million Milestone: Kuwaiti Contribution Fulfills Buffett Monetary Condition, NTI Press Release [pdf]

Dilemmas of Joint Ownership

Proliferation

Can one share centrifuge technology without disseminating proliferation-sensitive information?

Risk of premature deployment of sensitive nuclear technologies where they are not needed

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Current (and mid-term future) enrichment demand already covered

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Territoriality

How effectively will the fact that a plant is multinationally owned
reduce the risk of a “take over” by the host state?

The Way Forward

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Current Technical and Policy Challenges For Managing Nuclear Technologies

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