Global HEU Minimization Challenges - Political, technical and economic issues

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Overview

- Conversion of civilian HEU fueled research reactors (RERTR)
- The case of the research reactor FRM-II
- Naval fuel

Context: HEU minimization projects

Existing

- Conversion of civilian HEU fueled research reactors (RERTR)
- Take back and downblending programs
- Consolidation of storage sites within a country
- Improvement of MPC&A
- “Megatons to Megawatt“

Non-existing

- Phase out of *all* non-weapons uses of HEU

Conversion of research reactors

Rationale for using HEU in research reactors

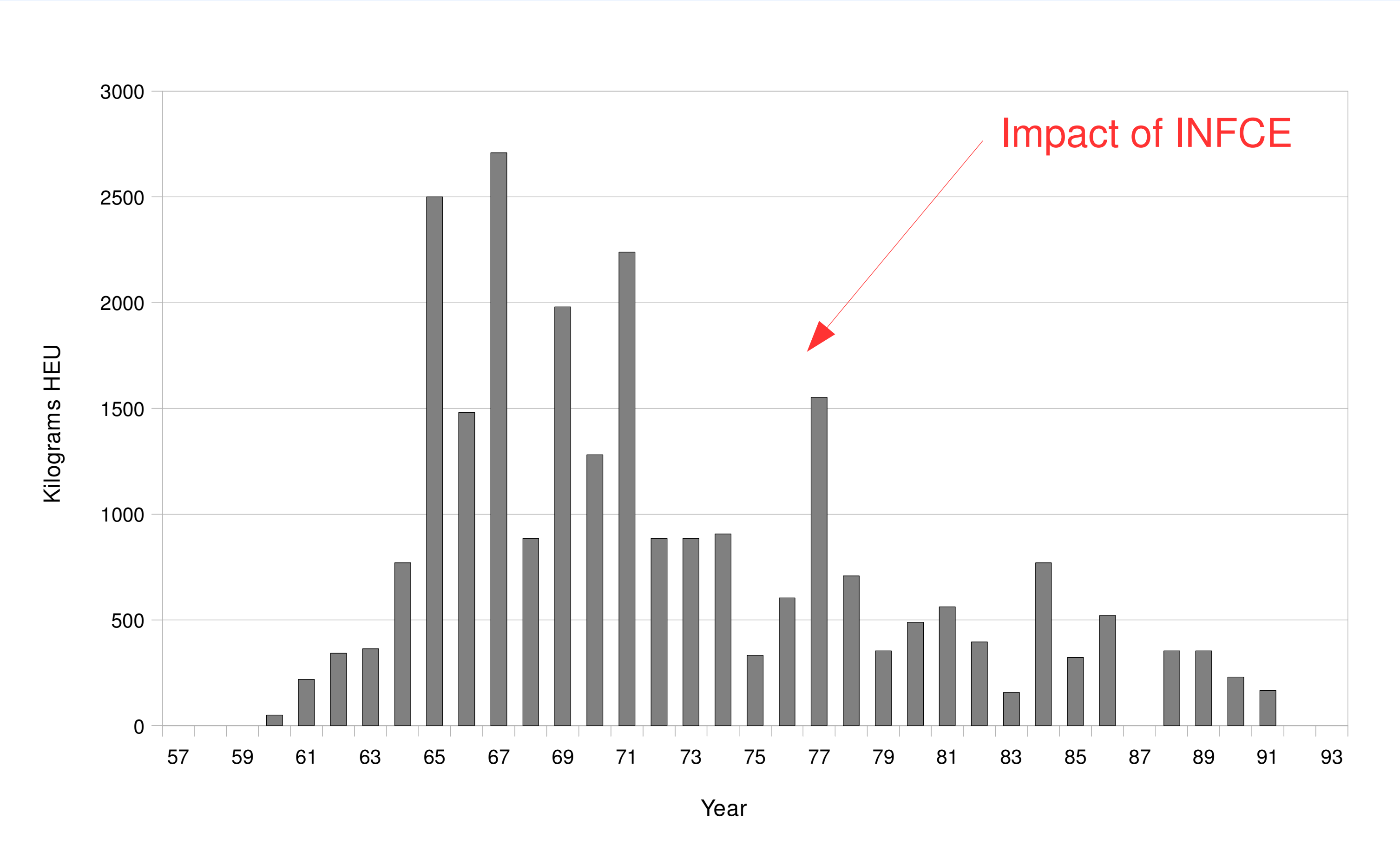
Wanted product: high neutron flux

Unwanted by-product: heat

With HEU, parasitic neutron absorption in U-238 is lower,
U-235 in the reactor core is denser,
ratio of neutrons per heat is higher

For these reasons, many research reactors had been fueled with HEU

HEU exported by the U.S.



Source: U.S. HEU Report 2001

Reduced Enrichment for Research and Test Reactor (RERTR) program

Objective:

Develop different fuels that contain LEU instead of HEU and that at the same time avoid significant disadvantages in experiment performance, economic, or safety aspects of the reactor

Initiated by the U.S. In 1978
Significant contributions by Germany

Conversion success?

Should the development be successful, it will be possible to convert the remaining research reactors. The expectation is that all research reactors will be either converted or will reach the end of their life times. New reactors are expected to be designed and constructed for LEU fuels. This way, the civilian use, trade, and international transfers of HEU could be entirely phased out.

RERTR: Conversion of many U.S. and European Reactors, but not all

Previously: Uranium oxide in an aluminium matrix (UAl_x/U_3O_8),
density about 1.5 g/cm^3

Replaced by Uranium silicide (U_3Si_2), density of 4 – 8 g/cm^3

No loss of performance, exceptions: Some modern high flux reactors

Under development: Fuels of even higher density, based on U-molybdenum alloys dispersed in an aluminium matrix, density of 8 – 9 g/cm^3

Under development: U-Molybdenum alloys as metals, density up to 16 g/cm^3

Time of availability not yet clear.

No new HEU research reactors for a long period

Instead, 17 new research reactor fueled with LEU

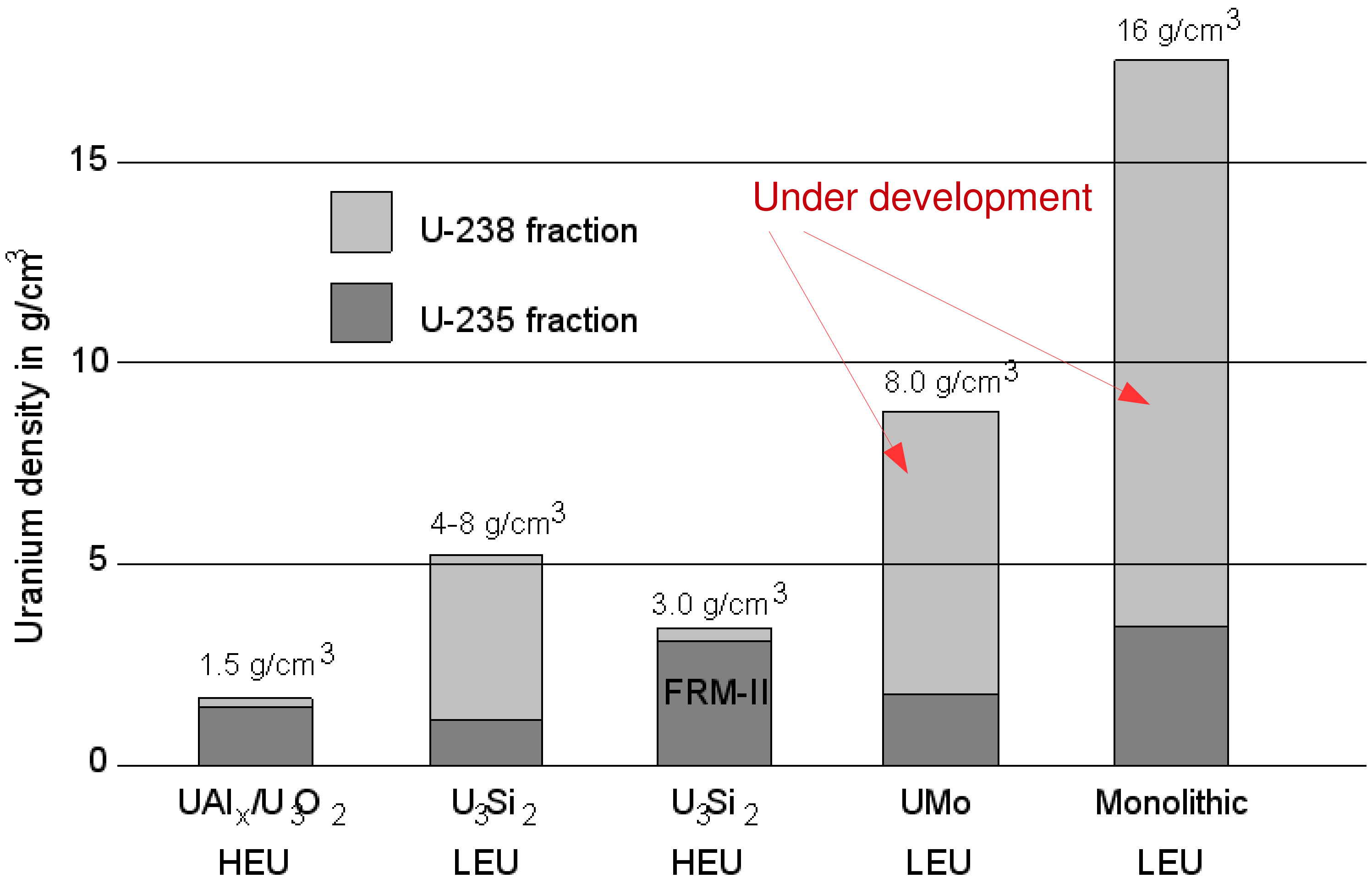
Exception: FRM-II in Garching near Munich

- design and planning started shortly after INFCE
- publicly debated since about 1993
- constructed since 1996
- operated since 2003

FRM-II uses the new silicide fuels (development pushed by RERTR), but with HEU

⇒ Higher flux than with traditional LEU dioxide fuel, or with LEU silicide fuel

Comparison of different fuels



Source: A. Glaser 2005

Technical reasoning for the choice of FRM-II fuel

For the same high neutron flux but LEU silicide fuel, a somewhat larger reactor core would have been needed.

This would have produced some more energy.

But with a particularly low energy output, particularly cold neutrons can be produced.

This reduces measuring time in experiments to a certain extent.

With a somewhat larger reactor core, experiments would have taken somewhat longer.

Political decision

What is more important?

Best neutron flux per energy?
or compliance with HEU minimization goal?

Licenses deal with

- nuclear activation,
- environmental dangers,
- accident risks,
- radiation protection,
- and disposal,

but do not mention nonproliferation or international relations.

Discussions on FRM-II

Heavy criticism domestically and internationally:

- The breach of the moratorium would set a precedent,
- imitators would follow,
- the efforts and successes of RERTR would be undermined,
- international trade would resume,
- the phase out of the civilian use of HEU would become impossible

Justifications by the proponents:

- Sooner or later, a first project would use every new fuel with HEU instead of LEU anyway.
- At that time (until 1995), the U.S. planned to build a new research reactor, the *Advanced Neutron Source* (ANS)
- At that time, the U.S. Department of Energy had been slow to convert U.S. Reactors
- At that time, there was a perceived double standard

The public debate (1)

- During the initial evaluation, there was no perceptible public debate.
- Nonproliferation was not taken seriously.
- Negative foreign policy aspects were downplayed.
- The decision making was not transparent and hardly made public.
- The debate on HEU started to late.
- The debate was uneducated on both sides

The uneducated public debate (2)

- Opponents focused on environmental aspects, only later used HEU argument, but many viewed it just as tool to stop the project altogether
- Proponents denounced HEU opponents of being antinuclear.
- Proponents, including the government, justified the HEU use by *environmental* aspects!

"The Federal Government has on numerous occasions explained that the use of HEU in the FRM-II project is highly recommended because of the specific scientific objectives involved, on grounds of cost, and in particular because of the comparatively limited effects on the environment and the smaller plutonium yield." (in Bundestag, 1993)

"Conversion of research reactors from high to low enrichment only shifts the risks. With low enrichment, substantially more plutonium will be bred during reactor operation than with high enrichment." (Bavarian Government, 1990)

The concept of proliferation resistance

Developed by INPRO (International Project on Innovative Nuclear Reactors and Fuel Cycles) and GIF (The Generation IV International Forum)

Some examples of requirements:

- States' commitments, obligations and policies regarding non-proliferation and its implementation should be adequate to fulfil international standards in the non-proliferation regime.
- The attractiveness of nuclear material and nuclear technology for a nuclear weapons program should be low.
- PR should be taken into account as early as possible.

Had a proliferation resistance evaluation taken place during the decision making phase, the discussion would have been more educated.

Benefits of conversion of naval reactors

- Would allow a realistic prospect for phasing out all HEU
- Would facilitate the verification of an FM(C)T
- Would close a loophole in NPT verification
- Would reduce proliferation risks

In 1995, the U.S. Navy rejected the idea of conversion, but in its reasoning ignored the RERTR efforts of developing denser fuels.

Comparison of research and naval reactors with respect to conversion

Property	Research reactors	Naval reactors
Power density	high, comparable	
Power	comparable	
Size of reactor core	small	
Product wanted	neutrons	power
Refueling frequency	higher	low
Burn-up	less	very high
Variety of designs	many	few
Scientific community engaged	large	small
Transparency	high	non-existent
Cladding and stabilizing fuel elements	being researched	unknown
Chemical composition of uranium fuel	several	oxide
RERTR efforts used	yes	no

Conversion of naval reactors?

1995 study of U.S. Navy:

- Conversion would need larger core
- Or would reduce lifetime because of less U-235

but

- Technology of current cores is from the later 1970ies
- No other fuel was available than oxide
- Navy study does not consider any other fuel
- “Materials delivered are either UF6, oxides, or metal“