The Future of Japan's Nuclear Fuel System: Some Recommendations

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Why did civilian reprocessing begin in the 1970s?

It was believed that there was only enough low-cost uranium in the world to fuel about 500 current-generation Light Water Reactors for 40 years.

Much more uranium efficient plutonium breeder reactors therefore would be required.

Reprocessing of spent fuel from existing power reactors was needed to obtain the plutonium for initial cores of the plutonium breeder reactors, which were expected imminently..

Reprocessing and proliferation

In 1974, **India** used its first separated civilian plutonium for a "peaceful" nuclear explosion. **Argentina, Brazil, South Korea, Pakistan and Taiwan** also were seeking or building "civilian" reprocessing plants to support weapons programs. Internal change and external pressure ended most of these programs. Today, Japan is the only non-weapon state that reprocesses.

Since North Korea's May 2009 nuclear test, however, **South Korea** has been demanding "nuclear sovereignty," i.e. the same right to reprocess as Japan despite its 1992 agreement with North Korea not to enrich or reprocess. South Korea is currently in very tough negotiations with the U.S. on whether or not their new Agreement of Cooperation will allow South Korea to reprocess.

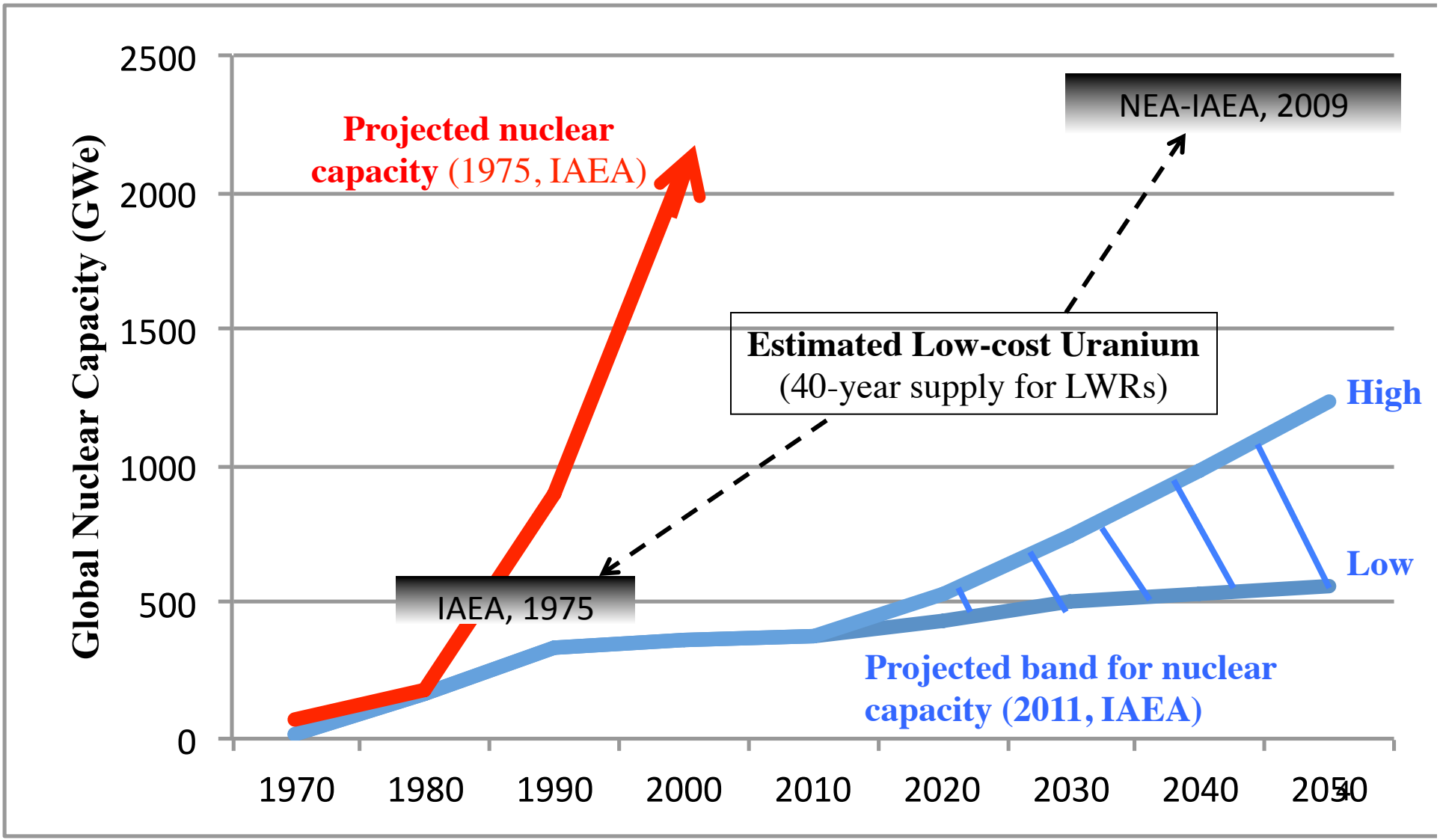
Most separated civilian plutonium is not weapon-grade. ***In a Nagasaki design, civilian plutonium would produce an explosion equivalent to at least 1000 tons of chemical explosive (vs. 20,000 tons for Nagasaki).* Using modern weapon designs, there would be little difference in the explosive powers of weapons using weapon-grade and power reactor plutonium***.

*J. Carson Mark, "Explosive Properties of Reactor-Grade Plutonium," *Science and Global Security*, 4, 111-128, 1993. Mark headed the Theoretical Division at the Los Alamos National Laboratory for decades and played a major role in nuclear weapons design.

But plutonium breeder reactors were not commercialized

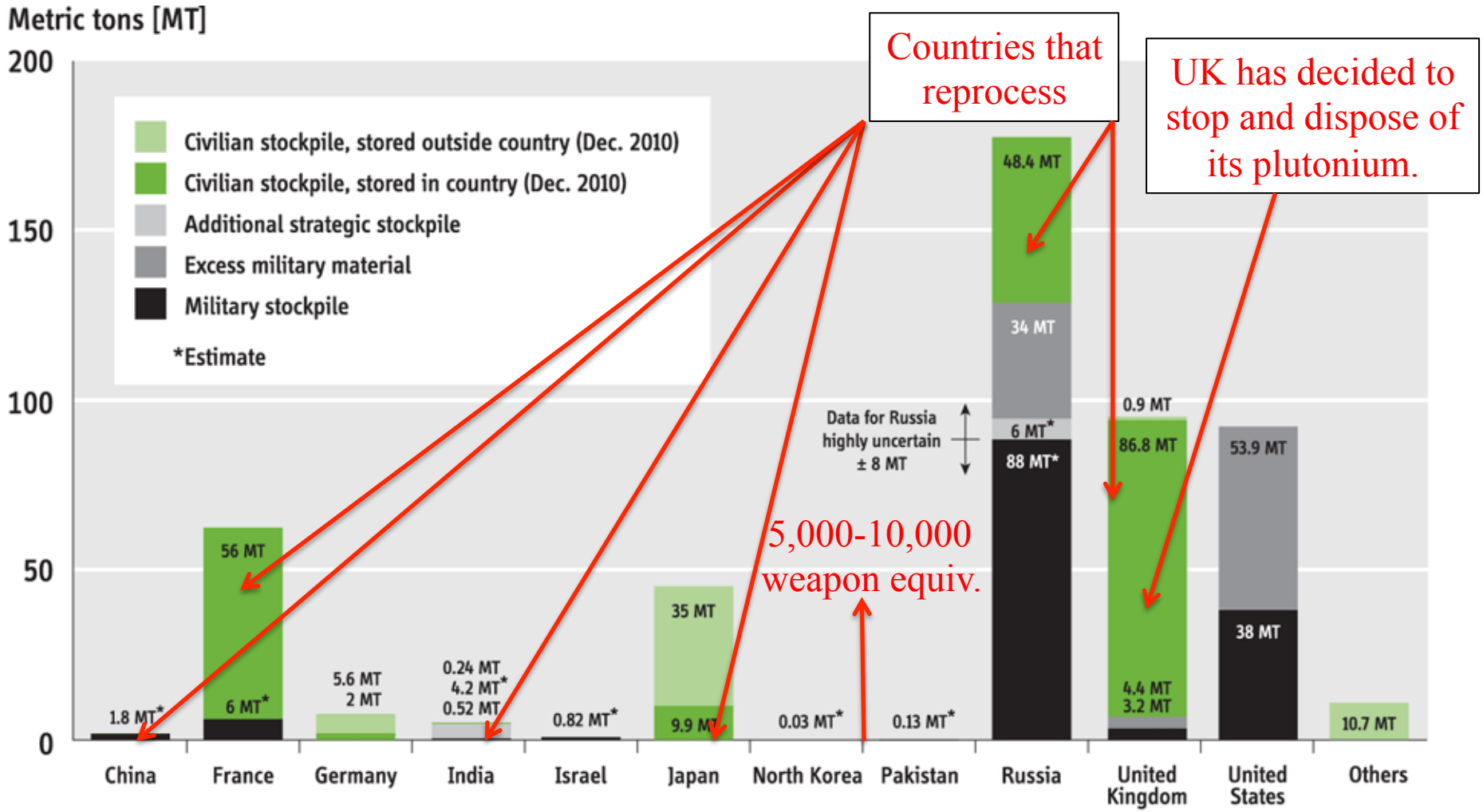
-- Nuclear capacity projections declined

-- Estimates of global low-cost uranium resources grew



"Halting the production of weapons-grade fissile material carries great significance from the perspective of both nuclear disarmament and nuclear security.
– Prime Minister Noda, Seoul Nuclear Security Summit, 27 March 2012

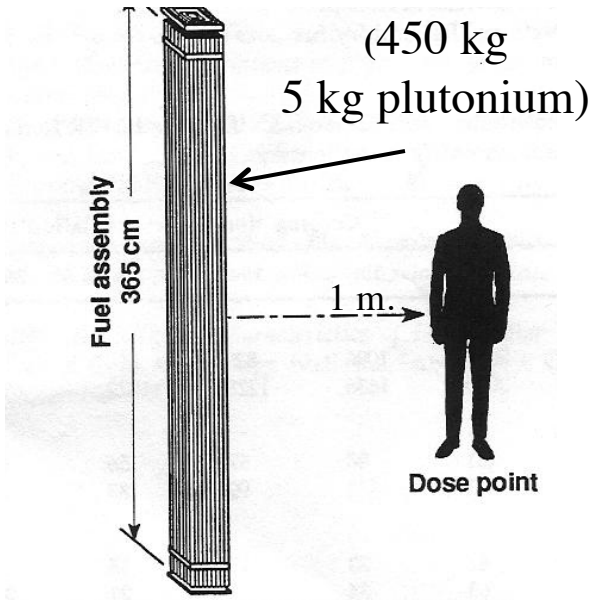
Civilian plutonium too – is weapon-usable



Why Reprocessing facilitates nuclear-weapon proliferation

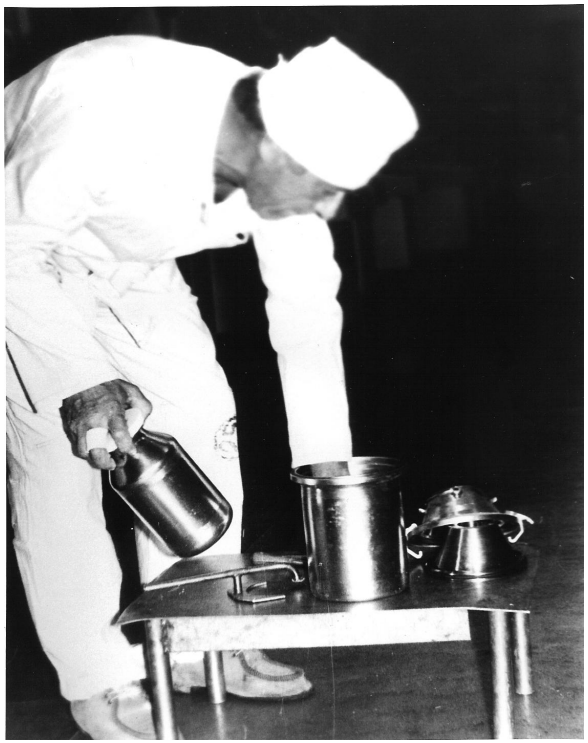
Plutonium in spent fuel is protected by a gamma radiation field produced by long-lived fission products (cesium-137).

Separated plutonium is handled easily.



igure 1. Dose rate from a PWR fuel assembly.

50 years after discharge, lethal dose from fuel assembly in 30 minutes (4 Sieverts).
Need remote processing behind thick walls to recover plutonium (i.e. reprocessing)



2.5 kg plutonium in light-weight container. Can be processed in a glove box, enough in 3 containers for Nagasaki-type bomb.

(Mayak Reprocessing Plant, 1994)

"We simply can't go on accumulating huge amounts of the very material, like separated plutonium, that we're trying to keep away from terrorists."
– President Obama, South Korea, 26 March 2012

Separation of civilian plutonium too must end

As much civilian plutonium (250,000 kg) as weapons plutonium in the world – enough to make 30,000 Nagasaki bombs or 60,000 modern warheads.

Plutonium also very dangerous radiologically. One gram, if inhaled by the population in a large city, would cause 10,000 cancer deaths.

U.S., Russia, the UK, France and China have ended production of plutonium for weapons. Only India, Pakistan and perhaps Israel continue.

U.S. and Russia have committed to eliminate 90,000 kg of their weapons plutonium – about one third of the global total.

Separation of civilian plutonium also must end. Today only three countries have large plutonium separation programs: France, Japan and UK, which has just decided to stop. (Also three other countries with smaller reprocessing programs that also must end: China, India and Russia.)

Suggestion #1. **Breeder reactor R&D**

We suggest that Japan consider ending its fast-neutron reactor R&D program – as most other countries have.

Civilian reprocessing was originally launched to supply startup plutonium for plutonium breeder reactors, which would use uranium much more efficiently.

But cost of uranium only a few percent of the cost of nuclear power and breeder reactors are costly and unreliable (*Monju*).

Fast-neutron reactors could, over centuries, reduce significantly the amount of plutonium and other transuranics but

"Estimates of changes in dose [from nuclear power and radioactive waste] are small…none of the dose reductions seem large enough to warrant the expense and additional operational risk of transmutation…."

– U.S. National Academy of Sciences, *Nuclear Wastes: Technologies for Separations and Transmutation* (1996) – also 23 May 2012 JAEC fuel cycle panel report.

Suggestion #2. **Reprocessing and plutonium reuse**

We suggest ending reprocessing.

Plutonium separation increases the danger of nuclear proliferation: ***France, India, Pakistan, North Korea,*** *Argentina, Brazil, South Korea, Sweden, Taiwan…*

Increases nuclear power costs significantly (JAEC, ~ 1 yen/kWh)

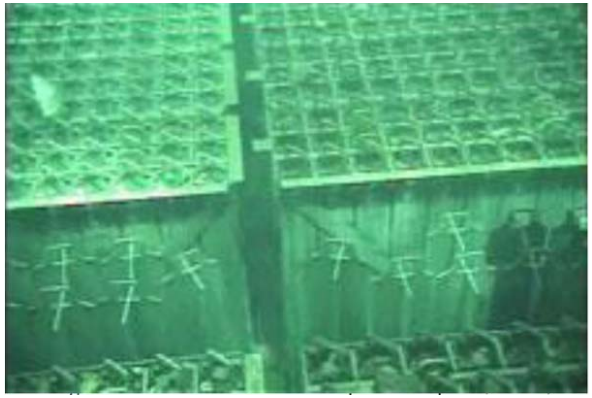
Does not reduce the cost or hazards of radioactive waste disposal.

The commitment to reprocessing only continues in Japan because of a lack of spent fuel storage. (JAEC, 2005)

Suggestion #3. ***Dry Cask Storage***

We suggest an intensive national-government program to construct dry cask storage at Japan's nuclear power plants for safety and as an alternative to reprocessing

Pools are dangerously dense-packed. Older spent fuel should be placed in dry cask storage. (F-D #4)



- The cask cooling function was not lost as the casks were cooled by natural air convection.
- So far, no issues on their integrity have been identified from the external appearance.

Figure II-2-56 Situation in Dry Storage Cask Facility

[Central research institute of electric power industry of Japan briefing, 31 January 2012]

Suggestion #4. **Plutonium disposal**

We suggest that Japan halt the construction of the Rokkasho MOX fuel plant and that Japan launch an R&D program on a plutonium waste form that could be disposed of directly with spent fuel.

Japan's MOX plan has stalled for 10 years (U.S. program too).
There are only 4 tons of separated plutonium at Rokkasho.
Direct disposal would be less costly.

Summary

Japan should consider:

1. ***Ending its fast-neutron reactor R&D program.***
2. ***Ending reprocessing.***
3. ***Roving older spent fuel from spent-fuel pools to place in safe dry cask storage.***
4. ***Halting construction of Rokkasho MOX fuel plant and launching an R&D program on a plutonium waste form that could be disposed of directly with spent fuel.***