Simplifying the Fissile Material Cutoff Treaty (FMCT) and making nuclear reductions and nonproliferation more stable and easier to verify

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For more: see International Panel on Fissile Materials

- *Plutonium Separation in Nuclear Power Programs: Status, Problems; and Prospects of Civilian Reprocessing Around the World*; (2015)
- *Banning the Production of Highly Enriched Uranium* (2015); and
- *Fast Breeder Reactor Programs: History and Status* (2010)

http://fissilematerials.org

Outline

- Turning the FMCT into a ban on the separation of plutonium and production of HEU for any purpose could strengthen the NPT.
- No economic or environmental justification for plutonium separation.
- Non-naval uses of HEU being phased out.
- Existing HEU stockpiles large enough for a 50-year transition to LEU naval fuel.

Gaps in the Nonproliferation Treaty (NPT)

- **NPT bans production of HEU and separation of plutonium and other fissile materials by the non-weapon states *for weapons* but allows their production and use for any other purpose.**
- On this basis, Japan has accumulated enough separated plutonium for more than 1,000 Nagasaki-type weapons, even though Pu separation costs an order of magnitude more than the fuel is worth.
- ***Uncertainties in some plutonium measurements ~1 percent.***
- Verification of naval HEU could interfere with naval operations. ***IAEA safeguards agreement for non-weapon states therefore allows removal of HEU from under safeguards for naval fuel use.***
- FMCT could extend ban on production of new fissile materials for weapons to the nuclear weapon states but with same verification weaknesses and gaps.
- ***Are these gaps necessary?***

Not just theoretical concerns

Plutonium separation

After each North Korean nuclear tests, public interest in acquiring nuclear weapons peaks in South Korea.

South Korea's government has been pressing the U.S. very hard for the same right to separate plutonium as Japan.

HEU production

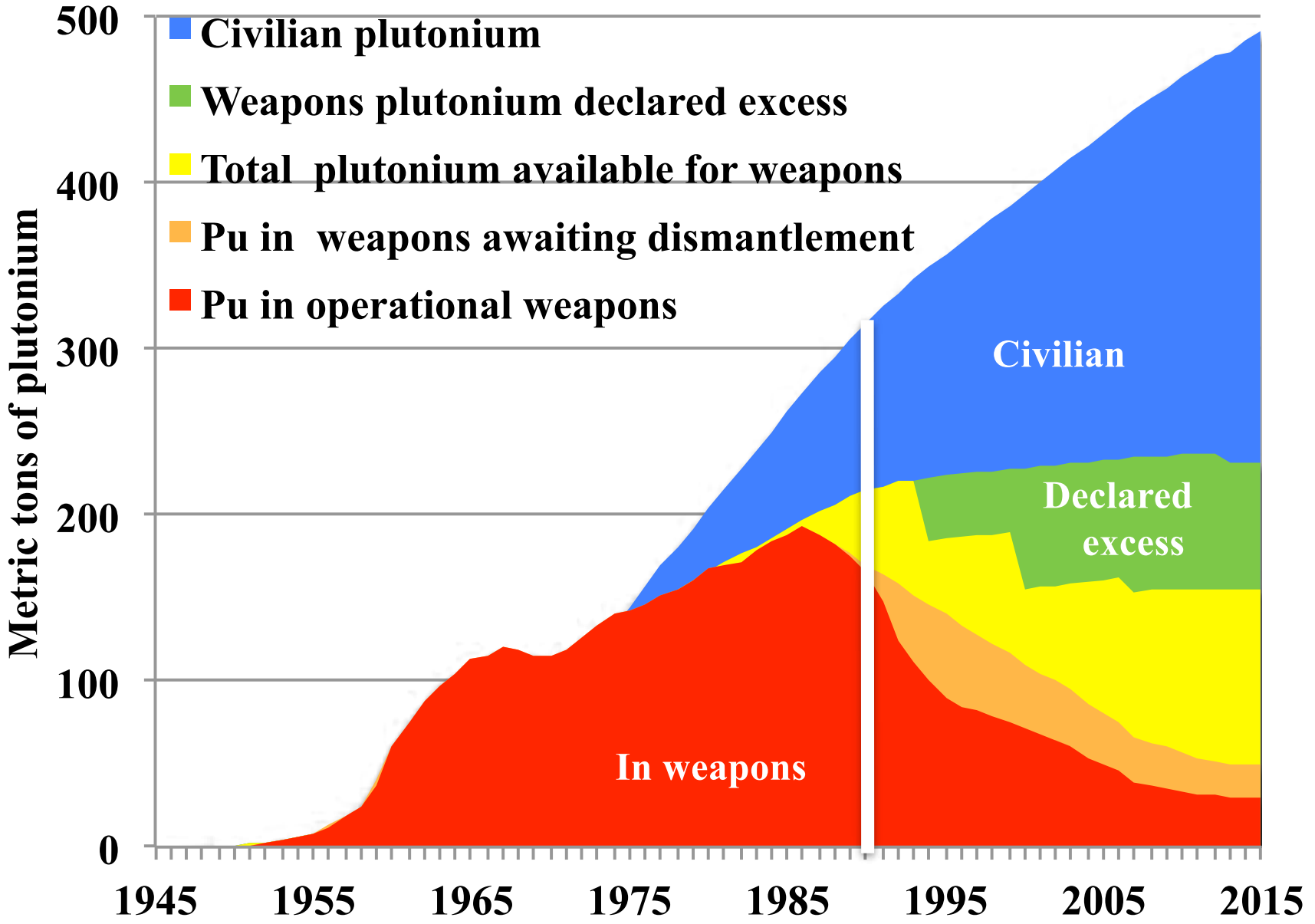
"***if our researchers have a need for greater presence under the sea, we must build small engines whose construction requires fuel enriched to 45 to 56 percent***."

--Fereydoun Abbasi-Davani, head, Atomic Energy Organization of Iran, Amadinejad Administration, 16 April 2013

Uranium enriched above 20% (HEU) is considered to be weapon usable.

Global stocks of *separated* plutonium

Military plutonium stocks have plateaued since the end of the Cold War and are set to decline but civilian stocks have tripled.



Only six countries separate Pu for reactor fuel today

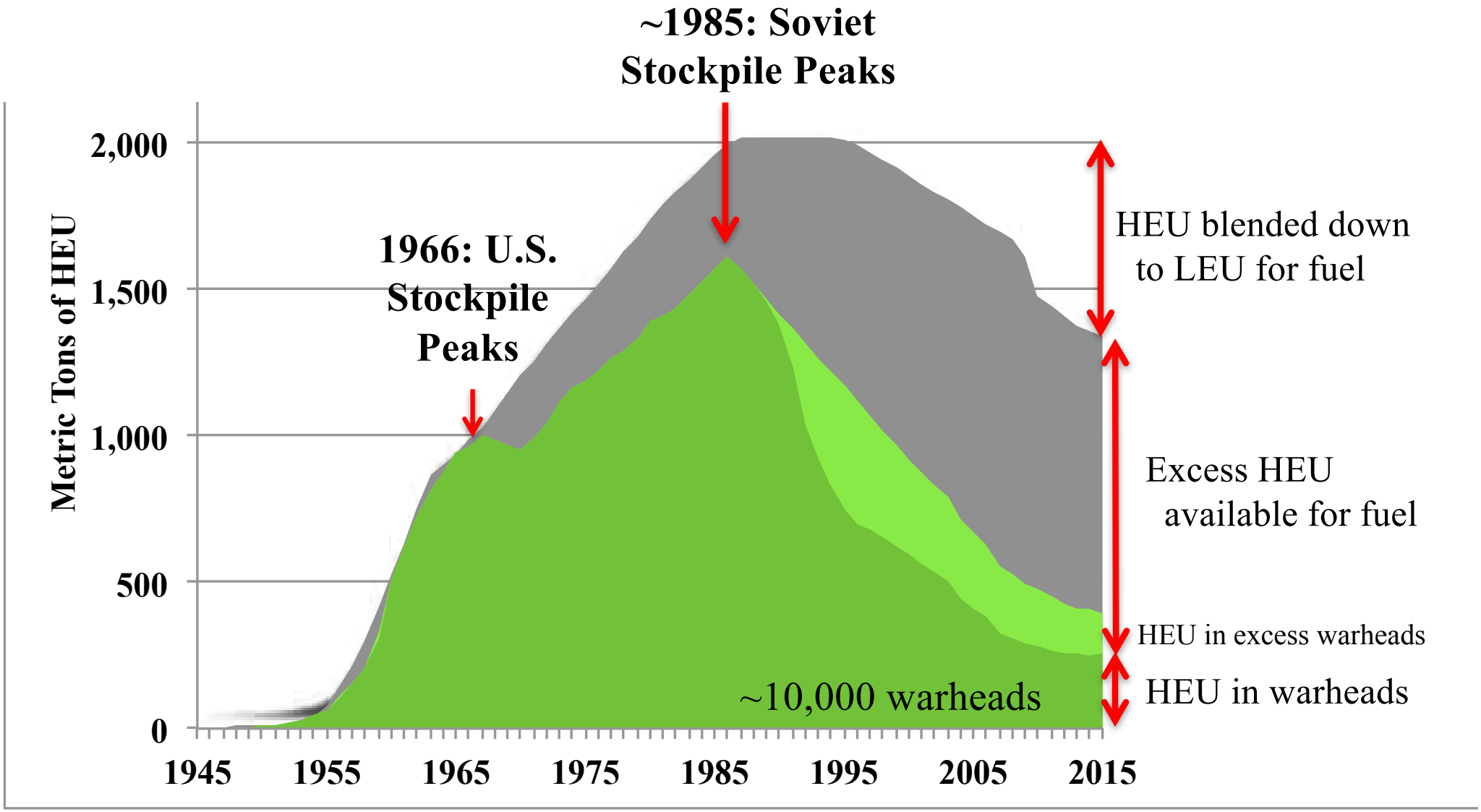
Pu separation for fuel launched 50 years ago to provide startup fuel for liquid-sodium-cooled plutonium "breeder" reactors that could produce more plutonium fuel than they consumed.

But only ~1 GWe of "demonstration" breeder capacity today.

- **India, Russia** still seek breeders on a much stretched out schedule;
- **France** using plutonium in light water reactor fuel and **Japan** is hoping to do the same but 10x cost of LEU fuel;
- **UK** quitting.
- **China** wants the technology.

If the "invisible hand" of the market were to finally prevail, we could agree to ban plutonium separation for any purpose.

Global HEU Stocks



Non-weapon uses of HEU ~ 7 tons/year

Mostly naval and all other uses being phased out.

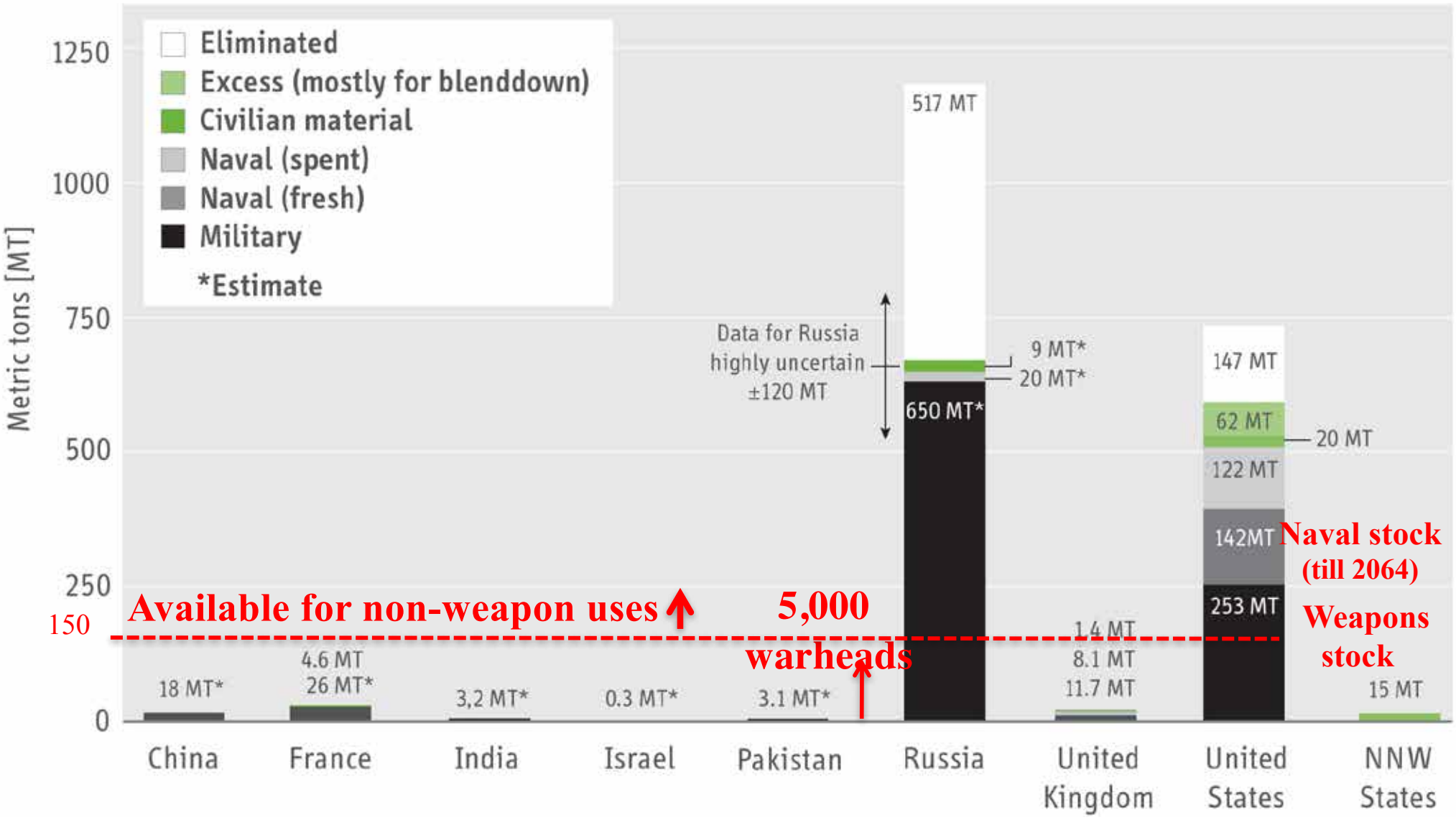
Use	**Estimated annual HEU use** (metric tons wge* per year)
Naval-reactor fuel	**~4** (2.5 U.S/UK, 1.5 Russia)
Isotope-production reactor fuel (Russia)	**~1** (until 2023)
Breeder-reactor fuel (Russia)	**~1** (until 2020-40)
Research reactor fuel	**~0.7** (down by half)
Medical isotope production targets	**~0.04**
Total	**~ 7 tons/year**

*wge = weapon-grade equivalent in terms of contained U-235

Estimated HEU Stocks in 2015: Mostly Russian and U.S.

Each needs only ~ 150 tons for ~5,000 warheads (incl. working stocks)

U.S. has enough for ~50 years of non-weapons uses.



Naval reactors becoming remaining users of HEU

New *G.R. Ford* aircraft carrier, at Newport News Shipbuilding, powered by twin reactors.

Naval fuel enrichment by country

Country	Nuclear ships and submarines	Fuel enrichment
U.S.	10 aircraft carriers, 73 submarines	**93.5+%**
U.K.	11 submarines	**93.5% from U.S.**
Russia	49 submarines (7 research), 2 cruisers, 6 icebreakers	**21-90+%**
India	1 submarine	**21-45%**
China	14 submarines	**5%?**
France	1 aircraft carrier, 10 submarines	**LEU (new sub will be <6%)**

Two pairs use HEU, two use LEU.

U.S. supplies UK with naval HEU and reactor technology.

Russia supplies India with naval-reactor technology.

China and France use LEU.

Door to using LEU for U.S. naval fuel has opened

Office of Naval Reactors *Report to Congress,* July 2016

"***a plan…to determine the technical and economic viability of an advanced fuel system which might enable use of LEU fuel in an aircraft carrier reactor. The fuel is unlikely to enable/allow conversion of current life-of-ship submarine reactors to LEU***."

Example effect of U.S. converting its submarines to LEU fuel would be more powerful but lifetime LEU cores would be larger than HEU cores and LEU cores the same size as the HEU cores would have to be replaced at mid-life.

Office of Naval Reactors says that larger cores can fit in existing aircraft carrier reactors but not in existing submarine reactors.

Can future U.S. submarine reactors be designed for larger LEU cores or rapid mid-life refueling?

Verification and stability benefits

Verification

Plutonium

If no plutonium separation then measurement uncertainty of difference between Pu that comes to reprocessing plants in spent fuel and amount of plutonium that was separated becomes a non-issue.

HEU

If no HEU-fueled naval reactors, then IAEA would not need to deal with verifying the naval fuel cycle in the weapon states and the stakes in the non-weapon states would be less.

Stability

No stockpiles of HEU and separated plutonium for non-weapon uses would would stabilize nonproliferation and nuclear reductions regimes.

Summary

- Plutonium separation and use not economic.
- Existing Russian and U.S. HEU stocks could supply current non-weapons uses for ~50 years.
- Within next decades, almost all HEU-fueled reactors other than naval reactors could be LEU fueled or retired.
- Designing US/UK naval reactors to use LEU fuel might be possible.
- Transitioning Russian and Indian naval reactors to LEU would be much easier (lower HEU enrichment and non-lifetime cores).
- The result would be more verifiable and stable nonproliferation and nuclear reduction regimes.