

The US Department of Energy's renewed but doomed promotion of sodium-cooled fast-neutron reactors and plutonium separation.

Why does Japan's nuclear energy research and development community want to join in?

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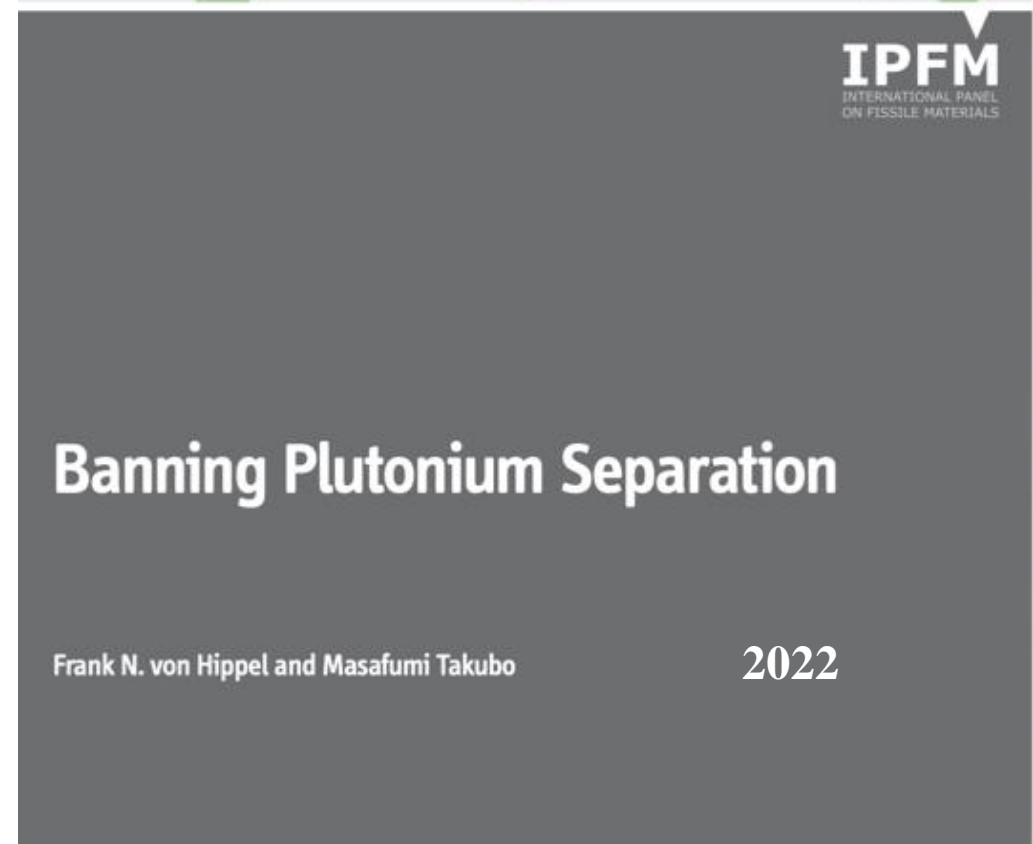
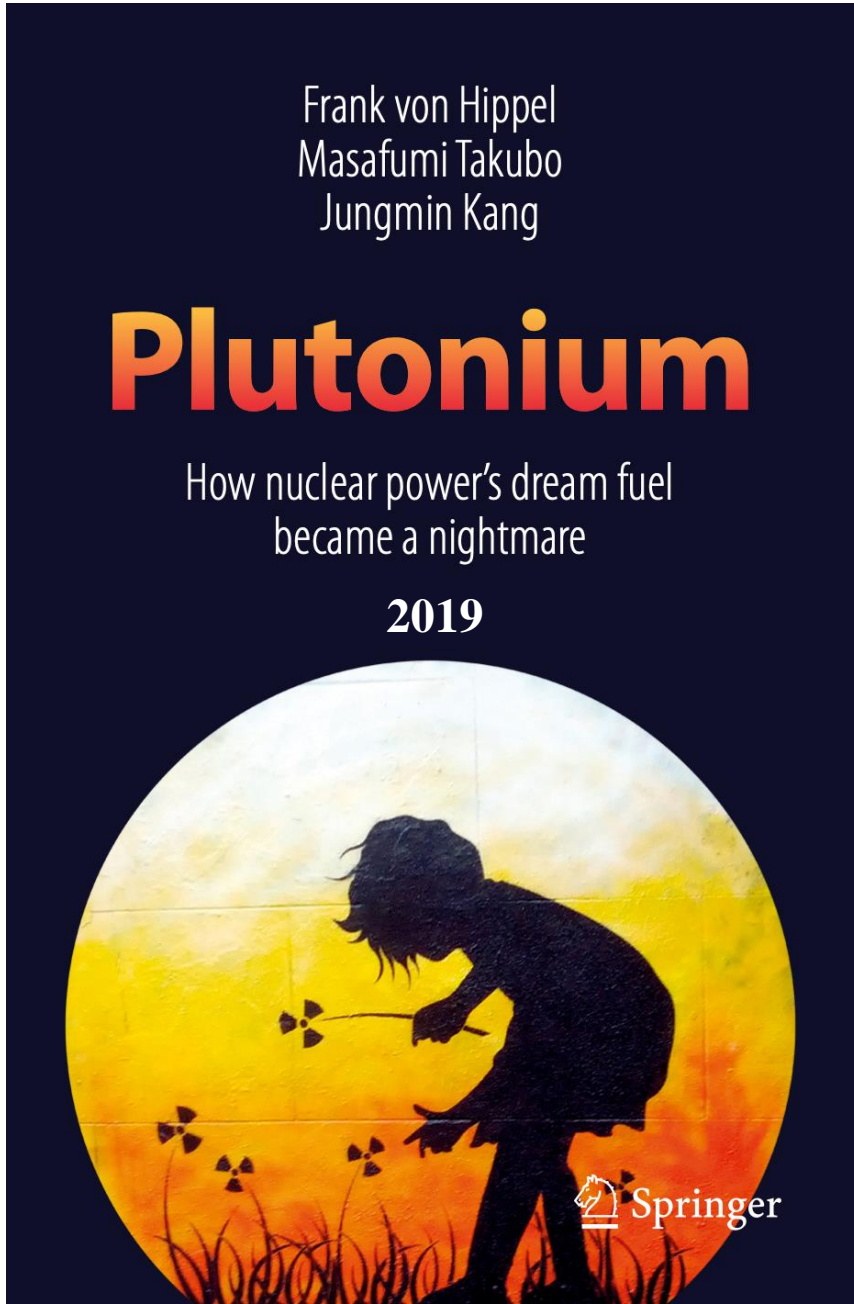
Program on Science and Global Security

Princeton University

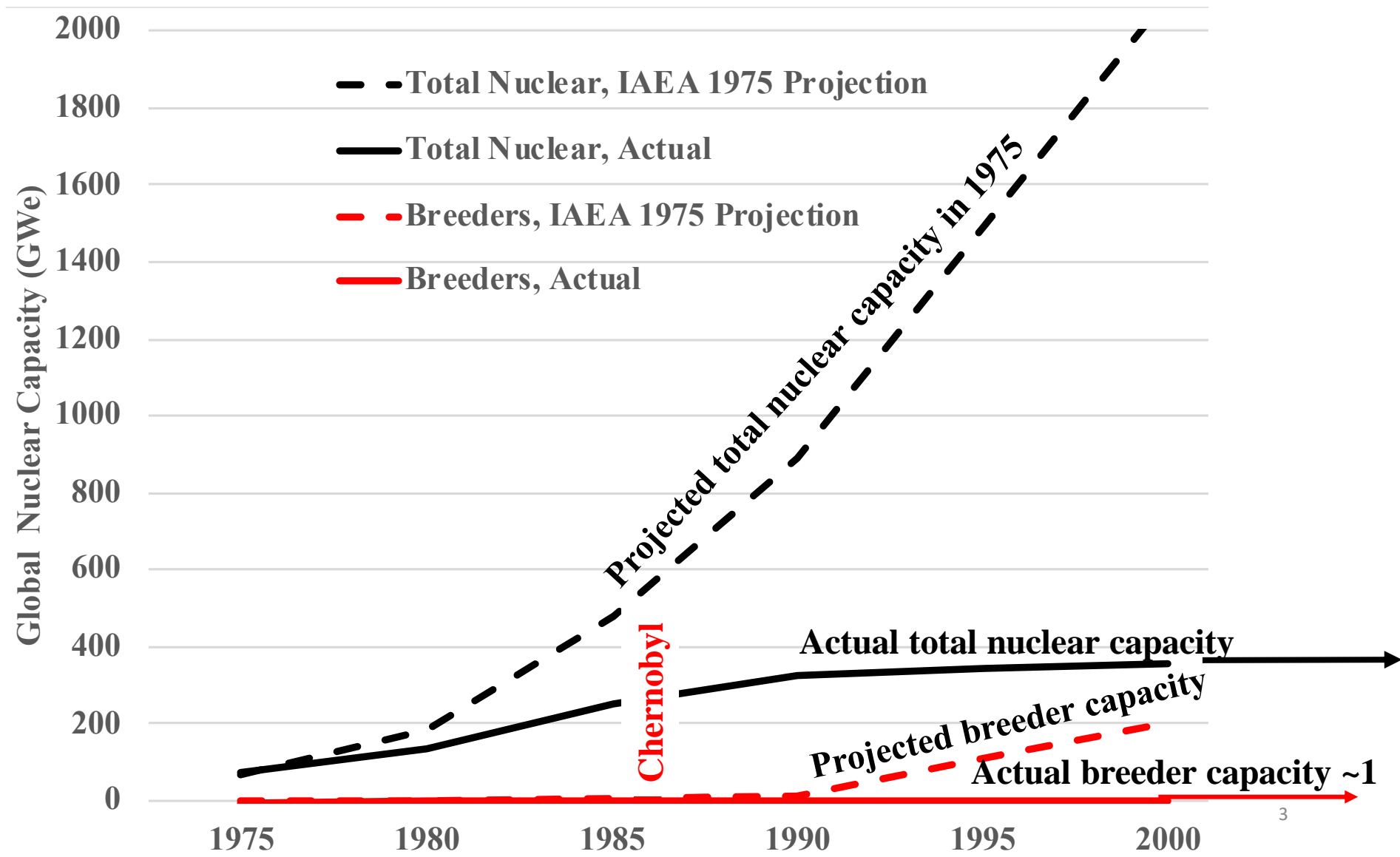
US-Japan Nuclear Energy Cooperation in Fast Neutron Reactors

(10 March 2023, via Zoom)

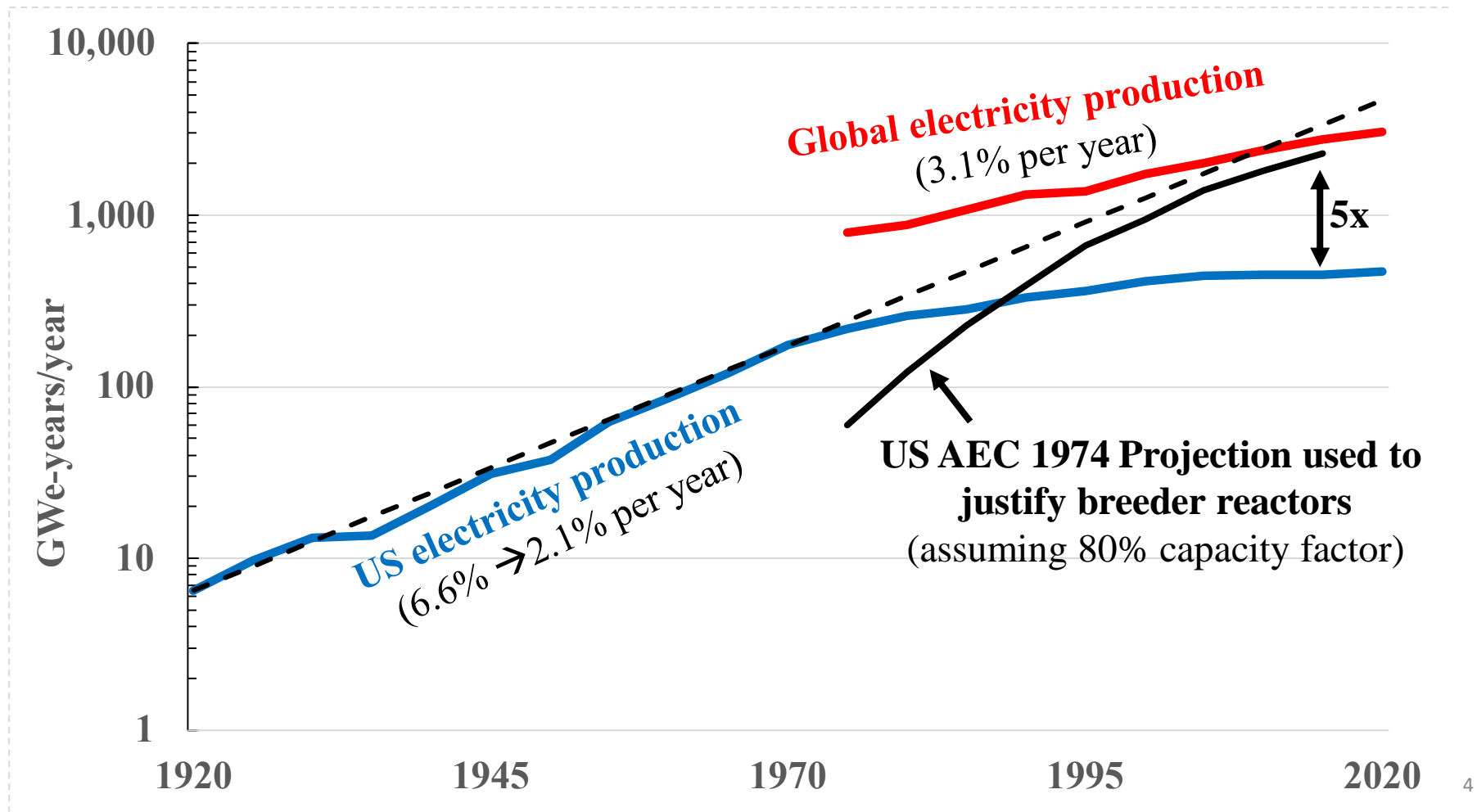
For background on plutonium issues see:



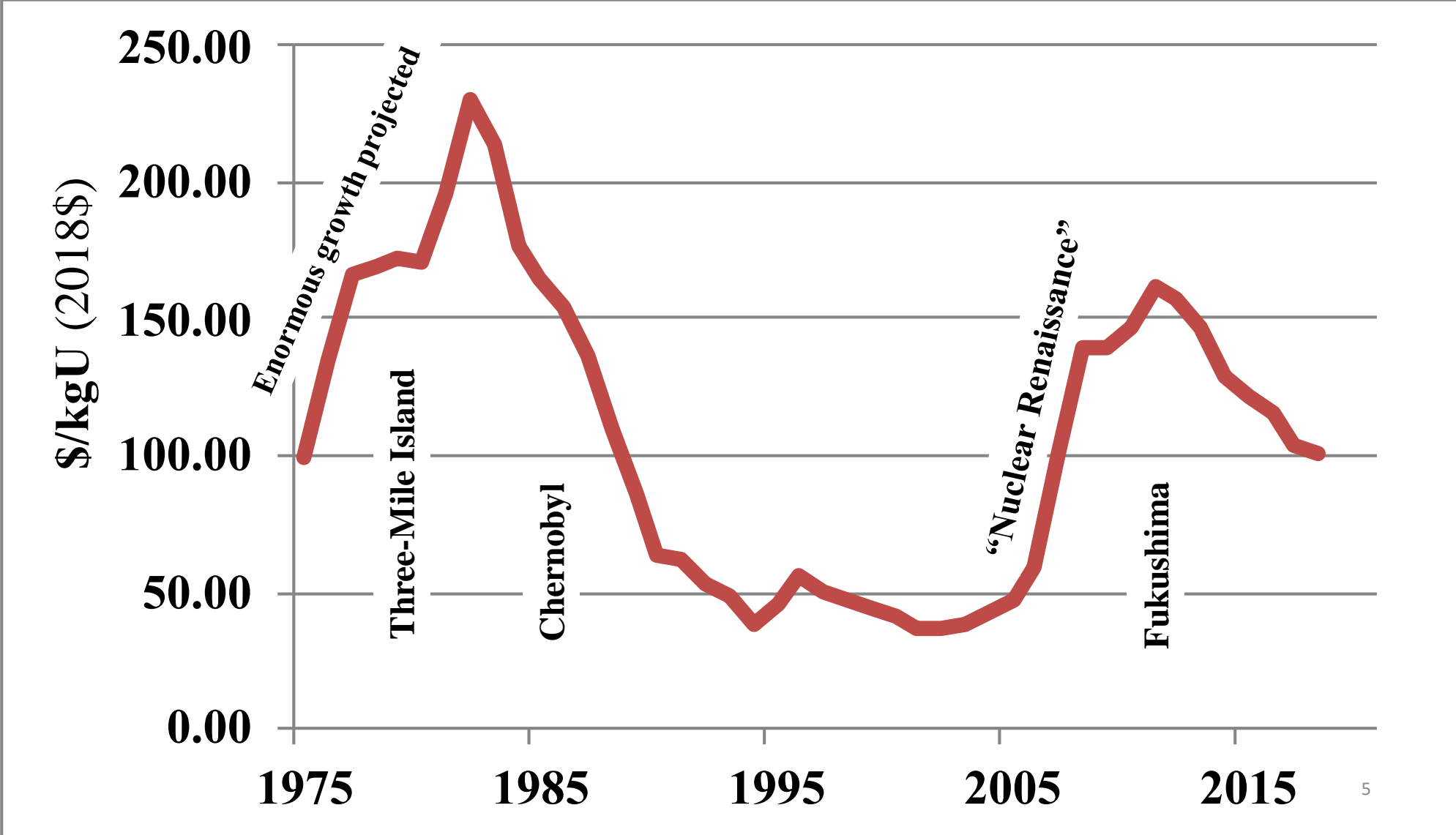
Sodium-cooled Fast-neutron plutonium Breeder Reactors (with reprocessing) were proposed to save uranium in anticipation of its depletion due to a rapid growth of nuclear power. After 1986 Chernobyl accident, however, nuclear power capacity plateaued. Commercial FBRs were not built.



US Atomic Energy Commission made similar projections. In 1977, we pointed out US historic electricity consumption growth rate had been twice that of US economy because electricity cost had been declining, *but that cost decline had come to an end*. We were right. *President Carter decided US breeder program was unnecessary.*



Sodium-cooled breeder reactors were not commercialized because they are costly and unreliable. Beyond speculative fluctuations, the cost of uranium for water-cooled reactors has stayed low at about \$0.003/kWh.



Desperation in US and Japan nuclear energy research, development communities

US. Only four new power reactor construction starts since 1977. Two of the four have been cancelled. Cost of other two has more than doubled.

- Trump Administration turned control of DOE's Office of Nuclear Energy over to the Idaho National Laboratory (INL), which prioritized building a new prototype sodium-cooled reactor.
- Biden Administration, with an “all-options” energy policy driven by climate concerns, has not changed this situation – probably to prevent nuclear advocates from opposing its policy.
- INL also has continued to promote spent fuel reprocessing and plutonium recycle, even though plutonium recycle has failed economically everywhere.
- Bill Gates, founder of Microsoft, with a fortune of \$100 billion, was persuaded to create a company, Terrapower, to commercialize fast neutron reactors and is partnering with DOE and General Electric (designer of the Fukushima reactors) in building a demonstration sodium-cooled reactor power reactor, *Natrium*, in Wyoming. It is to be fueled with uranium, but Terrapower has been funded by DOE to do research on reprocessing and plutonium recycle.

Japan. After failure of *Monju* and cancellation of France's fast neutron reactor project *ASTRID*, Japan's sodium-cooled reactor advocates want to partner with Terrapower.

But sodium burns in air or water



Sodium-cooled reactors proved to be costly and unreliable. Despite 60 years of efforts and more than \$100 billion in R&D and prototypes, they have not been commercialized

Capacity factor (CF) is average percentage of utilization of design output. Most prototypes or demonstration sodium-cooled reactors have had unacceptably low CFs.

Country	Prototype	Capacity (MWe)	Years of Operation	Capacity Factor
United States	Fermi I ("We almost lost Detroit")	66	1963-72	1%
United Kingdom	Dounreay Fast R.	260	1974-94	35%
France	Superphénix	1200	1985-98	3%
Japan	Monju	250	1994-2017	0
Global average	~400 water-cooled reactors	~900 av.	~30 years	~80%

Three countries are still trying

Russia, because of its great tolerance of sodium fires (14 fires in the first 14 years of BN-600 operation), has achieved nearly competitive capacity factors:

BN-600, 1980- (CF = 76%);

BN-800, 2015- (CF = 66%)

But Russia's breeders are still not economically competitive with water-cooled reactors and a construction decision on another prototype has been postponed until the 2030s.

China and India are building prototypes, *but the primary purpose of these reactors may be to produce plutonium for weapons*. Therefore, their economics as power producers may not matter.

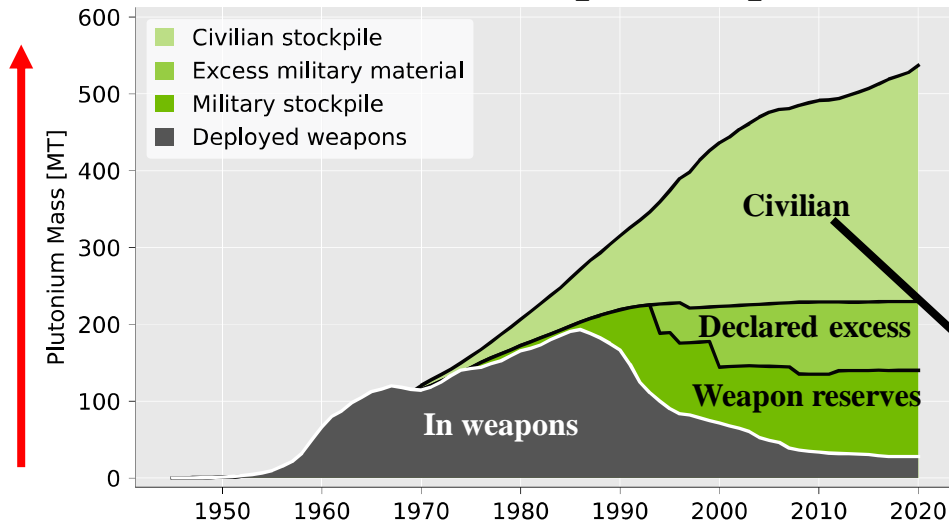
Recall that, in the 1950s, the United States and Canada provided India with a reactor to produce plutonium for its breeder program and with reprocessing technology.

India used the plutonium to launch its nuclear weapon program in the 1970s. Fifty years later, India still has not produced an operating breeder reactor.

Plutonium legacy of the Cold War and breeder reactor dream

**≈100,000 nuclear
weapon-equivalents**

**Total global stock of
separated plutonium**



+ **India (~7 tons)**

+ **China (small stock but big ambitions)**

**In France and Japan, plutonium recycle
saves 10% of fuel at 10x the cost.*

What can be done about the growing stock of dangerous separated plutonium?

1. ***Educate policy makers about the history.*** (Proponents call sodium-cooled reactors “advanced” - not because their designs are new but because their commercialization has failed.) Outside the nuclear-energy research and development community, there is no interest in using plutonium as a fuel.
2. ***End plutonium separation for any purpose.***
[“When you are in a hole, stop digging.”]
3. ***Place weapon-state civilian and excess nuclear-weapon plutonium under IAEA safeguards as all plutonium is in Japan.***
4. ***Japan should join with the United States and United Kingdom in organizing an international research program on options for disposing of existing stocks of unirradiated plutonium***
[The United States, after an effort to turn its excess plutonium into fuel for water-cooled reactors became too costly, plans to dilute it and bury it in a deep salt bed. Proposals in the United Kingdom to use plutonium as a fuel have been rejected by its nuclear utility. The UK has a research program on plutonium immobilization and burial.)