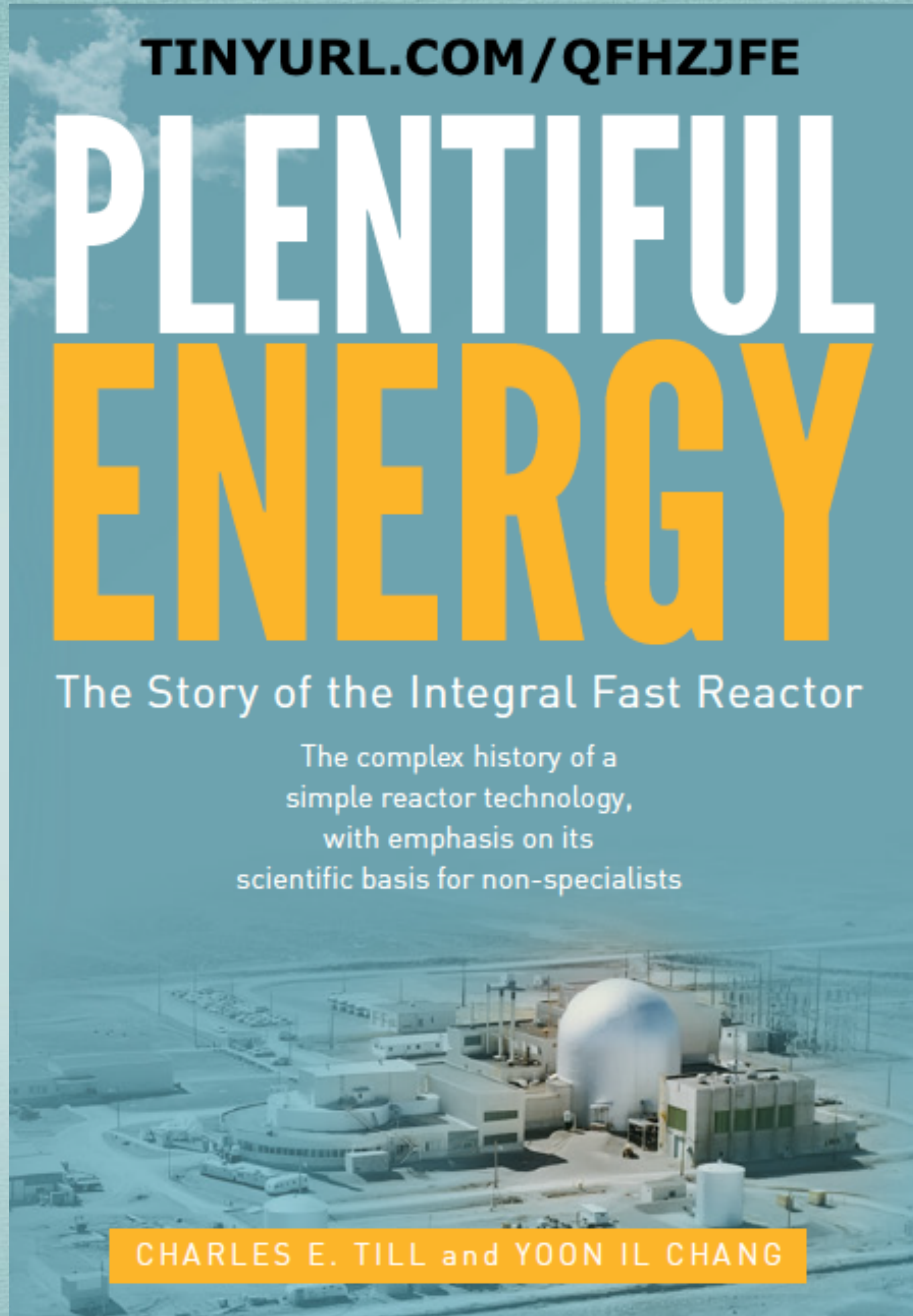
The Integral Fast Reactor


tinyurl.com/9992kma
PRESCRIPTION
FOR THE PLANET
The painless remedy for our
energy and environmental crises
by Tom Blees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PLENTIFUL
ENERGY
The Story of the Integral Fast Reactor
The complex history of a
simple reactor technology,
with emphasis on its
scientific basis for non-specialists
CHARLES E. TILL and YOON IL CHANG

Science Council for Global Initiatives

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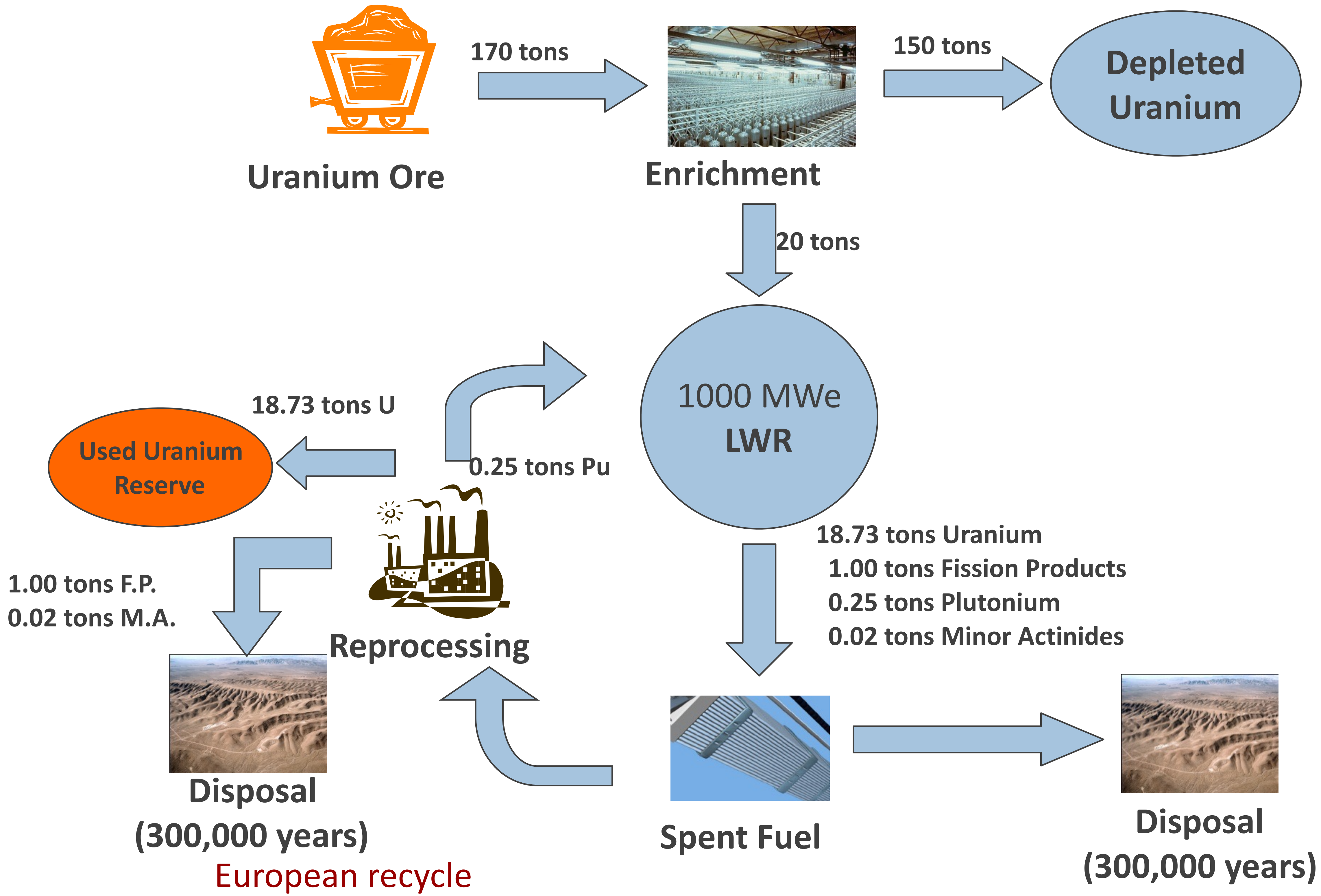
Positive proof of global warming.
18th Century
1900
1950
1970
1980
1990

Worldwide Sodium-Cooled Fast Reactor Experience

Country	Reactor	MWth/Mwe	Operations
U.S.	EBR-I EBR-II Fermi-1 FFTF	1/0.2 62.5/20 200/61 400	1951-63 1964-94 1965-72 1980-92
Russia	BR-5/10 BOR-60 BN-350 BN-600	8 60/12 1000/150 1470/600	1958-02 1969- 1973-99 1980-
France	Rapsodie Phenix SuperPhenix	40 563/250 3000/1240	1967-83 1974-09 1985-97
Japan	Joyo Monju	140 714/300	1978- 1993-
UK	DFR PFR	72/15 600/270	1963-77 1976-94
Germany	KNK-II	58/21	1972-91
India	FBTR	42.5/12	1985-
China	CEFR	65/20	2010-

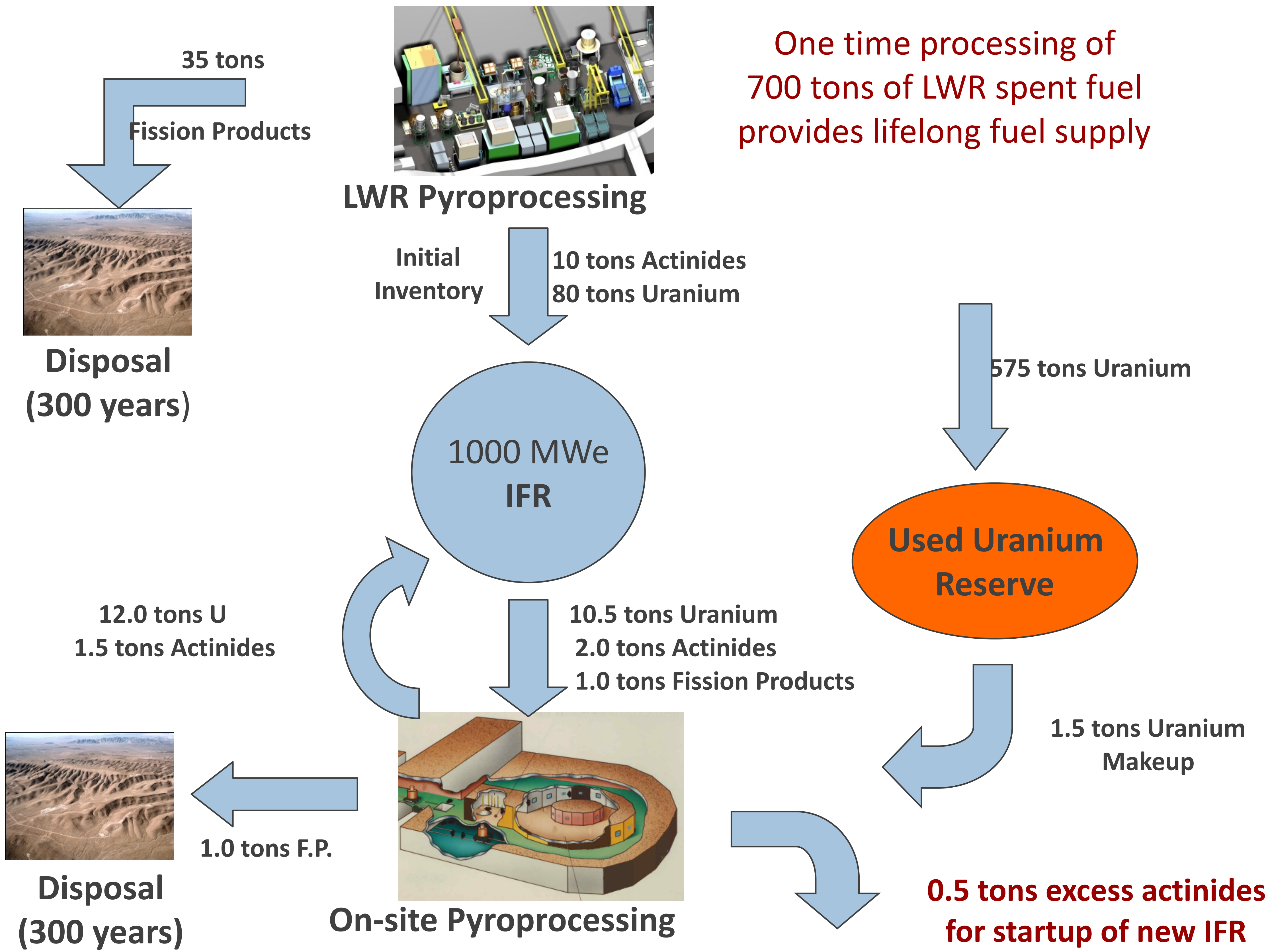
Uranium utilization is <1% in current LWRs



European recycle
- Saves 15% uranium
- But no reduction in waste life

Direct disposal is
the current U.S. policy

IFR is self-sufficient after initial startup



THE ESSENTIALS OF AN ACTINIDE-CONSUMING FUEL CYCLE

1000 MWe power plant

U-238 in
1 ton per year

Energy out

FP out
1 ton per year

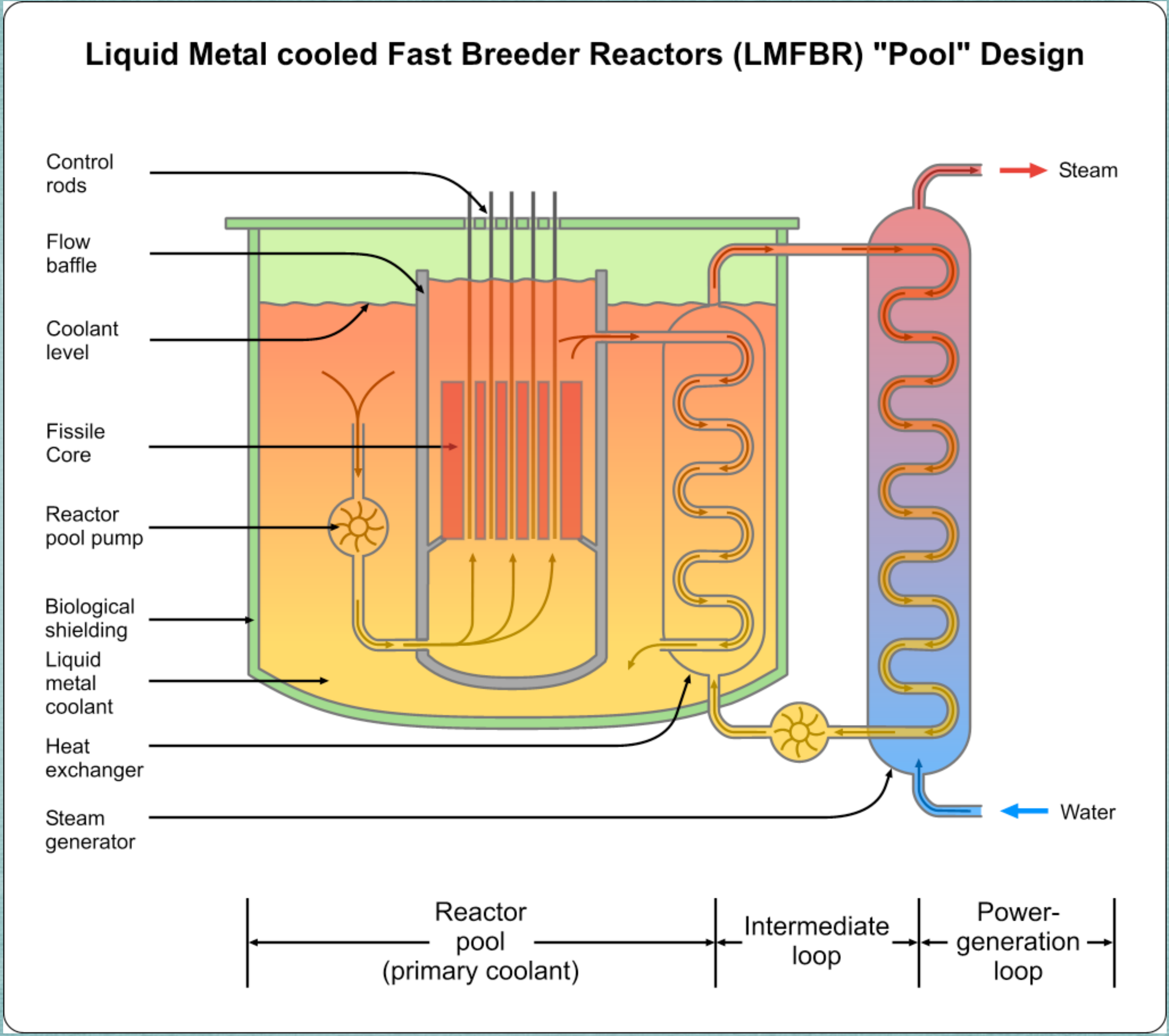
In the power plant:

- A fast reactor
- A facility to extract the fission products and make new fuel elements

NO LOOSE PLUTONIUM -- ANYWHERE!!

NO MORE ENRICHMENT OF URANIUM – EVER!!

THE INTEGRAL FAST REACTOR (IFR)



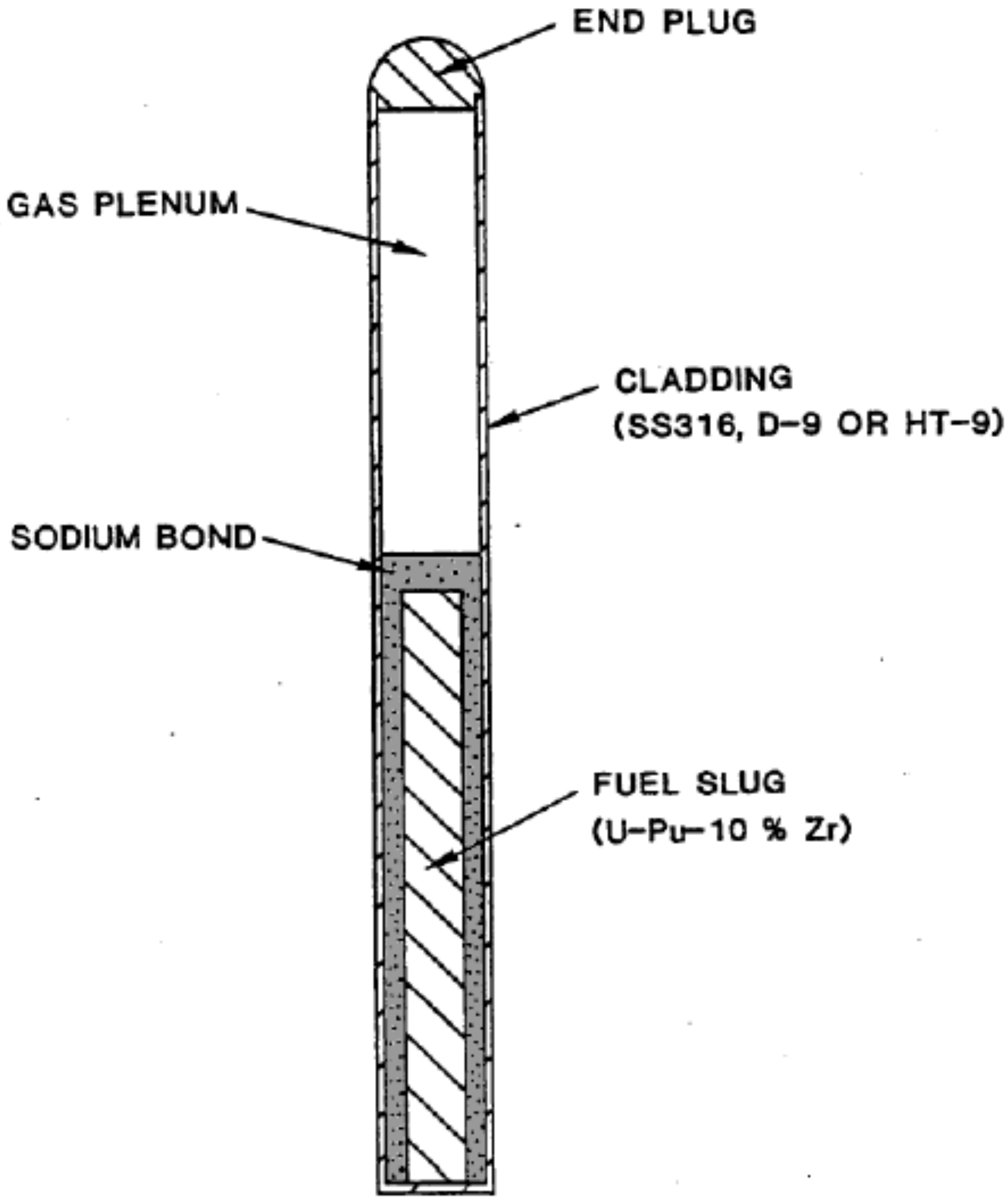
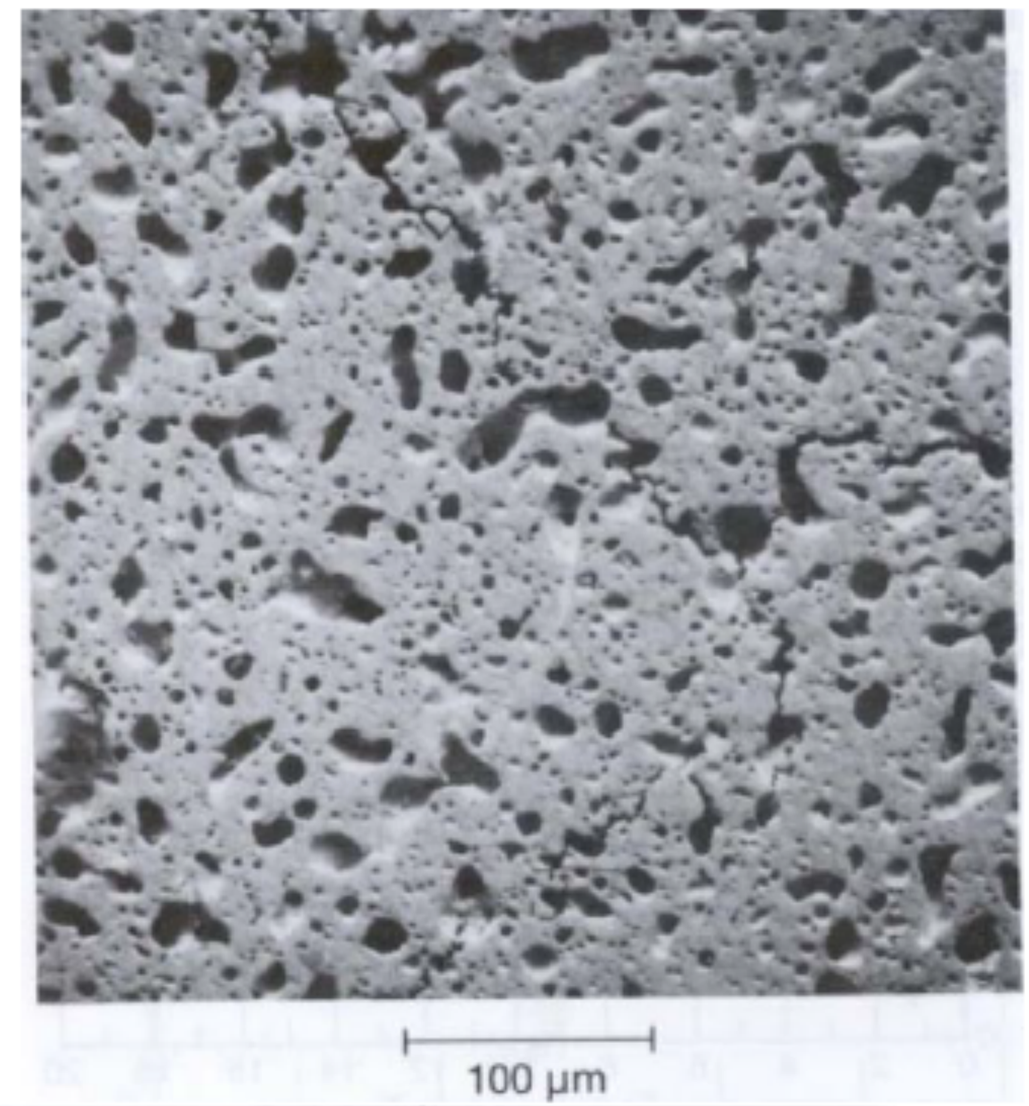
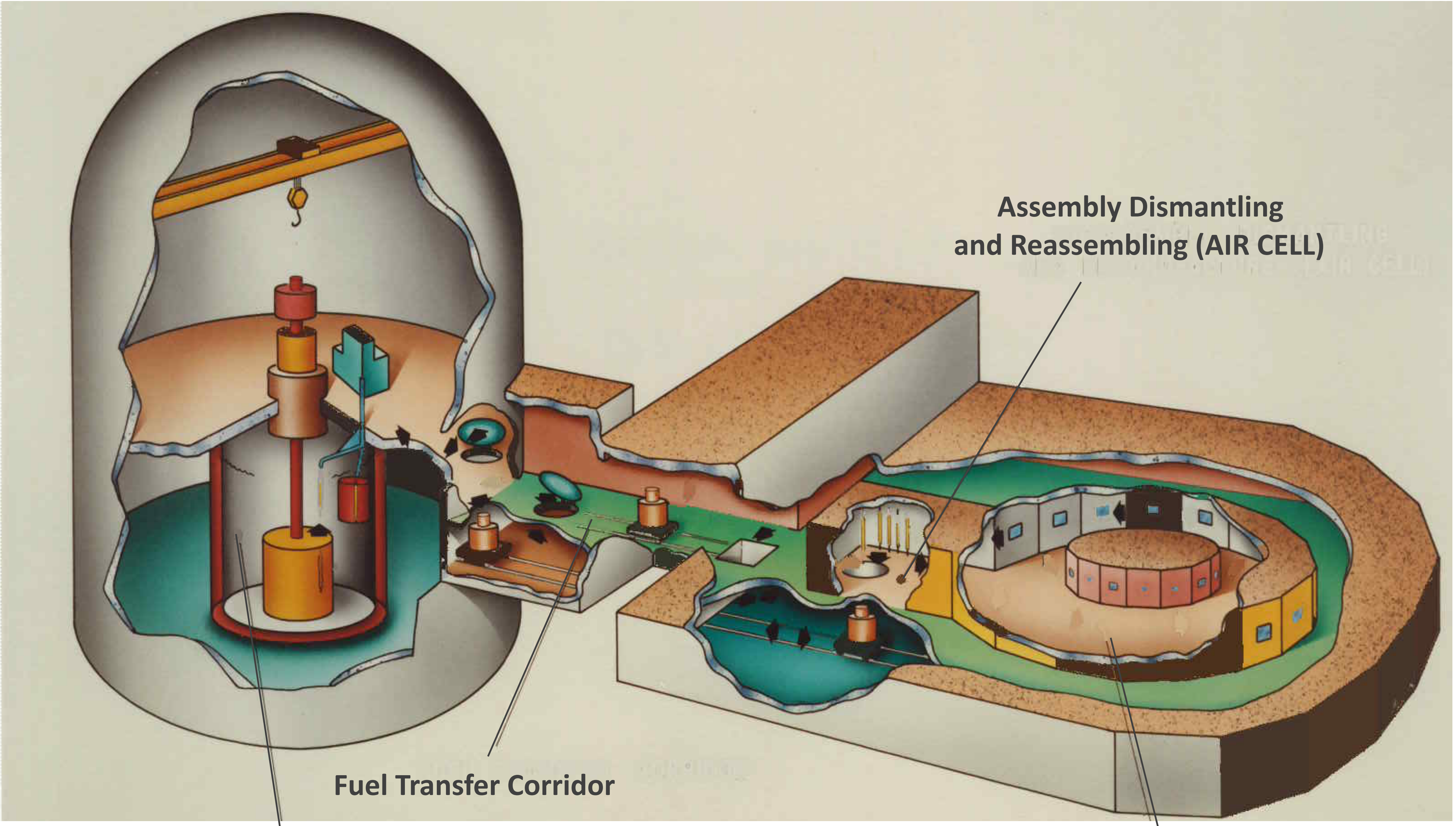


Figure 6-1. Schematic of metal fuel

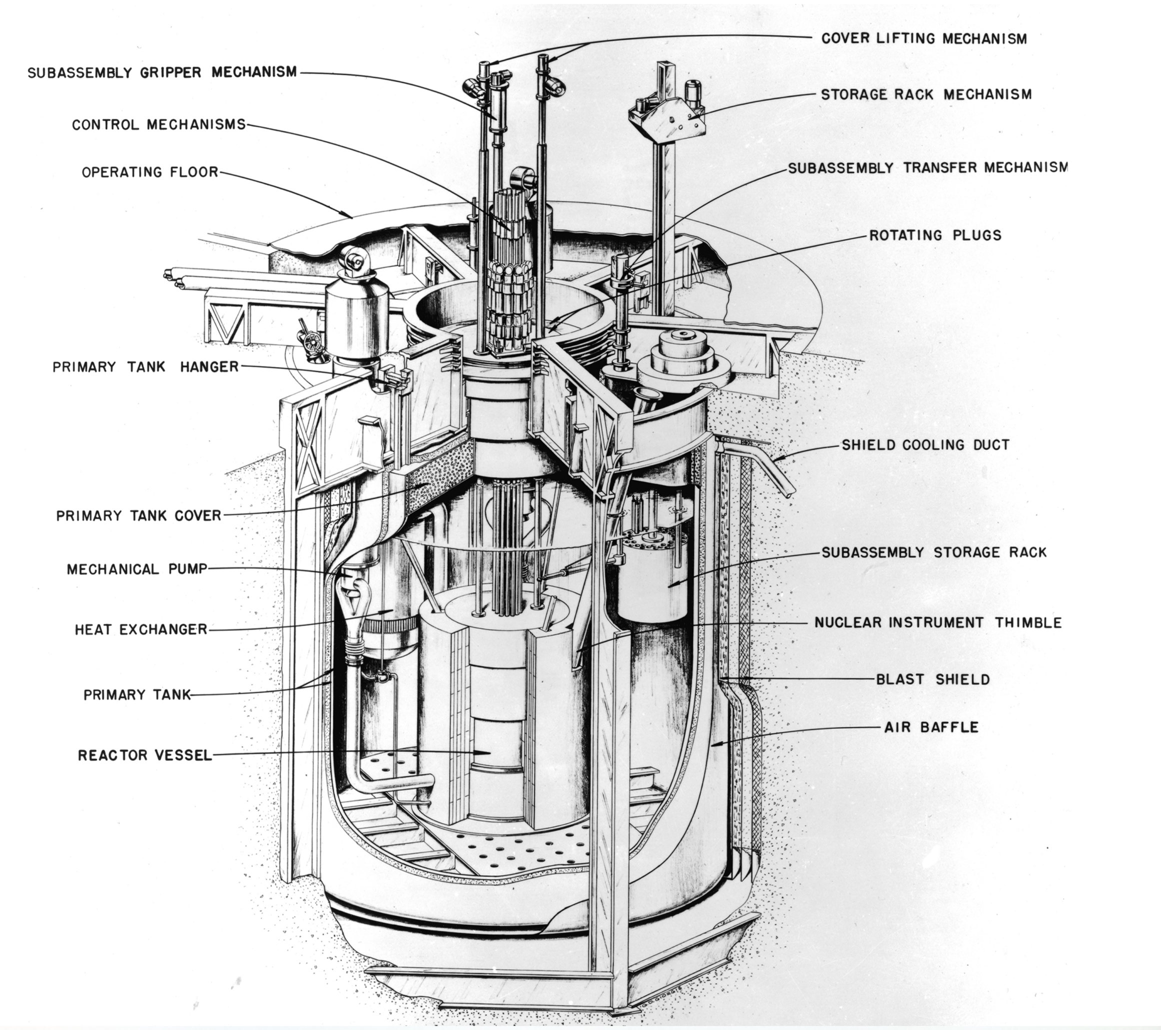


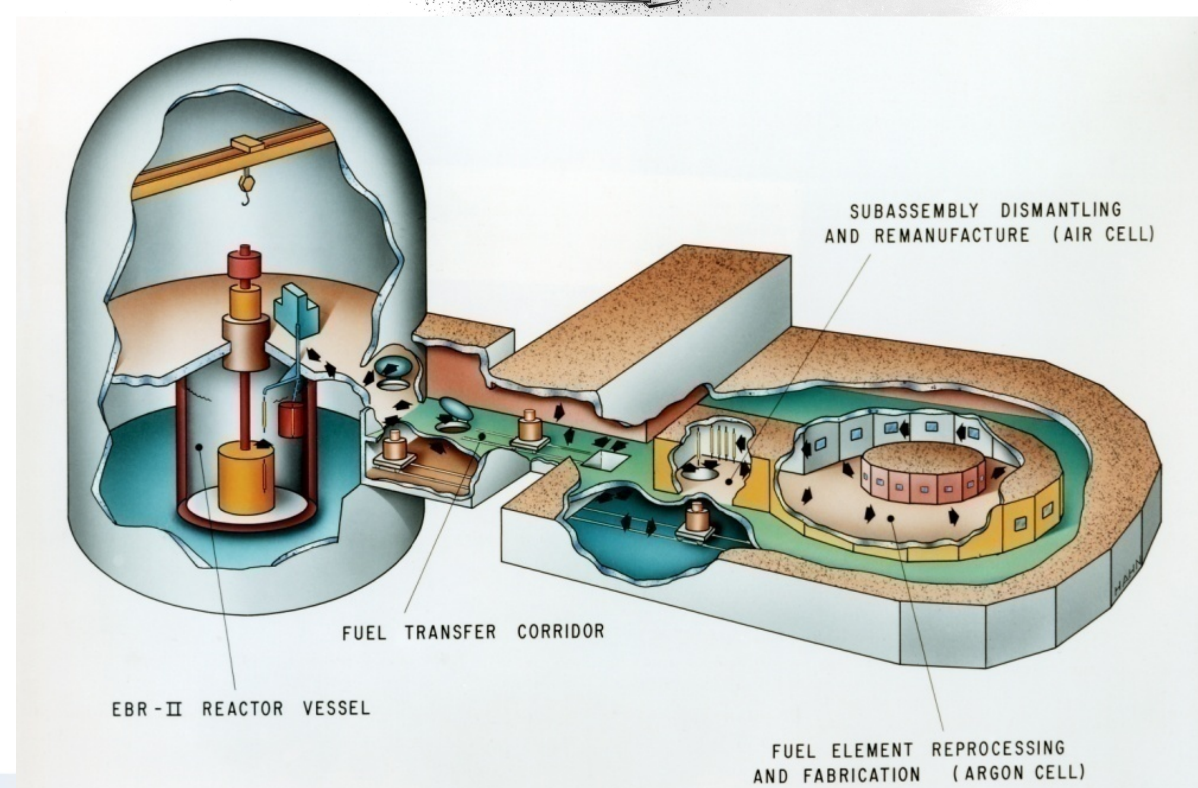
Fission gas pore structure of irradiated U-10Zr fuel


Assembly Dismantling
and Reassembling (AIR CELL)
Fuel Transfer Corridor
Reactor Vessel
Fuel Pin Pyroprocessing
and Refabrication (ARGON CELL)

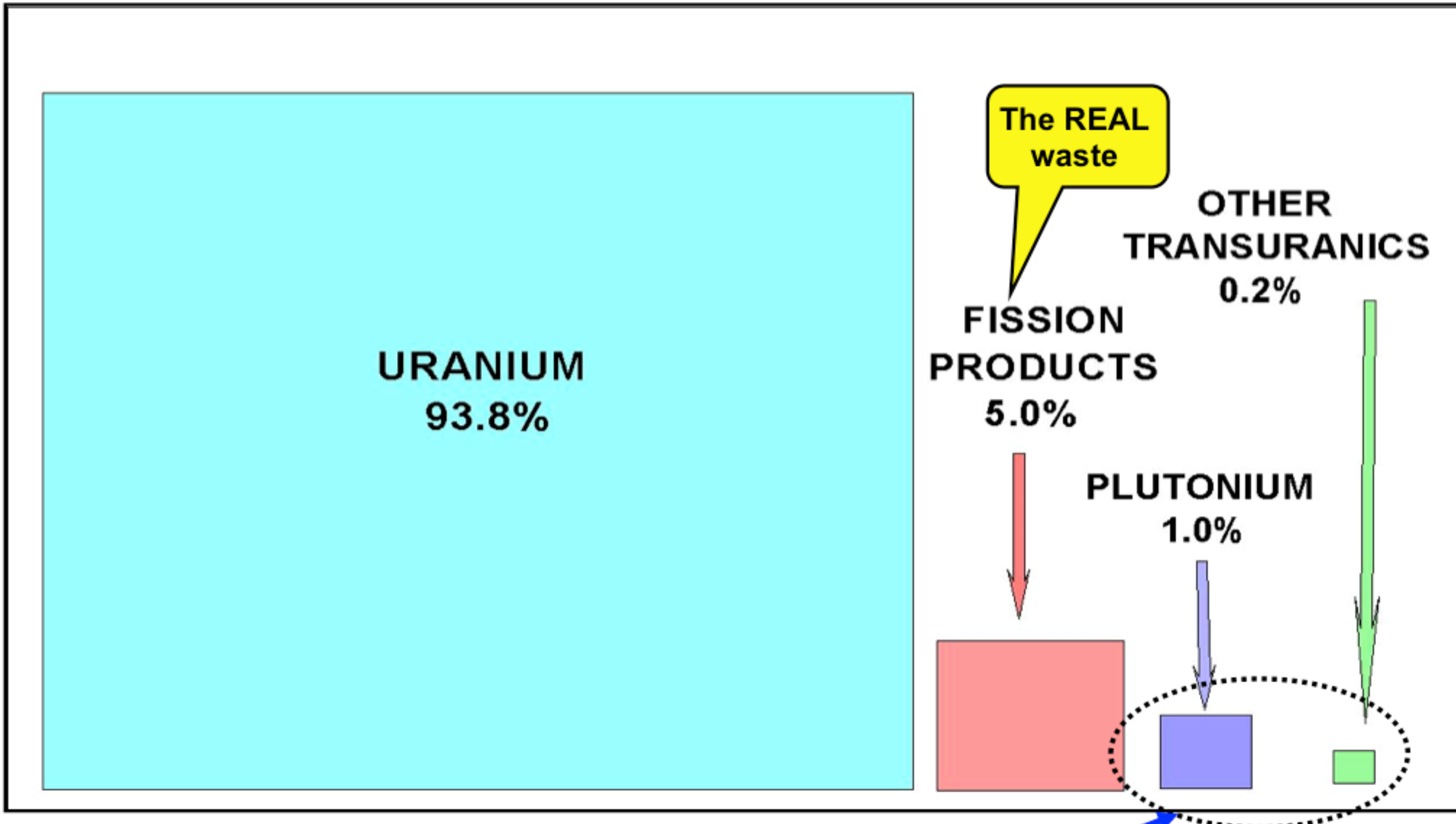
Experimental Breeder Reactor-II

- The first pool-type SFR started operation in 1964.
- Demonstrated recycle based on melt-refining from 1964-69: ~30,000 irradiated fuel pins were recycled with average turnaround time of 2 months from discharge to reload into the reactor.
- Successfully operated over 30 years: no steam generator tube leak, reliability of sodium components due to compatibility with sodium, etc.

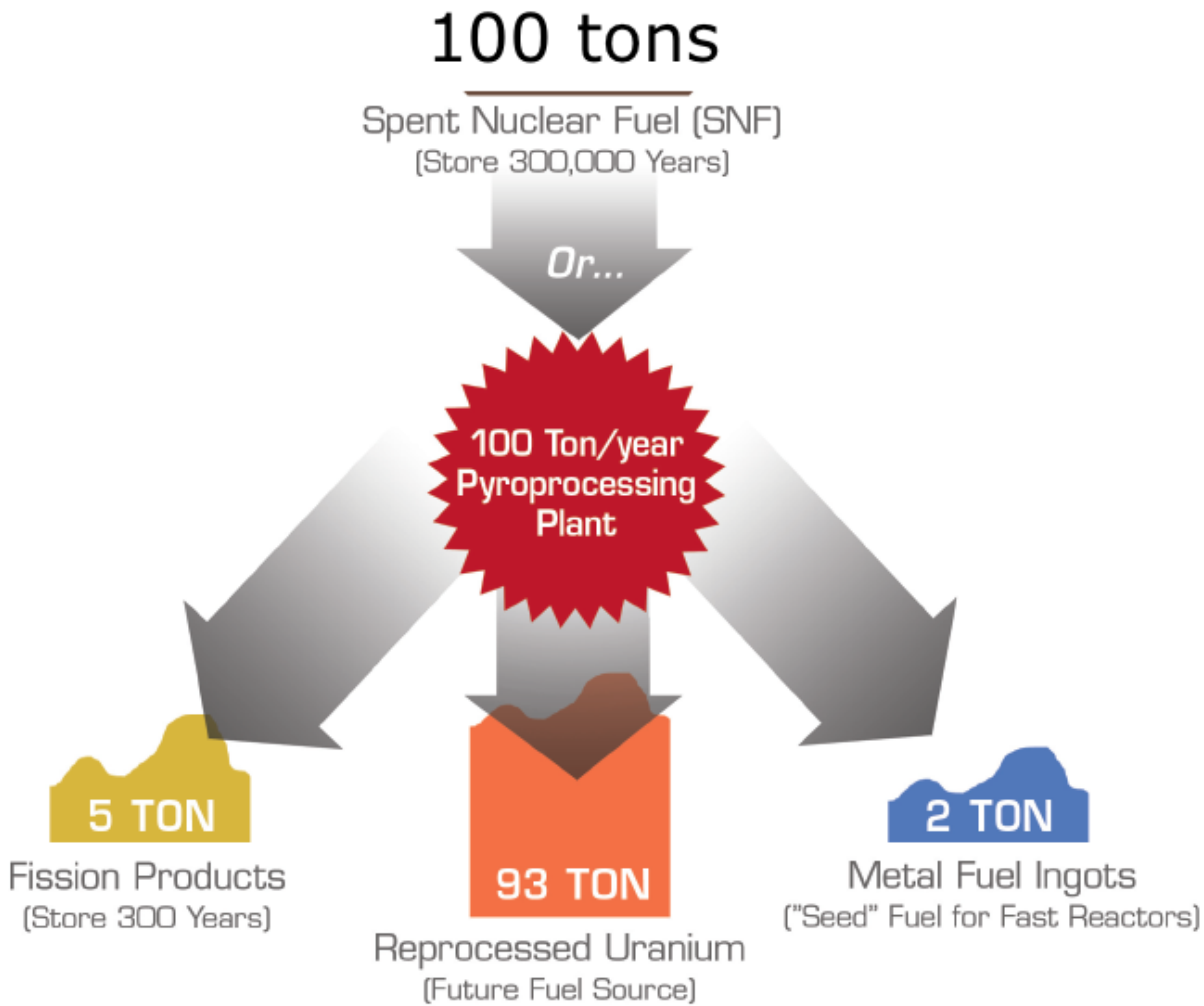




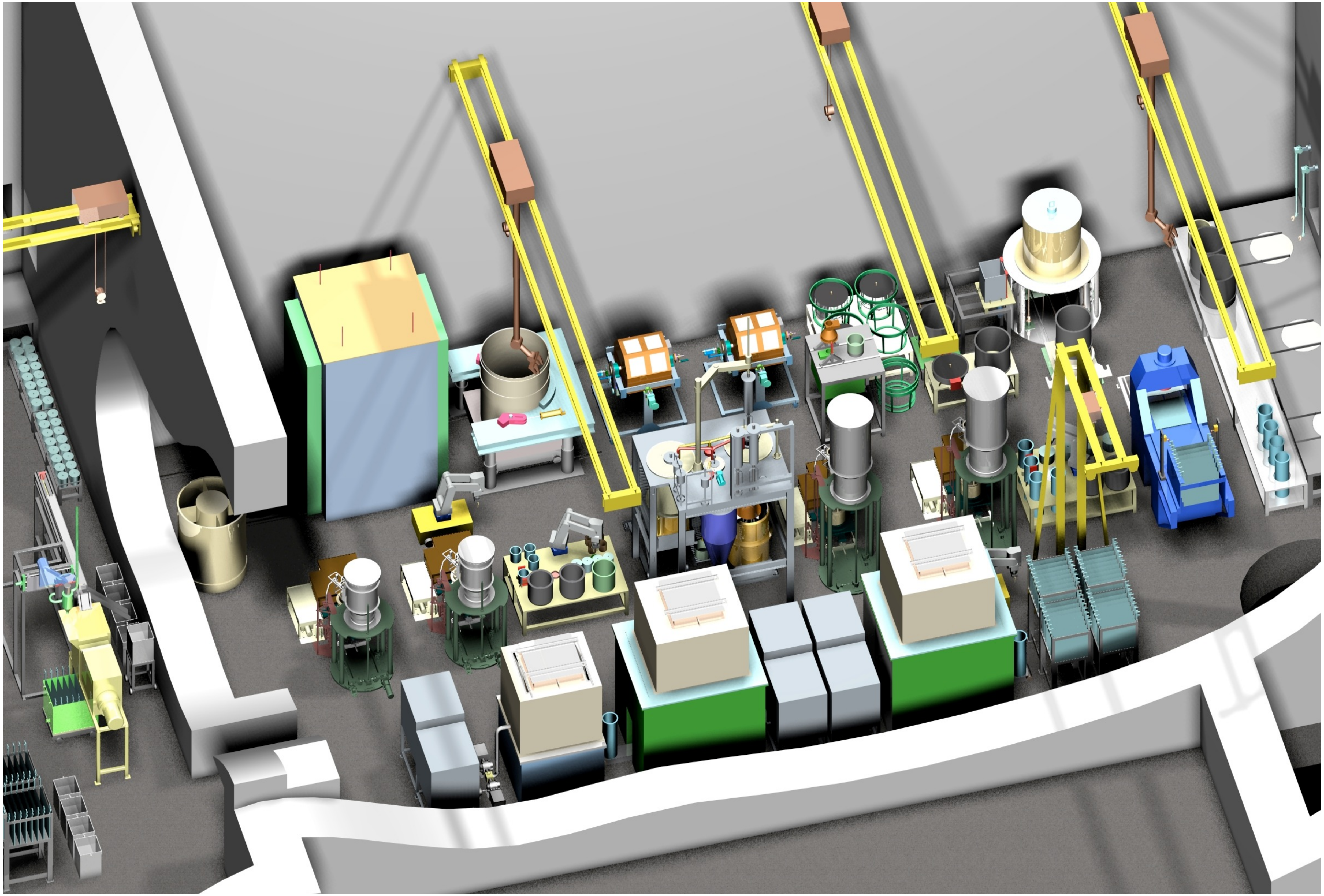
USED LWR FUEL *All of it is now treated as waste, but it's not*



With this portion consumed (in fast reactors), dangerous activity is gone in 300 years

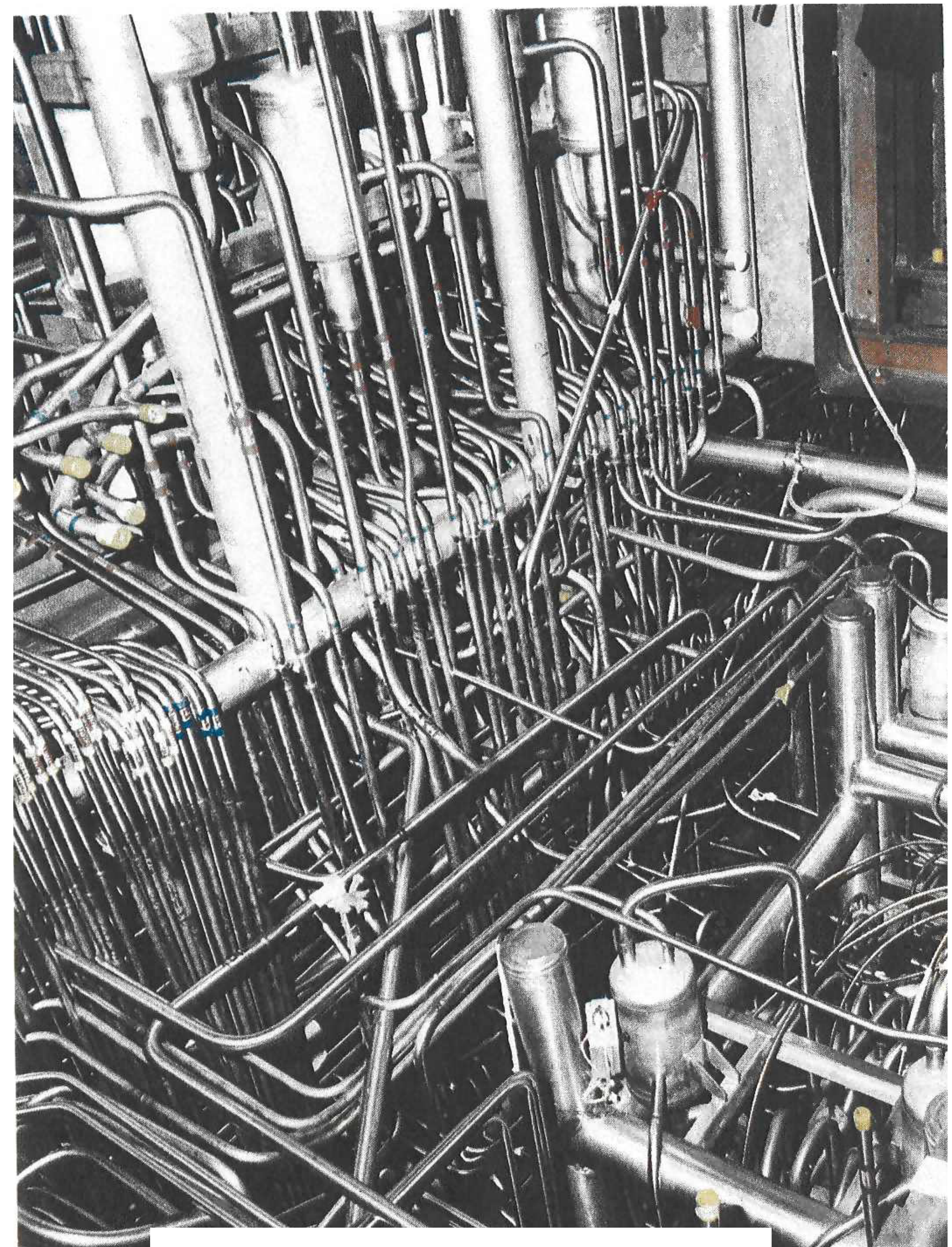

100 tons
Spent Nuclear Fuel (SNF)
(Store 300,000 Years)
Or...
100 Ton/year
Pyroprocessing
Plant
5 TON
Fission Products
(Store 300 Years)
93 TON
Reprocessed Uranium
(Future Fuel Source)
2 TON
Metal Fuel Ingots
("Seed" Fuel for Fast Reactors)

LWR Pyroprocessing Facility (100 T/yr)



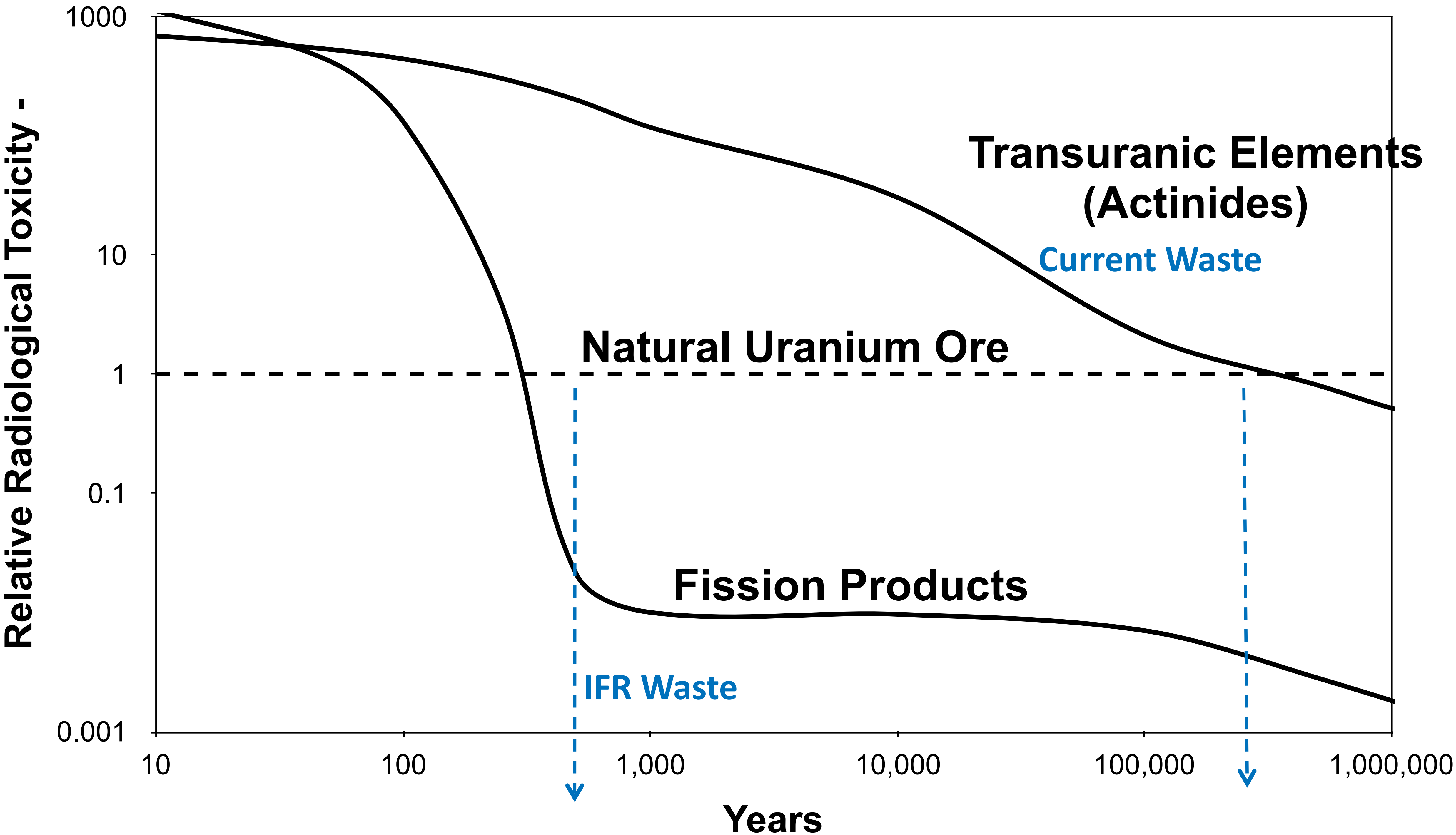
Pyroprocessing provides economic fuel cycle closure and intrinsic proliferation resistance

Pyroprocessing



Aqueous Reprocessing

Radiological Toxicity of LWR Spent Fuel



Pyroprocessing's Intrinsic Proliferation-Resistant Characteristics: Weapons Usability Comparison

	Weapon Grade Pu	Reactor Grade Pu	IFR Grade Actinide
Production	Low burnup PUREX	High burnup PUREX	Fast reactor Pyroprocess
Composition	Pure Pu 94% Pu-239	Pure Pu 65% Pu-fissile	Pu + MA + U 50% Pu-fissile
Thermal power w/kg	2 - 3	5 - 10	80 - 100
Spontaneous neutrons, n/s/g	60	200	300,000
Gamma radiation r/hr at ½ m	0.2	0.2	200

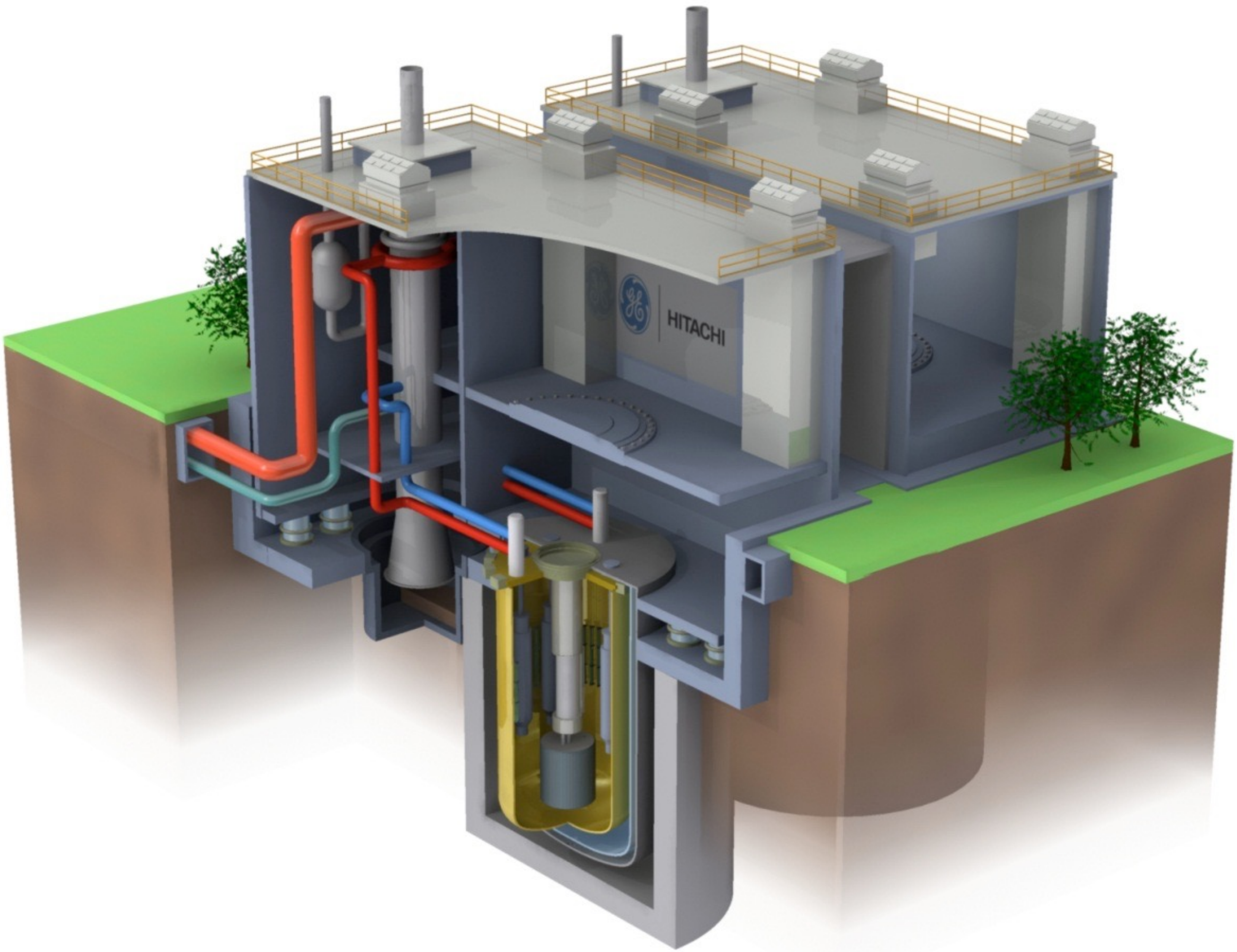
Capital Cost for LWR Pyroprocessing Facility

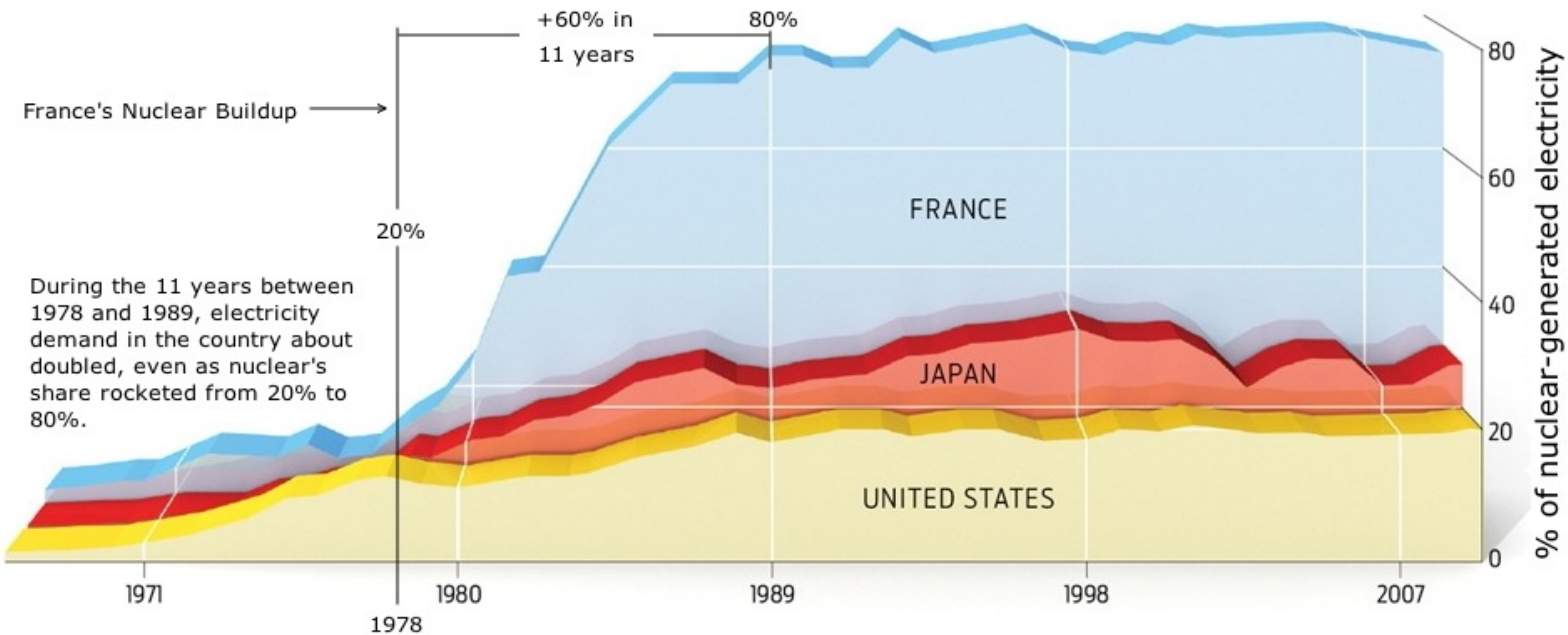
- The capital cost for the 100 ton/yr LWR pyroprocessing is estimated at:

Engineering	100
Construction	120
Equipment systems	100
Contingencies	80
Total	$400 million

- Even if the equipment systems are duplicated without any further scale-up, a commercial scale (800 T/yr) would cost about $2.5 billion, which is an order of magnitude less than equivalent aqueous reprocessing plants.
- The above is a very rough estimate based on experiences of the EBR-II FCF refurbishment (<$50 million) and the Fuel Manufacturing Facility ($4 million).

PRISM




+60% in
11 years
80%
France's Nuclear Buildup
20%
During the 11 years between 1978 and 1989, electricity demand in the country about doubled, even as nuclear's share rocketed from 20% to 80%.
FRANCE
JAPAN
UNITED STATES
% of nuclear-generated electricity
80
60
40
20
0
1971
1978
1980
1989
1998
2007


26285
M-25