

The Bush Administration's Global Nuclear Energy Partnership

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Renewed Congressional interest in reprocessing and recycle...

- In May 2005, the U.S. House of Representatives called on DOE to prepare:
 - “an integrated spent fuel recycling plan for implementation beginning in fiscal year 2007, including...reprocessing, preparation of mixed oxide fuel, vitrification of high level waste products, and temporary process storage”

...driven primarily by concerns about waste disposal

- **Rep. Hobson:** (chair, energy and water appropriations subcommittee)
“The current Yucca Mountain repository will be full to its authorized capacity by the year 2010. If we do not look to recycle our spent fuel, then DOE should start tomorrow to expand [the] Yucca Mountain repository or select a second site.”
“There are new reprocessing technologies that have the potential to minimize...streams of radioactive waste products and also eliminate the presence of separated plutonium.”

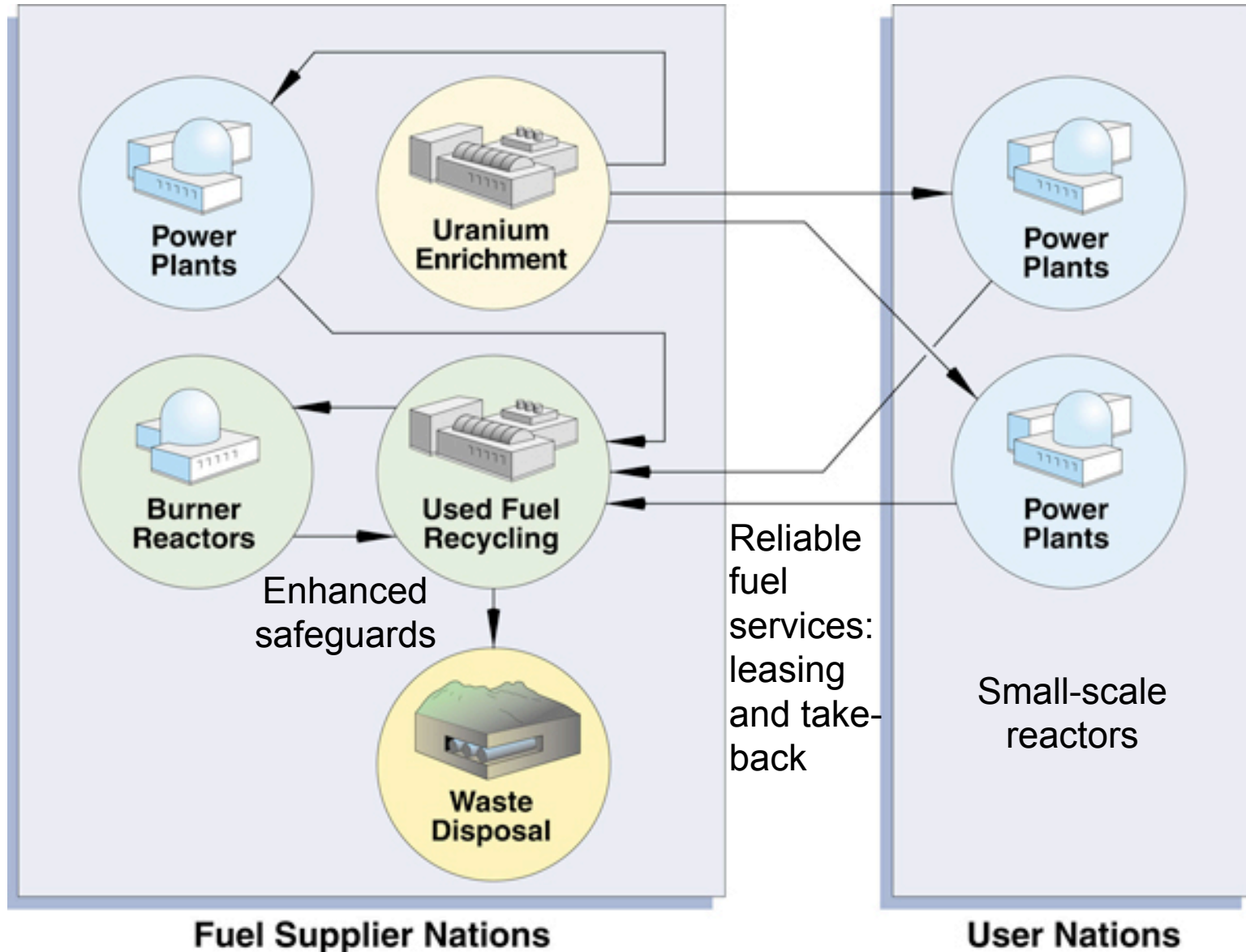
Proliferation concerns as well...

- The situation in Iran has focused attention on the spread of enrichment technology
- Other countries that acquired enrichment technology: Pakistan, Libya, North Korea, Iraq, South Africa, Brazil, Argentina, India, Israel...
- Given that most power reactors use enriched uranium, how can we stop the spread of enrichment technology?
- IAEA expert group report, INFCIRC/640: “Multilateral Approaches to the Nuclear Fuel Cycle” (Feb 2005)

Global Nuclear Energy Partnership

- Announced 6 February 2006 by U.S. Secretary of Energy Samuel Bodman
- Goals:
 - promote global expansion of nuclear energy
 - reduce risk of nuclear proliferation
 - minimize nuclear waste
- \$250 million budget request for FY07
 - \$97 million increase in NE budget over FY06

Global Nuclear Energy Partnership



“Reduce Risk of Proliferation”

- Develop separation processes and fuels that keep Pu mixed with other transuranics (and, perhaps, certain fission products)
- Confine enrichment and reprocessing/actinide recycle to small number of “fuel suppliers”
- Supplier nations provide fuel cycle services to supply all other nations:
 - lease low-enriched uranium (LEU) fuel
 - take back spent fuel for reprocessing (and waste disposal?)

“Minimize Waste”

- Direct disposal and PUREX with recycle in LWRs have similar repository requirements
- ~5x decrease in repository area (per GW-yr of electricity generated) possible if all transuranics are removed from waste
 - transuranics would be fabricated into fast-reactor fuel and transmuted
- ~100x decrease possible if Cs and Sr also removed from waste
 - would require surface storage for ~300 y

GNEP Elements

- Reliable fuel services
 - supplier nations partner to provide, take back fuel
- Advanced reprocessing
 - UREX+ engineering-scale demonstration by 2011
- Advanced burner reactors
 - 100-MW demo reactor by 2014; first commercial in 2022
- Advanced fuel-cycle facility
 - Fuel fab by 2016; aqueous by 2017; pyroproc by 2019
- Enhanced safeguards
 - Advanced materials accountancy and control
- Small-scale reactors
 - 30-350 MW reactors with long-lifetime cores

FY07 Budget Request (million US\$)

UREX+ Engineering-Scale Demonstration	155
Advanced Burner Reactor	25
Advanced Fuel Cycle Facility	20
Separation Technology Development	11
Advanced Fuels Development	9
Transmutation Engineering	6
Systems analysis, education, administration	24
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Total	250

A Critique of GNEP

- Economics
 - increased cost v. LWRs with direct disposal
- Proliferation
 - separation and recycle not as proliferation-resistant as storage/disposal of spent fuel
 - difficult to limit to “approved” fuel-cycle states
- Waste
 - cheaper solutions are available:
 - interim dry-cask storage (short term)
 - expansion of Yucca Mountain (medium term)
 - international disposal (long term)

Increased Cost

- A 1996 NRC study on Separation and Transmutation came to the following conclusion:

“The excess cost for an S&T disposal system over once-through disposal for the 62,000 tons of LWR spent fuel is uncertain but is likely to be no less than \$50 billion and easily could be over \$100 billion if adopted by the United States.”
- Equivalent to additional \$800-1600/kgHM, 2-4 mill/kWh, 4-8% cost of electricity

Increased Cost

- Widespread agreement that reprocessing and recycle is more expensive
- Advocates argue premium is small: 4-8% of COE
 - but total cost is high: \$1.5-3 billion/yr going forward, *plus* \$50-100 billion to reprocess 60,000 tons already discharged
 - who will pay? ratepayers? taxpayers?
- Advocates argue difference will disappear if nuclear power grows and U price increases
 - but premium is likely to persist throughout the century, even if nuclear grows substantially

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THE ECONOMICS OF REPROCESSING VERSUS DIRECT DISPOSAL OF SPENT NUCLEAR FUEL

FUEL CYCLE AND
MANAGEMENT

KEYWORDS: *reprocessing, economics, fuel cycles*

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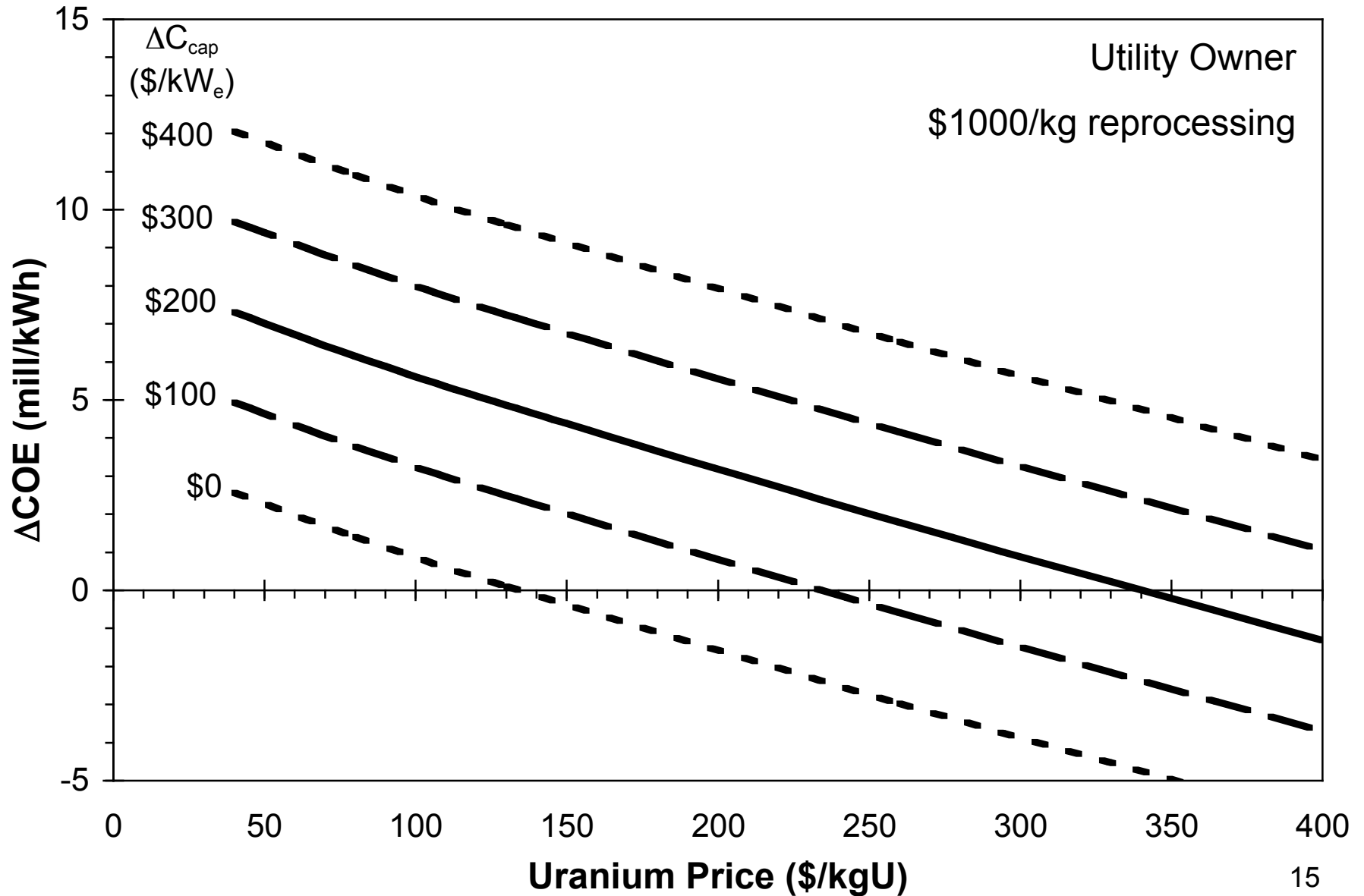
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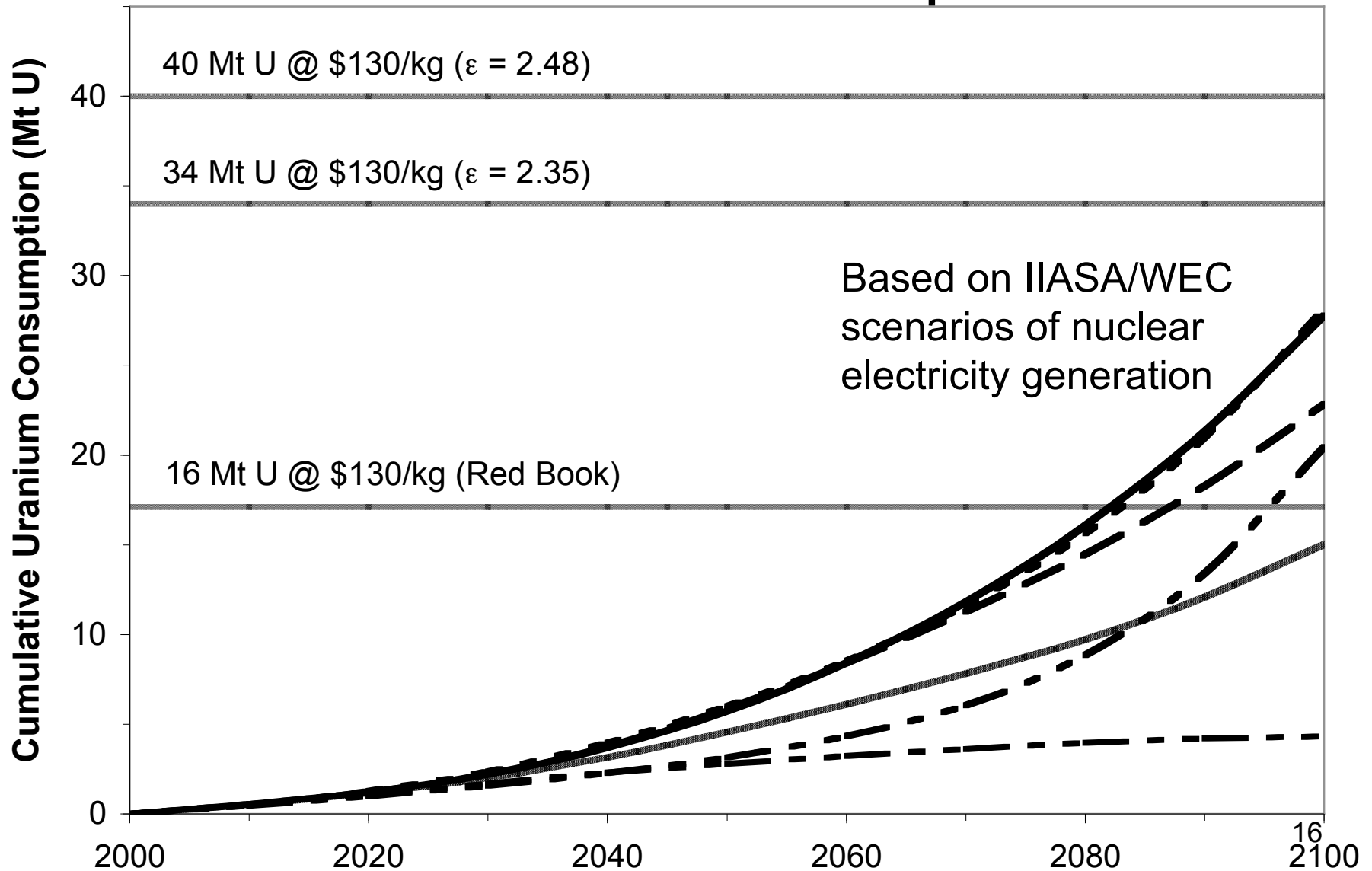
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Premium for Fast Reactors



Cumulative U consumption: LWRs with direct disposal



Proliferation Resistance

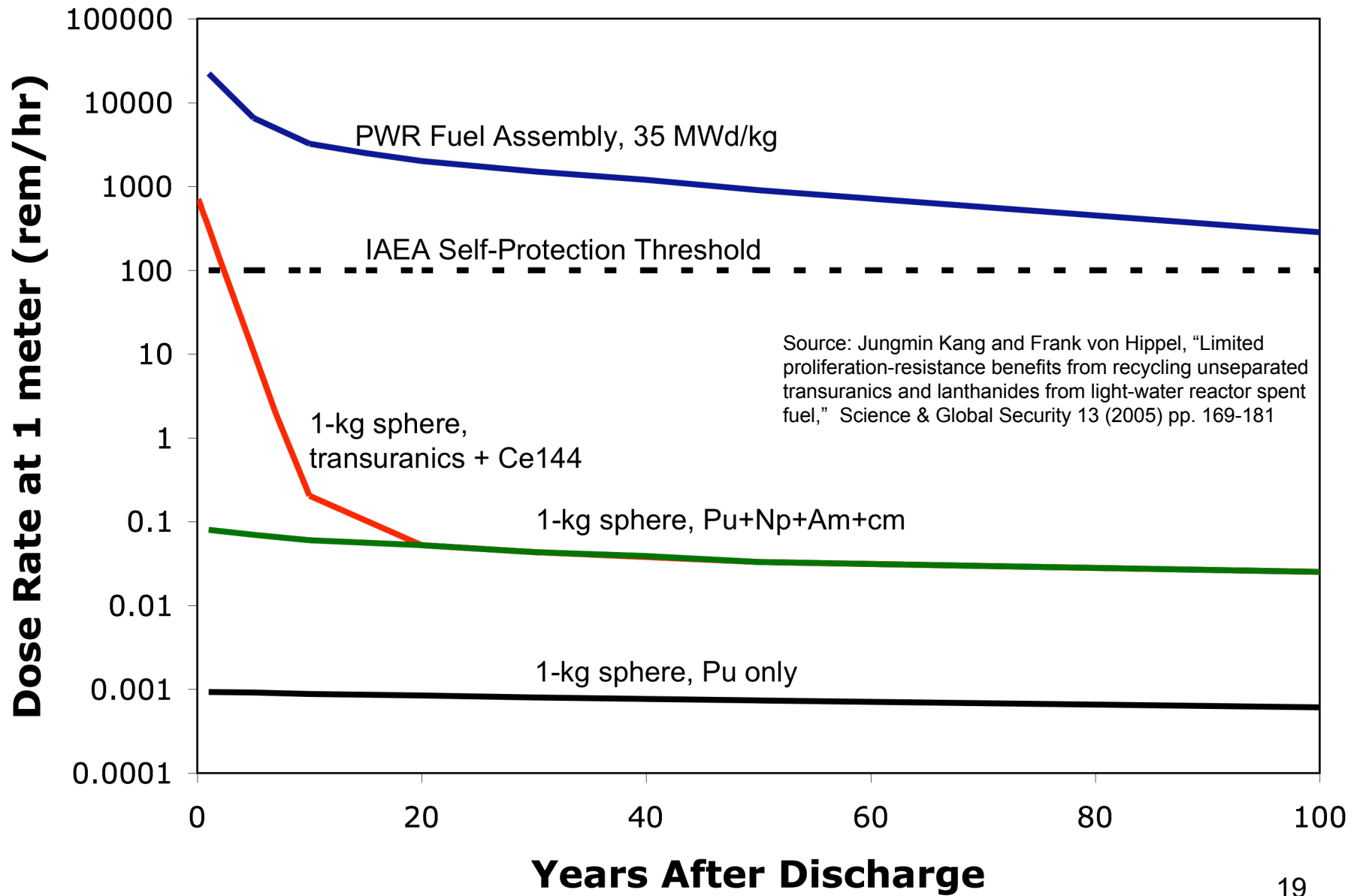
GNEP attempts to achieve increased proliferation resistance in several ways:

- enrichment, reprocessing and recycle are limited to certain “fuel supplier nations”
- supplier nations lease LEU fuel, take-back spent fuel from other nations
- develop proliferation-resistant reprocessing and recycle with enhanced safeguards

Proliferation-resistant R&R?

- Protect Pu by keeping it with gamma emitters
- UREX+: product is mixture of Np+Pu+Am+Cm
 - dose rate 1 meter from 1 kg sphere = ~0.05 rem/h:
~60x more than pure Pu, but 50,000-100,000x less than spent fuel, and 2000x less than IAEA standard (100 rem/h) for self-protection
- Pyroprocessing: product is TRU + REE
 - only potent gamma emitter is Ce-144; dose rate falls below IAEA standard after 2 y; to 0.05 rem/h after 20 y
- Theft of transuranic product (or fresh fuel)
 - TRU can be directly used in weapon or Pu can be separated in glove box using straightforward chemistry

Dose Rates at 1 meter



Reliable Fuel Services

- Leasing fresh fuel, take back spent fuel is good way to discourage enrichment and reprocessing
- Possible today, without reprocessing and recycle in supplier countries
 - storage, direct disposal is cheaper; why would supplier (or user) nations pay premium for transmutation?
- How will division of world into “supplier” and “user” countries be accomplished?
 - voluntary arrangements or binding norm?
 - how will number of supplier states be limited if perceived advantages accrue to suppliers?

Waste Disposal

- Direct disposal and PUREX wastes have about the same required repository area per TWh
 - disposal is cheap: 1 mill/kWh ($\sim 2\%$ COE)
- Recycle of all TRU can reduce repository area by $\sim 5x$, but at 3-5x cost per kWh
 - fast reactors achieve net decrease of $\sim 50\%$ of TRU per cycle, so many recycles are required
 - net burning rate ~ 0.7 tons TRU per GW_ey ; LWRs produce ~ 0.2 tons TRU/ GW_ey , so LWR:ABR $\sim 3:1$
 - 1000 fast-reactor GW_ey needed to burn TRU from U.S. LWR fuel discharged to date

No Waste Disposal Crisis

- No need to rush
 - dry casks provides safe and inexpensive option for 100 years
 - future of nuclear power will be much clearer in 20-30 years
 - plenty of time to available to make decisions about fuel cycle alternatives