Managing Spent Fuel and High-Level Waste: Interim and Long-Term Considerations

Presentation to the Blue Ribbon Commission on America's Nuclear Future

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Overview

- Reprocessing of spent fuel from existing reactors makes no sense, independent of one's views on the future of U.S. nuclear power. It will create huge expenses and risks without solving the waste problem.
- Please get the facts on French and British reprocessing and put them before the public. The present mythologizing about extracting 90 to 95 percent of the "energy value" is harmful, independent of one's views on nuclear power.
- Address interim storage security issues – present storage policies are not adequate. We need open frame, low density pool storage and hardened dry storage on-site.
- Create a path for a scientifically sound repository program. A minimum of ten years of scientific research is needed prior to initiation of a siting process.
- Set a radiation protection standard in advance, such as the 10 millirem per year peak dose used by the National Research Council in 1983.
- An accountable non-DOE institution is needed for development of the repository program.

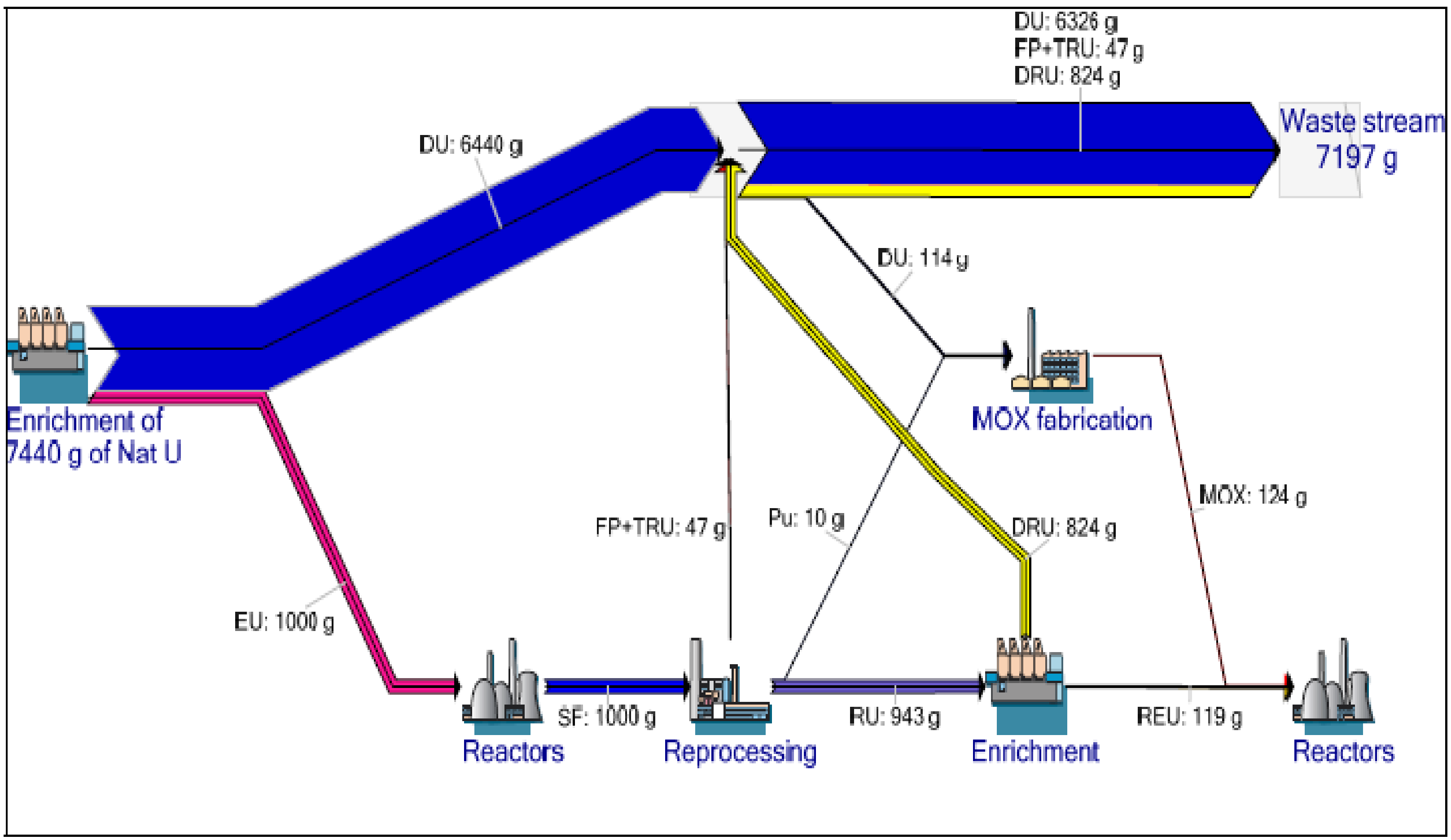
Spent fuel from present U.S. reactor fleet

- There will be ~100,000 metric tons of spent fuel from the existing reactor fleet (exact amount will depend on relicensing)
- It contains ~1,000 metric tons of plutonium, enough for ~12,000 to 14,000 nuclear bombs
- Almost all the heat is in the fission products (~4,600 metric tons). Includes some very long –lived radionuclides.
- U-238 is ~93,000 metric tons – non-fissile
- U-235 is ~700 metric tons
- U-236 is ~500 metric tons – a problem radionuclide
- Rest consists of miscellaneous radionuclides, mainly minor actinides like neptunium

Typical Fresh and Spent Fuel Composition -- PWR

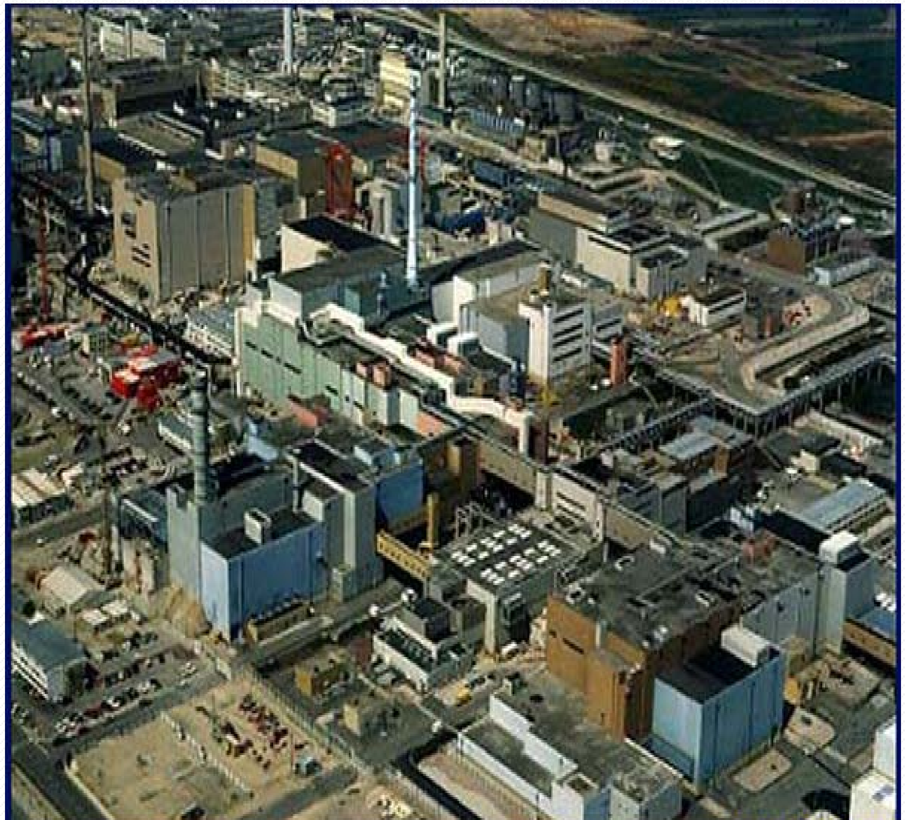
Uranium Isotope	Fresh Fuel	Spent Fuel
Trace U	~0.04	~0.02
U-235	4	0.68
U-236	0	0.52
U-238	96	93.05
Pu isotopes	0	0.99
FP	0	4.62
Non-Pu-TRU	0	0.095

LWR uranium resource use – necessarily less than ~1 percent even with repeated reprocessing



Reprocessing in France (and Britain)

- Most recovered Pu used as fuel; yet ~over 50 metric tons equivalent surplus French Pu, plus other countries' Pu stored there
- Cost: ~two cents per kWh more for electricity generated from MOX. Total ~$1 billion per year (2008$).
- MOX spent fuel will have to be managed and, most likely, disposed of.
- Liquid high-level waste storage creates significant unnecessary risks
- 100 million liters of liquid radioactive waste into English Channel per year, polluting ocean all the way to the Arctic.
- 11 of 15 OSPAR parties voted to voted to urge Britain and France stop reprocessing
- Britain has used none of its reprocessed plutonium.
- Both need repositories. Public opposition has been intense even in France.
- Ask Britain and France officially for their data.
- Reprocessing is continuing due to policy inertia and largely government-owned companies, not for economics.



(Credit COGEMA)

View of the COGEMA-La Hague reprocessing plant, France

LWR System Radwaste volumes (m^3) with and without reprocessing

System	Spent fuel or High-level waste	GTCC waste	Total repository waste	Low-level waste	Annual radiological transports (rail plus truck)	Comments
LWR once-through	70,990	2,500	73,490	150,000 to 585,000	165,000	
LWR with reprocessing	52,000	407,000	459,000	1,740,000 to 2,175,000	1,224,000	~100 million liters of liquid radioactive waste reprocessing discharges per year (Note 2)
Ratio with/without reprocessing	0.73	163	6.2	3.7 to 11.6 (max to max and min to min)	7.4	

Source: DOE/EIS-0396 GNEP Draft Table 4.8-6 (p. 4-139)

Breeder reactor issues

- Sodium-cooled breeders have the highest breeding ratio, a major reason for RD&D focus on this design approach.
- No discernible learning curve after six decades and ~$100 billion. Superphénix and Monju, latest demonstration plants, have among the worst records. The extensive problems are well-documented.
- Trying to use all or most reprocessed uranium-238 as a resource in breeders would be prohibitively costly - $8 trillion and ~100,000 reactor years for the U.S. alone at an excess cost of just 1 cent per kWh. It would take hundreds of years to do it.
- Reprocessing no sense from a resource point of view either – depleted uranium is a better quality, much lower cost, and much larger resource for conversion to Pu-239 in breeders. Far more than enough is already available.

Interim management policy

- Direct disposal of spent fuel decision should be maintained. Reprocessing existing spent fuel plus repository development would increase waste management costs and risks considerably.
- Low-density, open-frame, spent fuel pool storage
- Move as much spent fuel as possible to hardened dry storage.
- Store spent fuel on-site or as close to the site as possible (if safety considerations preclude on-site storage for extended periods)
- Moving spent fuel to centralized storage while reactors are operating needlessly increases risks.

Basic geologic isolation system

Three elements of an isolation system:

- Spent fuel, containers, engineered barriers
- Repository backfill and sealing system (including shaft and drift sealing)
- Host rock and geologic setting

Each element must be evaluated. Natural analogs for materials have been studied and need more attention. All elements must work together for containment and to provide redundancy. For instance, metal containers in an oxidizing environment, as in Yucca Mountain, invite problems. Metal containers in a reducing environment, as in Sweden, provide a sounder approach.

Long-term management process: step 1

- Initiate a decade of scientific research on various combinations of the three elements of geologic isolation prior to any siting process directed at specific sites.
- Set a radiation protection standard independent of the site and before site selection process begins. The 1983 National Research Council Report on geologic isolation used a 10 millirem per year peak dose (i.e., maximum dose at any time in the future) as the basis for its assessment. While a standard for a million years is not enforceable in the same sense as regulations are in the present (since the repository will be closed in a far shorter time), a dose limit similar to that used by in the 1983 report is an indication of the present commitment to protect future generations as we do ourselves today and should be set in advance of the siting process.
- Yucca Mountain standard setting process was poor – when site could not meet the proposed standard, a new standard was mandated, instead of a new site. 40 CFR 191 is a problem too – it does not limit peak dose.
- Create an independent (non-DOE) institution with effective oversight, including from state, local, and tribal governments, for the development and implementation of the geologic isolation system

Long-term management step 2

- Create siting criteria and process that puts science first.
- Politicizing the site selection only compounds the great difficulties. Yucca Mountain, R.I.P, except for lessons learned.
- Thorough underground research should be done at laboratory sites that are NOT repository locations on combinations of containers, engineered barriers and sealing systems will reduce uncertainties in estimating future impact. Sweden did 25 years of such research.
- Economic incentives should not be a part of the process until technical issues are settled. Putting incentives first will likely result in environmental injustice.
- The history of attempting incentives in the United States is not promising – all attempts have failed so far. The lesson: focus on the science.

“America’s nuclear future”?

- Breeders cannot make a significant contribution to addressing the climate problem since most of CO_2 reduction must be achieved in 30 years or less
- Even advanced reprocessing technologies have significant proliferation risks – not much less than PUREX, according to a study published by Brookhaven National Laboratory.
- Japan’s commercialization date for sodium-cooled breeders is now 2050. If we are going to develop long-term technologies, it is much better to focus on nuclear fusion, which has almost none of the disadvantages of fission.
- Use of RD&D resources for advanced nuclear technologies should be compared to effectiveness of using them for efficiency and renewables prior to a recommendation on what, if any, nuclear fission RD&D to pursue.

Resources

- **Reprocessing**: Arjun Makhijani, *The Mythology and Messy Reality of Nuclear Fuel Reprocessing*, IEER, 2010. http://www.ieer.org/reports/reprocessing2010.pdf
- **Reprocessing proliferation risk**: R.Bari et. al, *Proliferation Risk Reduction Study of Alternative Spent Fuel Processing*, Brookhaven National Laboratory, July 2009, http://www.bnl.gov/isd/documents/70289.pdf
- **Breeders**: Breeders: T. Cochran et al., *Fast Breeder Reactor Programs: History and Status,* IPFM, 2010, http://www.fissilematerials.org/blog/rr08.pdf
- **Transmutation**: H. Zerriffi and Annie Makhijani, *The Nuclear Alchemy Gamble*, IEER, 2000, http://www.ieer.org/reports/transm/report.pdf
- **Interim storage**: Principles for Safeguarding Waste at Nuclear Reactors, signed by well over 100 groups.
- **French Repository Program**: Disposal of Highly Radioactive Wastes in France: An IEER Evaluation, http://www.ieer.org/sdafiles/13-4.pdf
- **Renewable energy system**: Arjun Makhijani, *Carbon-free and Nuclear-Free: Roadmap for U.S. Energy Policy*, IEER, 2008. Free download at http://www.ieer.org/carbonfree/CarbonFreeNuclearFree.pdf