INSTITUTE FOR ENERGY AND ENVIRONMENTAL RESEARCH

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TOO HOT TO HANDLE: MANAGING RADIOACTIVE WASTE IN THE UNITED STATES

For

Hanford Challenge Nuclear Waste Scholar Series

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Types of waste problems

- Military and civilian
- Process producing the waste
  - **Uranium mining and milling**
  - Uranium processing into fuels
    - Depleted uranium
  - **Reactor spent fuel**
  - **Reprocessing (plutonium separation) – military and civilian**
  - Reactor "low-level" wastes
  - Bomb production wastes – transuranic, "low-level"
  - Greater-than-Class-C waste
  - Decommissioning wastes
- Longevity
- Health and ecosystem risks – amount, composition, and form of the waste
- Security risks

Uranium mine, grants, New Mexico, ca. 1968
~200 million tons or more mine wastes in the US. ~85% of nuclear fuel uranium is imported – so now most mine waste is abroad

Source: DOE, on Wikimedia Commons at https://commons.wikimedia.org/wiki/File:HD.11D.063_(14740428290).jpg

Radium and acid leaking into San Miguel River Colorado, 1972. >200 million metric tons of mill tailings

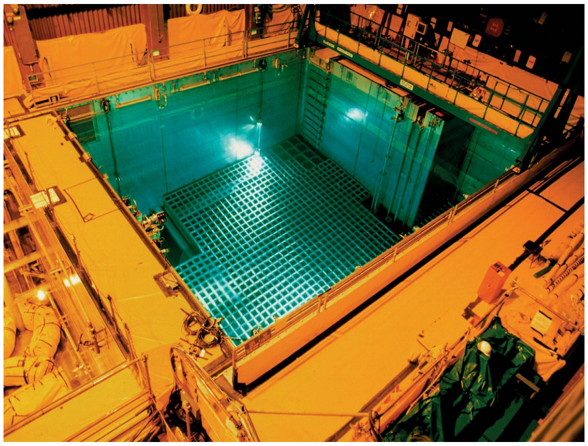
Photographer, Bill Gillette, Source:EPA on Wikimedia Commons at https://commons.wikimedia.org/wiki/File:ACID_AND_RADIUM_226_LEAKING_FROM_URANIUM_MILL_TAILINGS_POND_INTO_THE_SAN_MIGUEL_RIVER_-_NARA_-_543771.jpg

~500,000 metric tons of depleted uranium and also now munition wastes scattered in the US and war zones. DU cylinders (14 t each). DU being converted from fluoride to oxide (to stabilize)

Source: U S DOE on Wikimedia commons at https://commons.wikimedia.org/wiki/File:OR14_211_(27100882232).jpg

Spent fuel storage. Total ~90,000 metric tons

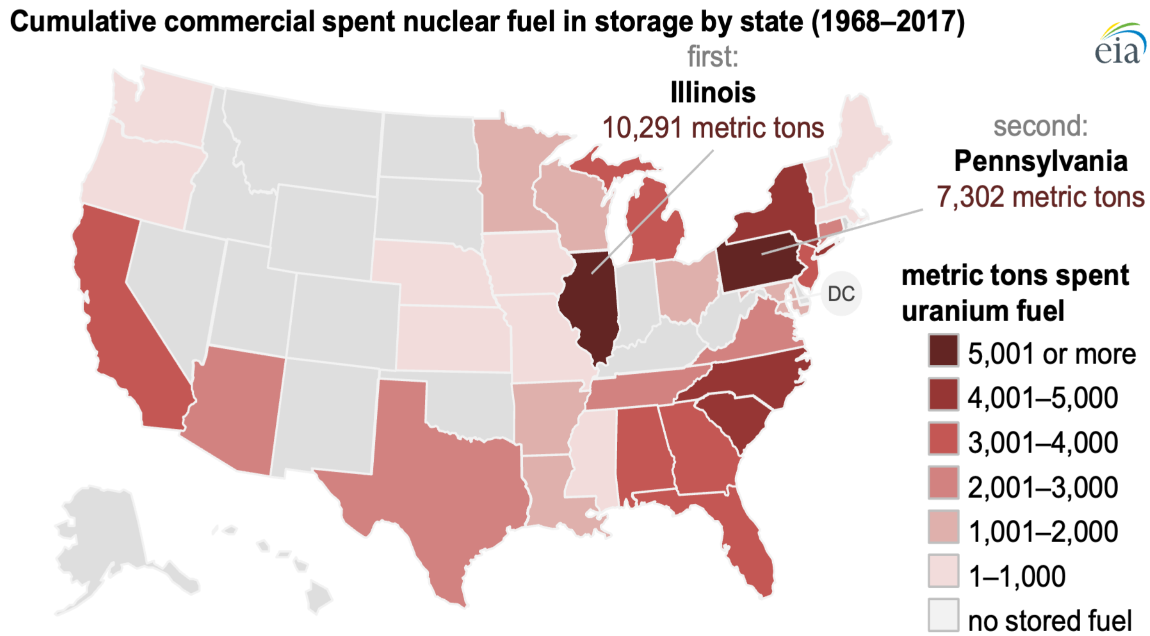
San Onofre Spent Fuel Pool



Dry cask storage

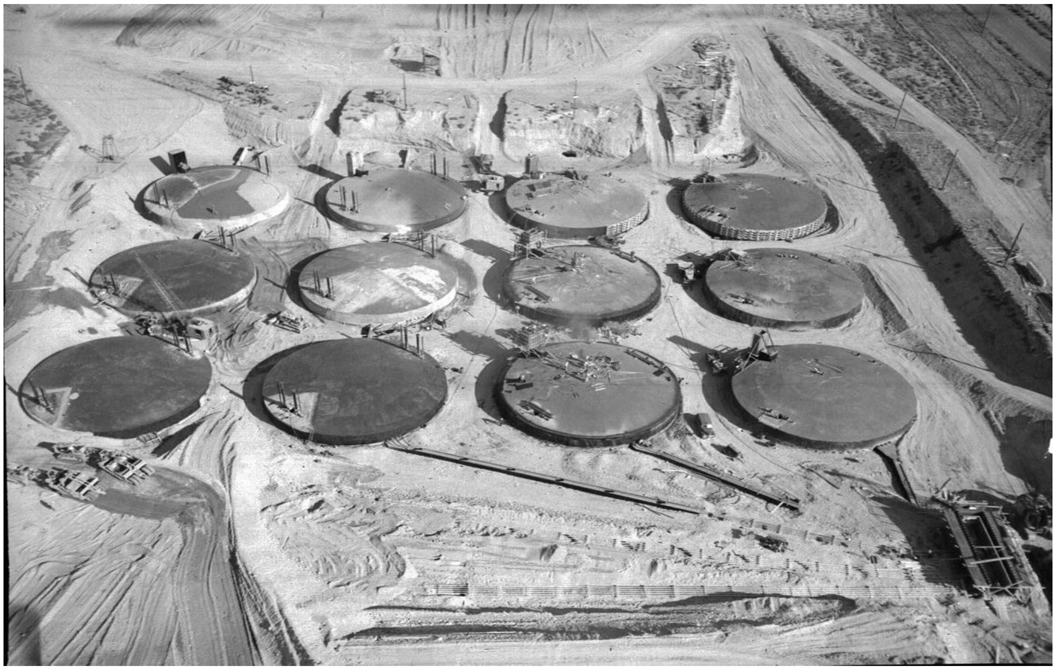
Sources: NRC, Wikimedia Commons at https://commons.wikimedia.org/wiki/File:San_Onofre_Nuclear_Generating_Station_spent_fuel_pool,_2014.jpg and

2022 inventory ~90,000 metric tons, adding ~2,000 metric tons/year



Source: EIA at https://www.eia.gov/todayinenergy/detail.php?id=47796

High-level wastes. Hanford, SRS, Idaho (all different situations)



Source: US DOE on Wikimedia commons at https://commons.wikimedia.org/wiki/File:Hanford_tank_farm.jpg

Fresh reactor fuel and spent fuel, recent typical values for 4% U-235 fuel, 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

Overall situation as of 2022

90,000 metric tons contain

- 800 metric tons of plutonium, ~10,000 to 15,000 nuclear bombs
- Almost all the heat is in the fission products (~4,000 metric tons). Includes some very long –lived radionuclides: I-129, Tc-99, Cs-135 and billions of curies of Sr-90 and Cs-137 (~28 and 30-y half-life)
- Long lived transuranic radionuclides, neptnium,-237, plutonium-239, plutonium-240 (total
- U-238 is ~82,000 metric tons – non-fissile
- U-235 is ~700 metric tons
- U-236 is ~400 metric tons – a problem radionuclide
- Rest consists of miscellaneous radionuclides, mainly minor
- Actinides like neptunium
- Short-term: Need hardened on-site storage (HOSS)

Reprocessing wastes

- Stop reprocessing and don't restart. Civilian: high-level vitrified waste volume ~0.7 times spent fuel. But repository volume, include transuranic and long-lived Greater than Class C waste ~7 times spent fuel. Plus proliferation risk.
- More separated civilian Pu than in all the nuclear weapons in all nuclear weapon states
- Hanford is a mess. I feel like Bernard Shaw who came to the United States in the middle of the Great Depression and a reporter asked "what should we do?" And he said: "I told you the last time I was here and you haven't done it."
- I told the DOE ca. 1998 what to do and they did not do it. I'll recount that for you.

Reference: Containing the Cold War Mess, IEER, 1997, at http://ieer.org/wp/wp-content/uploads/1997/10/ccwm.pdf

High-level waste isolation system

- Long-term on-site storage risks – environmental are orders of magnitude more than repository: loss of river basis, coastal ecosystems, lake ecosystems and severe security risks
- No "good" solution, deep geologic isolation is the least bad by far.
- 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.

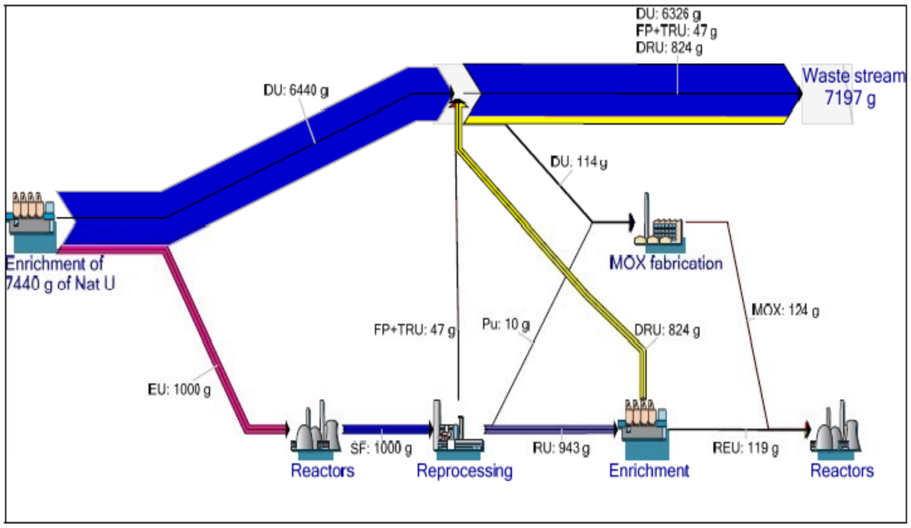
Consent must be informed. A necessary **precondition**: sound science

- 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

Q & A

SUPPLEMENTARY SLIDES

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



IEER diagram

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)

Dry storage NUHOMS casks, San Onofre Nuclear Generating Station

Figure V.1-1: NUHOMS® horizontal dry storage systems at San Onofre.

http://sanonofresafety.files.wordpress.com/2013/06/nuhomsdrystoragesystemsanonofre.jpg; DOE photo.

Federal repository history

- Early failure: Lyons. Kansas
- 1979 – Preferred path for high-level waste and spent fuel is a repository – Interagency task Force
- 1982 - Nuclear Waste Policy Act
- 1982-1986: A process marked by dismal decisions in the West and ending a political cancellation (after a meeting in the White House with then Vice President Bush's staff) of the second repository in the East.
- 1987: a political choice of Yucca Mountain, estimated in 1983 to be possibly the worst site (by the National Academies), though they did not say so in words – but estimates in the 1983 report indicated highest does likely at Yucca Mountain: limited groundwater and no surface water for dilution (among other reasons).
- Changing standards when Yucca Mountain deficiencies become evident (both EPA and NRC)
- Since 2009 - Present impasse with Yucca Mountain in legal limbo, taxpayers paying for storage, and no path forward.
- 2012: Court says NRC does not have a valid waste confidence document. Now NRC has a bizarre "continued storage" rule – saying storage on surface would be safe essentially forever.
- Note: The Department of Energy has never met a repository it did not like since the 1960s.
- 2014: WIPP (Waste Isolation Pilot Project - in NM) fire – not anticipated and hence no preparation for response.

Yucca Mountain in Nevada was to be the US geologic repository. $15 billion has been spent, but President Obama halted further development of Yucca Mountain. The site has never opened.
Deaf Smith County in Texas was a candidate for a repository before Yucca Mountain was chosen, but farmers and ranchers in the Panhandle fought the proposal due to concerns about water contamination