NUCLEAR WASTE DISPOSAL (44)

I Main topics
  A Types of nuclear waste
  B Disposal options
  C Experience of different countries in nuclear waste disposal
  D U.S. approach to nuclear waste disposal

II Types of nuclear waste

  http://www.nrc.gov/waste.html

  A High-level (HLW): waste from spent or reprocessed fuel
    1 Require heavy shielding
    2 10.2×10^6 ft^3 + 0.085×10^6 ft^3 (Since 1980)
    3 10^0-10^2 m^3 per 1000 MW reactor/year (Milnes, 1985)
    4 In form of liquids, solids, sludge, and "cakes" (powder)
    5 Main concern: ^{239}Pu; $\tau \approx 24{,}000$ years
  B Transuranic (TRU): man-made radioactive elements (e.g., plutonium)
    1 26×10^6 ft^3 + 0.025×10^6 ft^3 (Since 1980)
    2 α-particle emitters (particularly injurious to cell tissue)
    3 Main concern: ^{239}Pu; $\tau \approx 24{,}000$ years
  C Low-level (LLW) not high-level, not uranium mill tailings;
    less than 10 nanocuries of TRU (e.g., contaminated clothes)
    1 Do not require heavy shielding
    2 10^3-10^5 m^3 per 1000 MW reactor/year (Milnes, 1985)
    3 Main concern: ^{90}Sr and ^{137}Cs; $\tau \approx 30$ years
    4 Mostly β-particle emitters
    5 Main disposal options
      a Shallow burial
      b Dumping at sea
      c Liquid injection
      d Grout injection (Oak Ridge)

III High-level waste disposal options

	Pros	Cons
Geologic Disposal	• Detailed characterization • Many rock types theoretically OK	Political factors: • Unstable funding • Bureaucratic control • Expediency can outweigh science • "NIMBYism"
Crystalline basement rocks (e.g., granites and gneiss)	Rocks are strong Permeability is low	Fracture flow Nearby mineral wealth
Volcanic rocks (e.g., basalt and tuff*)	Rocks strength Permeability is low Chemical sorption	Fracture flow High variability of basalt
Shale or clay	Low permeability	Rock strength
Salt	Low permeability Fractures heal	Can dissolve
Deep borehole Injection	Relatively inexpensive On-site disposal	Liquefied waste Fractures
Deep Underground melting	Relatively inexpensive On-site disposal	Before solidifying, melt is highly mobile Fractures
Icebed disposal	Remoteness	Climate change Antarctic Treaty of 1959
Seabed disposal	Low permeability rock Dilution Remoteness	Access to biosphere Biologic concentration of radioactivity Law of the Sea
Extra-terrestrial disposal	Permanent disposal	Rocket failure Loss of an energy resource

IV Experience of different countries in nuclear waste disposal
- A Need to be self-dependent requires use of a variety of rocks
- B Sweden
  - 1 Decouple politics from site selection
- C Switzerland
  - 1 Great openness after initial concealment of program
  - 2 Variety of sites being examined
- D Canada
  - 1 Crystalline rock sites being examined
  - 2 Has Underground Rock Laboratory

V U.S. approach to nuclear waste disposal
- A Definition of acceptability
  - 1 No more than 1,000 cancer deaths in the next 10,000 years; emphasis on travel time to biosphere
  - 2 Legal criterion, not a "scientific" or "engineering" criterion
  - 3 10,000 year standard
    - a How the human race will evolve in 10,000 years?
    - b Geologic time frame for an "engineering" problem
    - c Pushes limits of our predictive ability
- B Detailed standards set; Earth treated like an engineering material
- C Quality assurance
  - 1 Provides detailed “paper trail” of work
  - 2 Tends to put technical control in hands of bureaucrats
- D Yucca Mountain; DOE site
  - 1 Selection process
  - 2 Key geotechnical issues:
    - a Tectonic activity (seismicity and volcanism)
    - b Fracture hydrogeology and hydrogeochemistry of tuff

E Alternative sites

1 Hanford, Washington (basalt); DOE site
  Key geotechnical issues: fractures in basalt, catastrophic floods, high variability in sedimentary sequences

2 Deaf Smith County, Texas (salt)
  Key geotechnical issues: Ogallala aquifer

3 WIPP (Carlsbad, New Mexico)
  Key geotechnical issues: gas pressure, salt dissolution, fractured dolomite above repository

<u>References</u>

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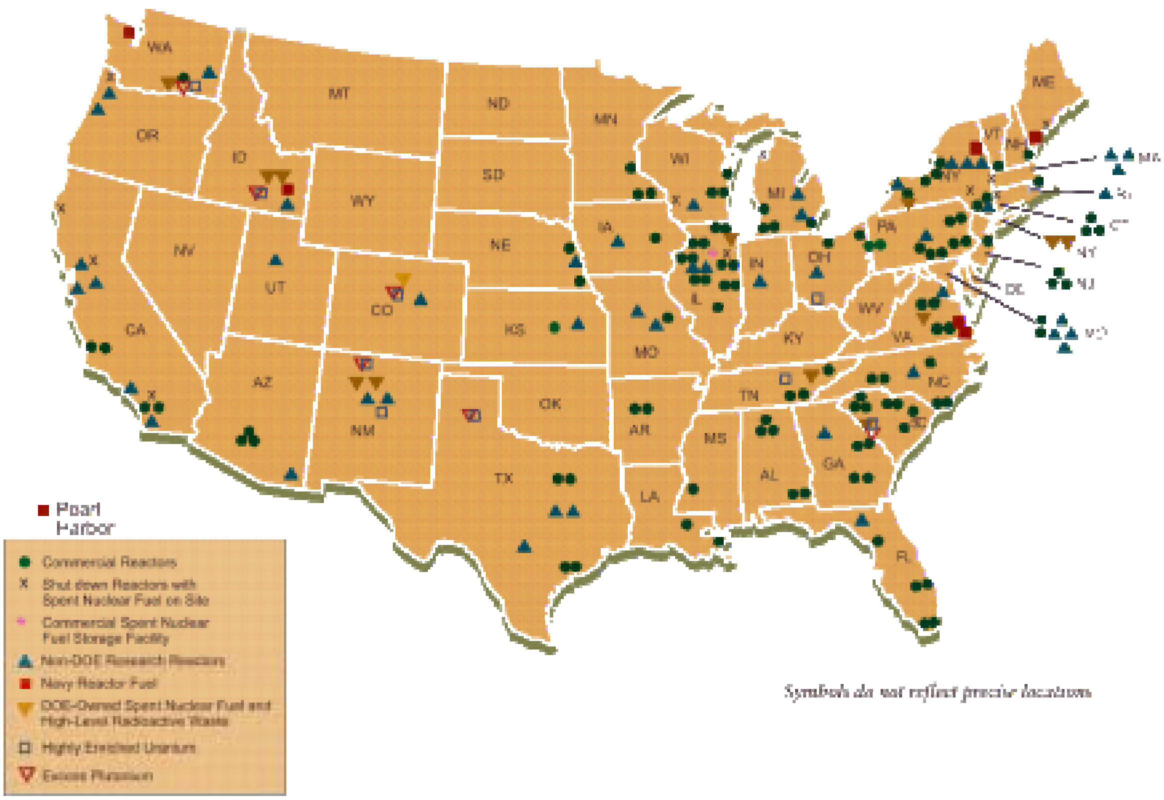
Selected Country Programs for High-Level Waste Burial
http://www.platts.com/features/nukewastedisposal/index.shtml

Country	Earliest Planned Year	Status of Program
Argentina	2040	Granite site selected at Gastre, Chubut
Canada	2020	Independent commission conducting four-year study of government plan to bury irradiated fuel in granite at yet-to-be-identified site
China	none	Irradiated fuel to be reprocessed; Gobi desert sites under investigation
Finland	Construction to begin in 2003-2004.	The Finnish Parliament May 18 2001 decided on a permanent disposal site for HLW in Olkiluoto, Eurajoki. Operation of the facility will start in 2020.
France	2010	Three sites to be selected and studied; final site not to be selected until 2006
Germany	2008	Gorleben salt dome sole site to be studied
India	2010	Irradiated fuel to be reprocessed, waste stored for 20 years, then buried in yet-to-be-identified granite site
Italy	2040	Irradiated fuel to be reprocessed, and waste stored for 50-60 years before burial in clay or granite
Japan	2020	Limited site studies. Cooperative program with China to build underground research facility
Netherlands	2040	Interim storage of reprocessing waste for 50-100 years before eventual burial, possibly in another country
Sweden	2020	Granite site selected in 1997; evaluation studies under way at Aspo site near Oskarshamn nuclear complex
United States	2010	Yucca Mountain site being studied. Will receive 70,000 tons of waste if approved
United Kingdom	2030	Fifty-year storage approved in 1982; exploring options for permanent disposal

Locations of Spent Nuclear Fuel and High-Level Radioactive Waste Destined for Geologic Disposal



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