Sandia National Laboratories

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Current Status of Spent Nuclear Fuel Management in the U.S.

PRESENTED BY

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Outline

- Status of the US program
- Options for geologic disposal in the US and other nations
- Discussion of the interface between repository science and social science

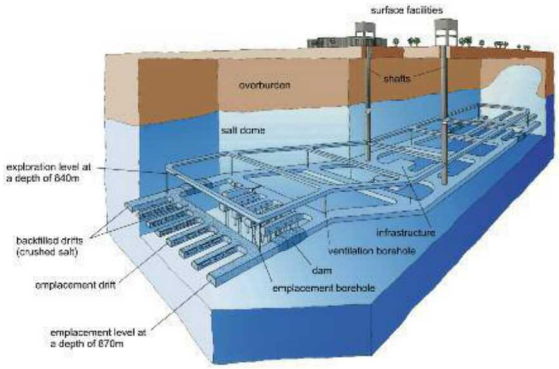
Spent Nuclear Fuel and High-Level Radioactive Waste Disposal: The Goal

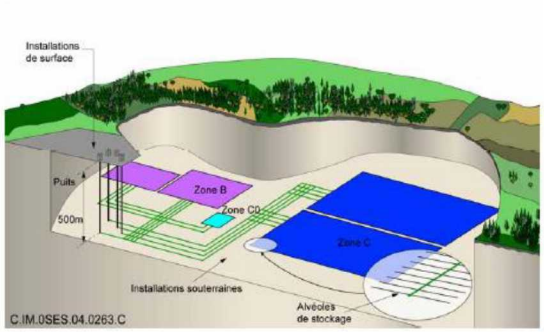
"There has been, for decades, a worldwide consensus in the nuclear technical community for disposal through geological isolation of high-level waste (HLW), including spent nuclear fuel (SNF)."

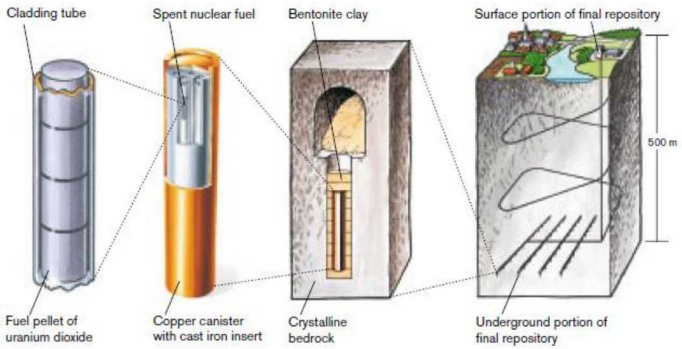
"Geological disposal remains the only long-term solution available."

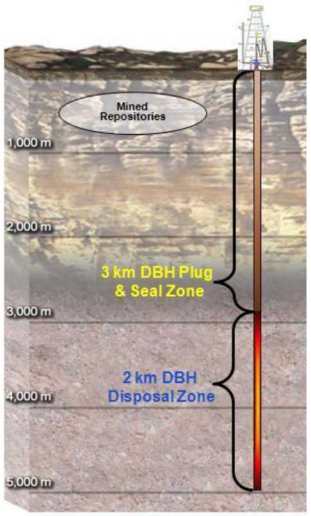
National Research Council, 2001

Deep geologic disposal has been planned since the 1950s





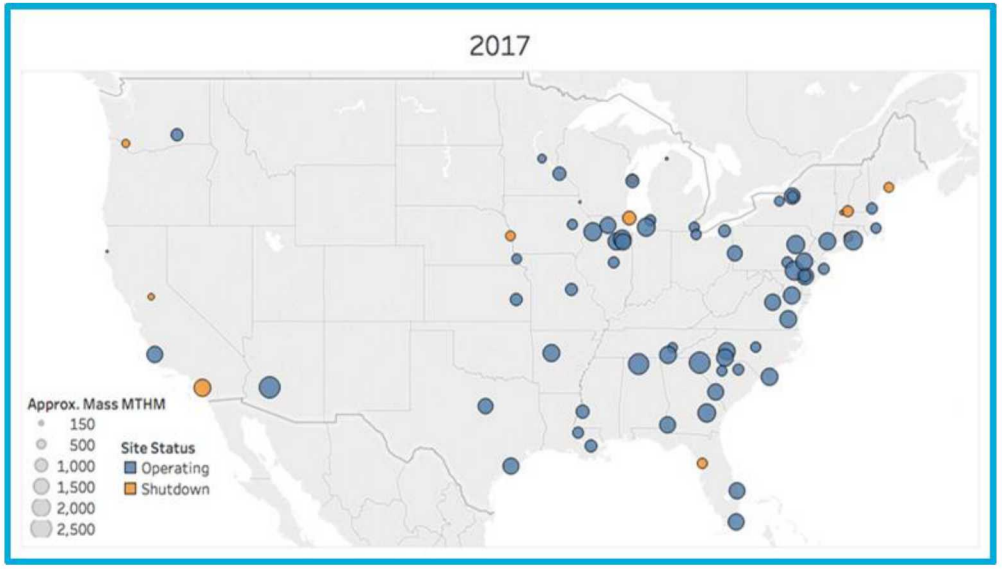




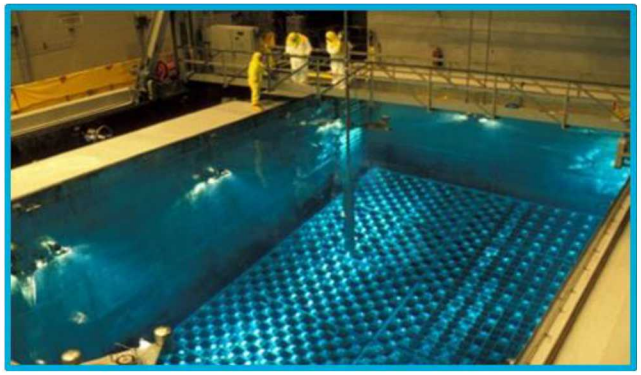
Geologic Disposal in the US: The Reality

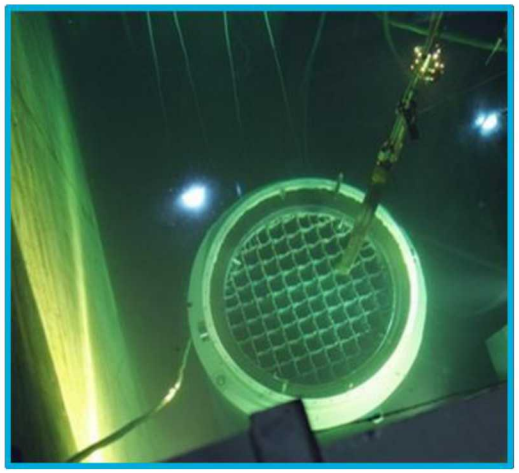
Commercial SNF is in Temporary Storage at 75 Sites in 34 States

- Pool storage provides cooling and shielding of radiation
  - Primary risks for spent fuel pools are associated with loss of the cooling and shielding water
- US pools have reached capacity limits and utilities have implemented dry storage
- Some facilities have shutdown and all that remains is "stranded" fuel at an independent spent fuel storage installation (ISFSI)



Map of the US commercial SNF storage from Bonano et al. 2018



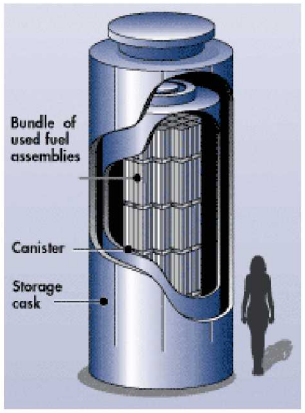


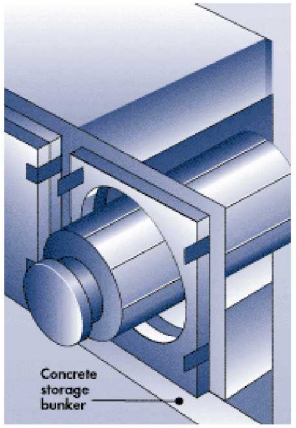
Dry Cask Storage System Terminology

Dry Cask Storage Systems (DCSSs) include:

- Dry cask/canister storage systems using dual purpose canisters (DPCs) that are certified for both storage and transportation (right-hand photographs)
  - The welded stainless steel DPC is placed in a concrete and steel overpack (vertical cask or horizontal bunker) for shielding and protection during storage. The DPC is removed from the storage overpack and placed in a shielded transportation cask for transport.
  - Vertical DPC designs can be above or below grade
- "Bare fuel" casks with bolted lids, integral shielding and no overpack, available in cast iron and forged steel designs (bottom left photograph)
  - Few sites in the U.S. continue to load these systems

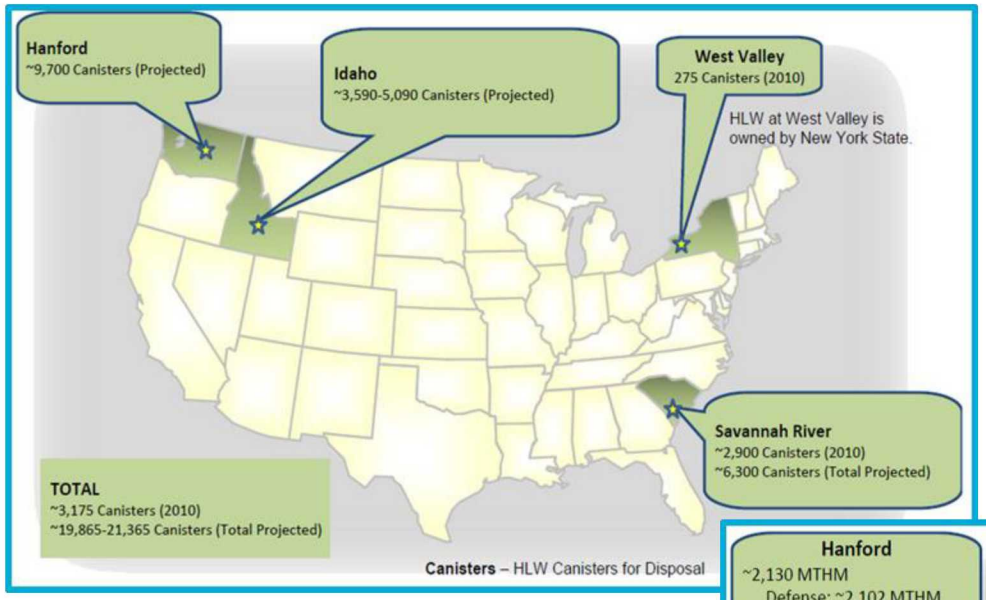
Multiple vendors provide NRC-certified dry storage systems to utilities





Geologic Disposal in the US: The Reality (cont.)

DOE-managed SNF and HLW is in Temporary Storage at 5 Sites in 5 States

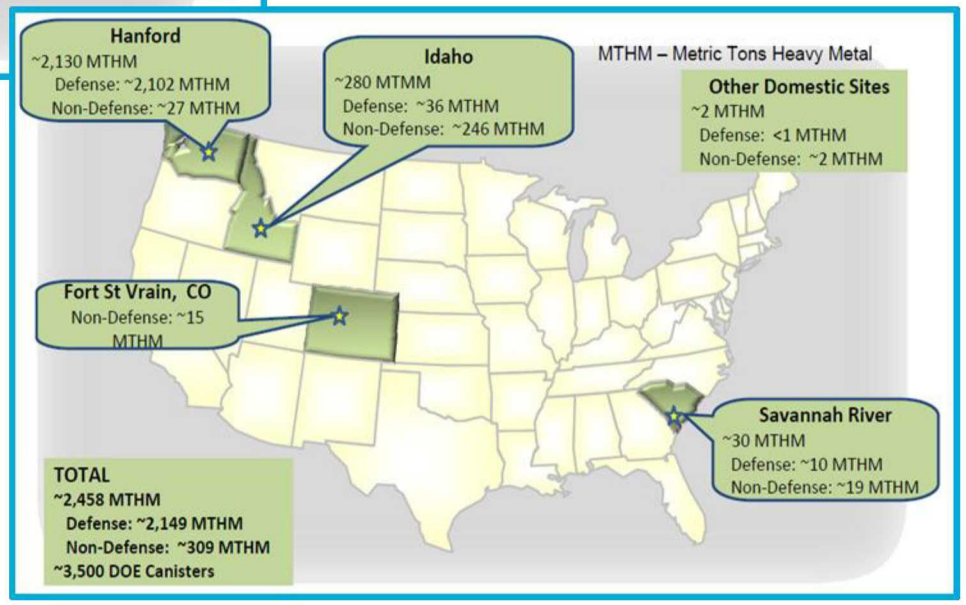


DOE-Managed HLW

~20,000 total canisters (projected)

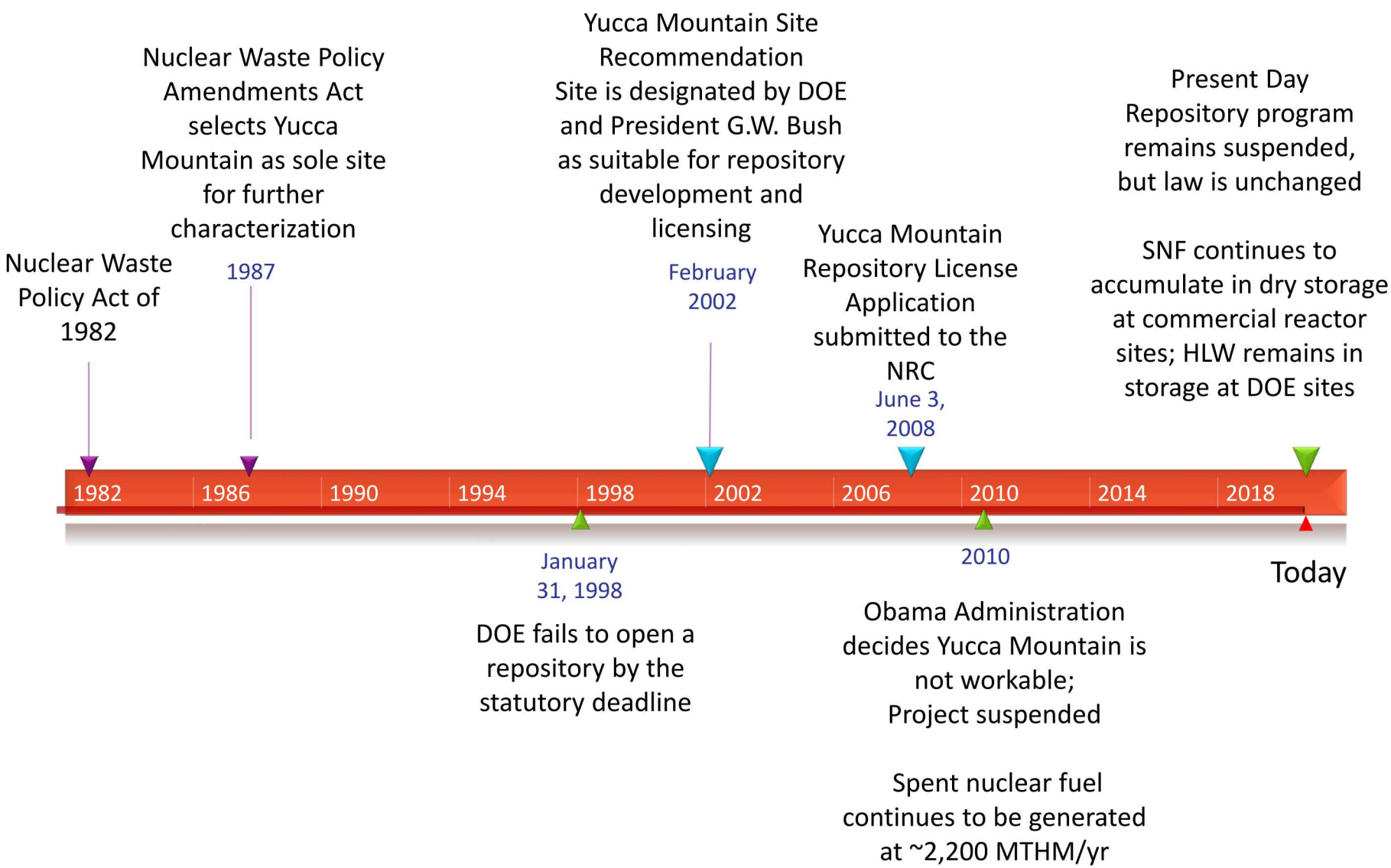
DOE-Managed SNF

~2,458 Metric Tons



Source: Marcinowski, F., "Overview of DOE's Spent Nuclear Fuel and High-Level Waste," presentation to the Blue Ribbon Commission on America's Nuclear Future, March, 25, 2010, Washington, DC.

Timeline of the U.S. Repository Program

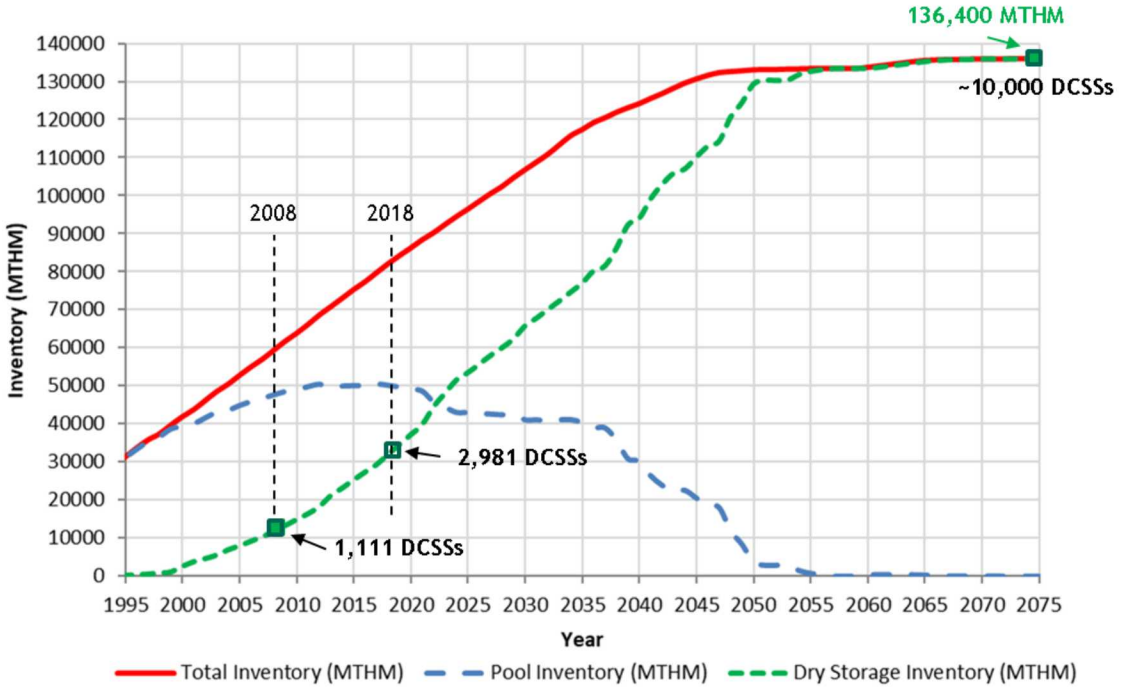


Current Status of the US Program

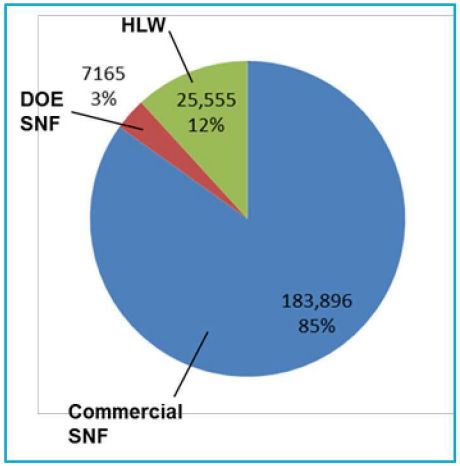
- **2008**: Yucca Mountain Repository License Application submitted
- **2009**: Department of Energy (DOE) determines Yucca Mountain to be unworkable
- **2010**: Last year of funding for Yucca Mountain project
- **2012**: Blue Ribbon Commission on America's Nuclear Future completes its recommendations, including a call for a consent-based process to identify alternative storage and disposal sites
- **2013**: Federal Court of Appeals orders Nuclear Regulatory Commission (NRC) to complete its staff review of the Yucca Mountain application with remaining funds
- **2015**: NRC staff completes Yucca Mountain review, finds that "the DOE has demonstrated compliance with the NRC regulatory requirements" for both preclosure and postclosure safety
- **2015**: DOE begins consideration of a separate repository for defense high-level wastes and initiates first phase of public interactions planning for a consent-based siting process for both storage and disposal facilities. (Both activities terminated 2017.)
- **2016-18**: Private sector applications to the NRC for consolidated interim storage (Waste Control Specialists [now Interim Storage Partners] in Andrews, TX and Holtec in Eddy/Lea Counties, NM)
- **2019**: Yucca Mountain licensing process remains suspended, and approximately 300 technical contentions remain to be heard before a licensing board can reach a decision

US Projections of SNF and HLW

Projection assumes full license renewals and no new reactor construction or disposal (updated from Bonano et al., 2018)



Projected Volumes of SNF and HLW in 2048



Volumes shown in m^3 assuming constant rate of nuclear power generation and packaging of future commercial SNF in existing designs of dual-purpose canisters.

Approx. 80,000 MTHM (metric tons heavy metal) of commercial SNF in storage in the US as of Dec. 2017

Approx. 30,000 MTHM in dry storage at reactor sites, in 2,981 cask/canister systems as of Dec. 2018

- Balance in pools, mainly at reactors

Approx. 2200 MTHM of SNF generated nationwide each year

- Approximately 160 new dry storage canisters are loaded each year in the US

Observations on Current Practice

- Current practice is safe and secure
  - Extending current practice raises data needs; e.g., canister integrity, fuel integrity, aging management practices
- Current practice is optimized for reactor site operations
  - Occupational dose
  - Operational efficiency of the reactor
  - Cost-effective on-site safety
- Current practice is not optimized for transportation or disposal
  - Thermal load, package size, and package design

Placing spent fuel in dry storage in dual purpose canisters (DPCs) commits the US to some combination of three options

1) **Repackaging spent fuel in the future**
2) **Constructing one or more repositories that can accommodate DPCs**
3) **Storing spent fuel at surface facilities indefinitely, repackaging as needed**

Each option is technically feasible, but none is what was originally planned

After Decades of Repository Science and Engineering, What Do We Have?

- Repository programs in multiple nations
  - Belgium, Canada, China, Czech Republic, Finland, France, Germany, Japan, Korea, Russia, Spain, Sweden, Switzerland, United Kingdom, United States …
- Detailed safety assessments have been published for multiple disposal concepts, e.g.,
  - Switzerland: Opalinus Clay, 2002
  - France; Dossier 2005 Argile, 2005
  - USA: Yucca Mountain License Application for a repository in tuff, 2008
  - Sweden: Forsmark site in granite, 2011
  - Finland: Safety Case for Olkiluoto site in gneiss, 2012
  - Canada: Hypothetical repository in carbonate, 2013
- One deep mined repository has been in operation for transuranic waste (the Waste Isolation Pilot Plant in the US) since 1999

First order conclusions about geologic disposal

- **There are multiple approaches to achieving safe geologic isolation**
- **Estimated long-term doses are very low for each of the disposal concepts that have been analyzed in detail**
- **Safe isolation can be achieved for both SNF and HLW**

Status of Deep Geologic Disposal Programs World-Wide

Nation	Host Rock	Status
Finland	Granitic Gneiss	Construction license granted 2015. Operations application to be submitted in 2020
Sweden	Granite	License application submitted 2011
France	Argillite	Disposal operations planned for 2025
Canada	Granite, sedimentary rock	Candidate sites being identified
China	Granite	Repository proposed in 2050
Russia	Granite, gneiss	Licensing planned for 2029
Germany	Salt, other	Uncertain
USA	Salt (transuranic waste at the Waste Isolation Pilot Plant) Volcanic Tuff (Yucca Mountain)	WIPP: operating Yucca Mountain: suspended

Others: Belgium (clay), Korea (granite), Japan (sedimentary rock, granite), UK (uncertain), Spain (uncertain), Switzerland (clay), Czech Republic (granitic rock), all nations with nuclear power.

Source: Information from Faybishenko et al., 2016

Discussion: What does the Nation do Next?

Continue Implementing the Nuclear Waste Policy Act?

- Restart licensing for Yucca Mountain?
- Abandon Yucca Mountain and have DOE report to Congress with recommendations for further action?

Amend the Nuclear Waste Policy Act to allow other options?

- Federal management of commercial spent fuel in consolidated interim storage?
- Federal consideration of disposal sites other than Yucca Mountain?
- Private sector management of spent fuel and high-level waste disposal?

Questions to consider

- Who decides basic policy questions?
  - Congress and the Federal Courts
- Who pays?
  - Ratepayers (The Nuclear Waste Fund)
  - Taxpayers (The Judgment Fund)
- What is the role of science in the decision-making process?

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