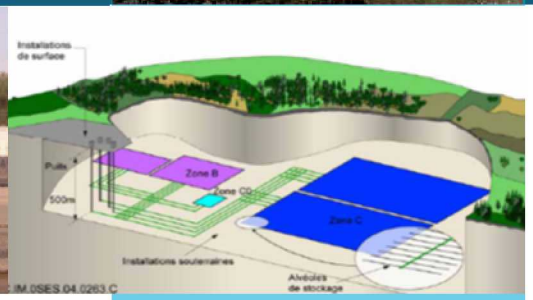
SAND2019-3894C

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



PRESENTED BY

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International High-Level Radioactive Waste Management Conference, Knoxville, TN

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Outline

- Status of the US program
- Options for geologic disposal in the US and other nations
- Concluding Remarks

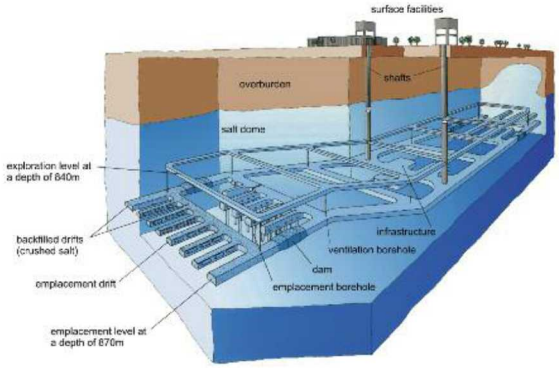
Spent Nuclear Fuel and High-Level Radioactive Waste Disposal: The Goal

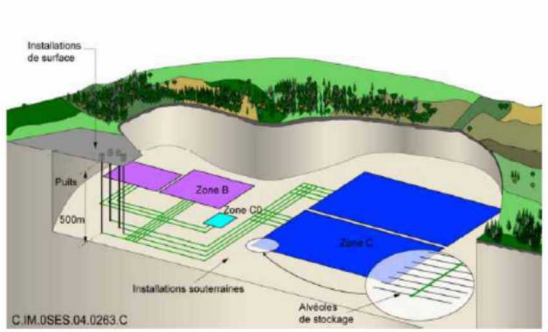
"There has been, for decades, a worldwide consensus in the nuclear technical community for disposal through geological isolation of high-level waste (HLW), including spent nuclear fuel (SNF)."

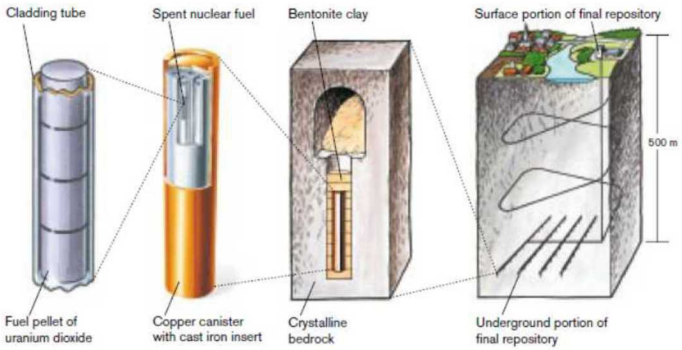
"Geological disposal remains the only long-term solution available."

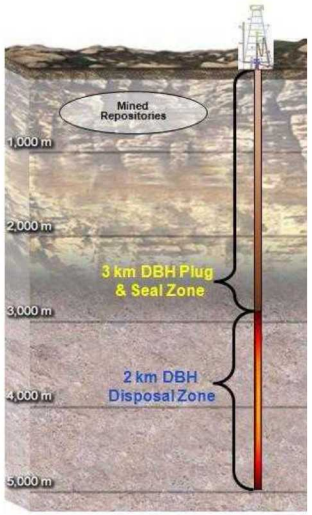
National Research Council, 2001

Deep geologic disposal has been planned since the 1950s





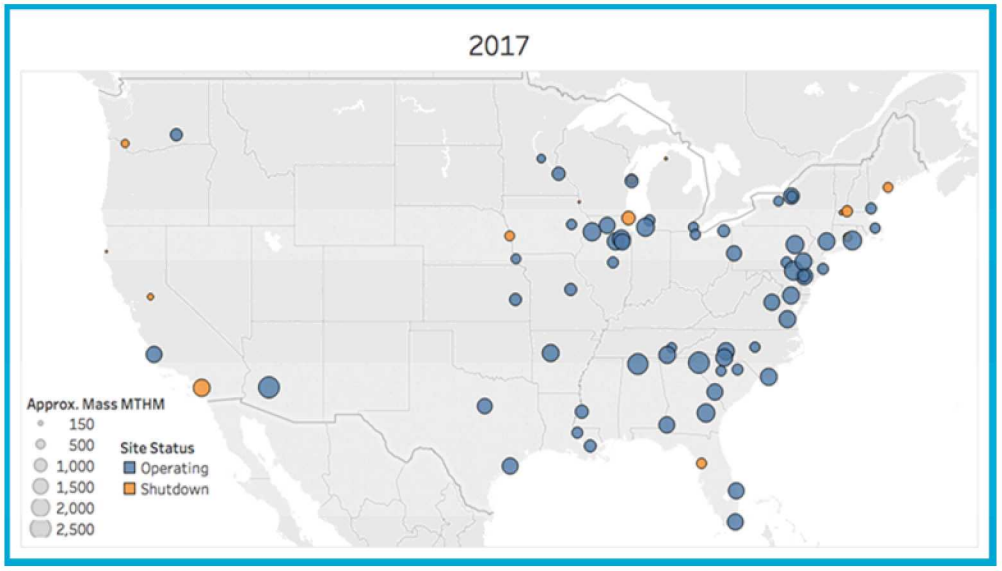




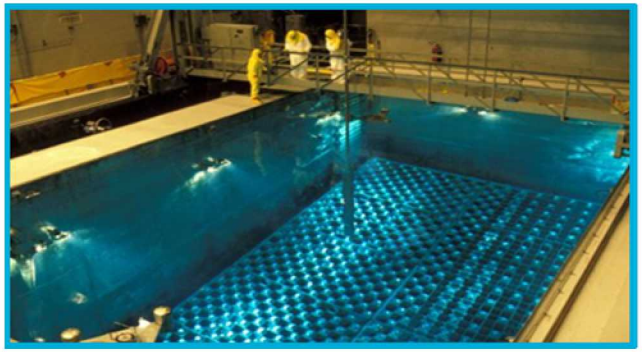
Geologic Disposal in the US: The Reality

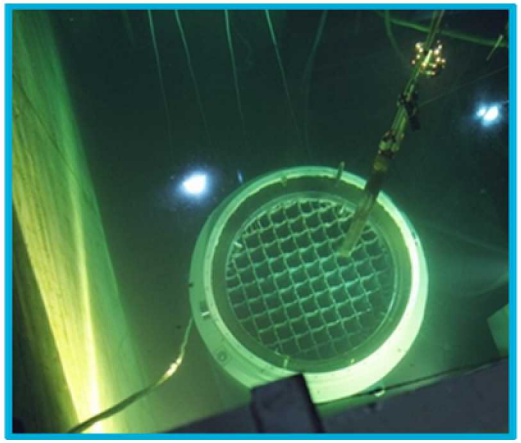
Commercial SNF is in Temporary Storage at 75 Sites in 34 States

- 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



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



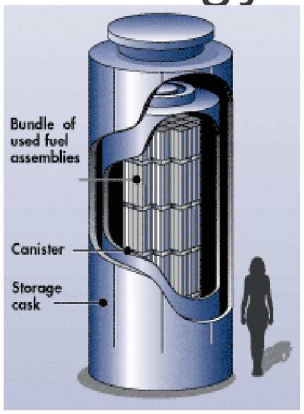


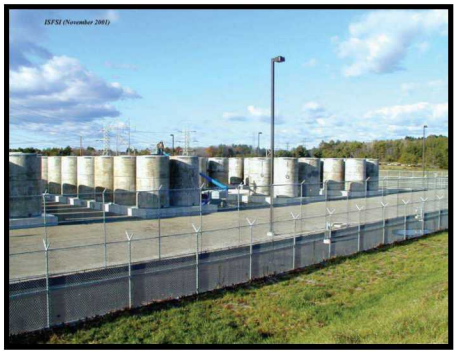
Dry Cask Storage System Terminology

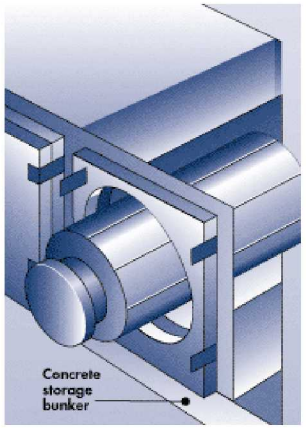
Dry Cask Storage Systems (DCSSs) include:

- 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

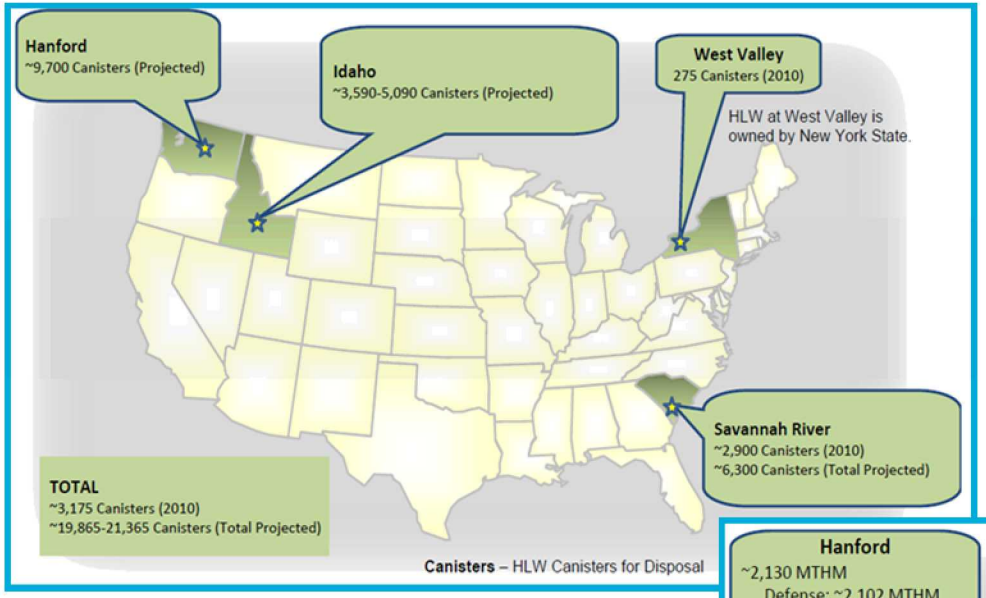






Geologic Disposal in the US: The Reality (cont.)

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

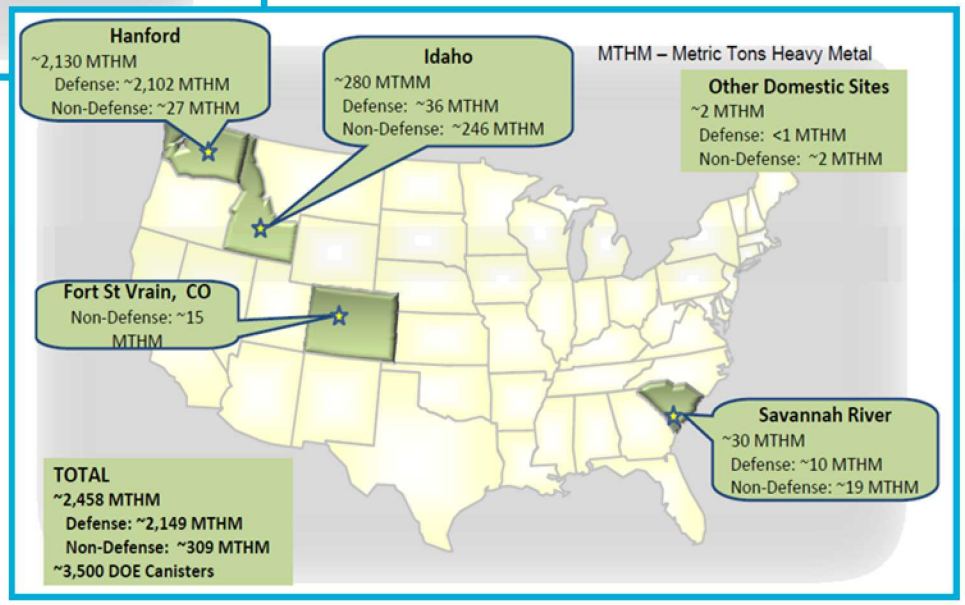


DOE-Managed HLW

~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

1982
Nuclear Waste Policy Act of 1982

1987
Nuclear Waste Policy Amendments Act selects Yucca Mountain as sole site for further characterization

January 31, 1998
DOE fails to open a repository by the statutory deadline

February 2002
Yucca Mountain Site Recommendation Site is designated by DOE and President G.W. Bush as suitable for repository development and licensing

June 3, 2008
Yucca Mountain Repository License Application submitted to the NRC

2010
Obama Administration decides Yucca Mountain is not workable; Project suspended

Spent nuclear fuel continues to be generated at ~2,200 MTHM/yr.

Present Day
Repository program remains suspended, but law is unchanged

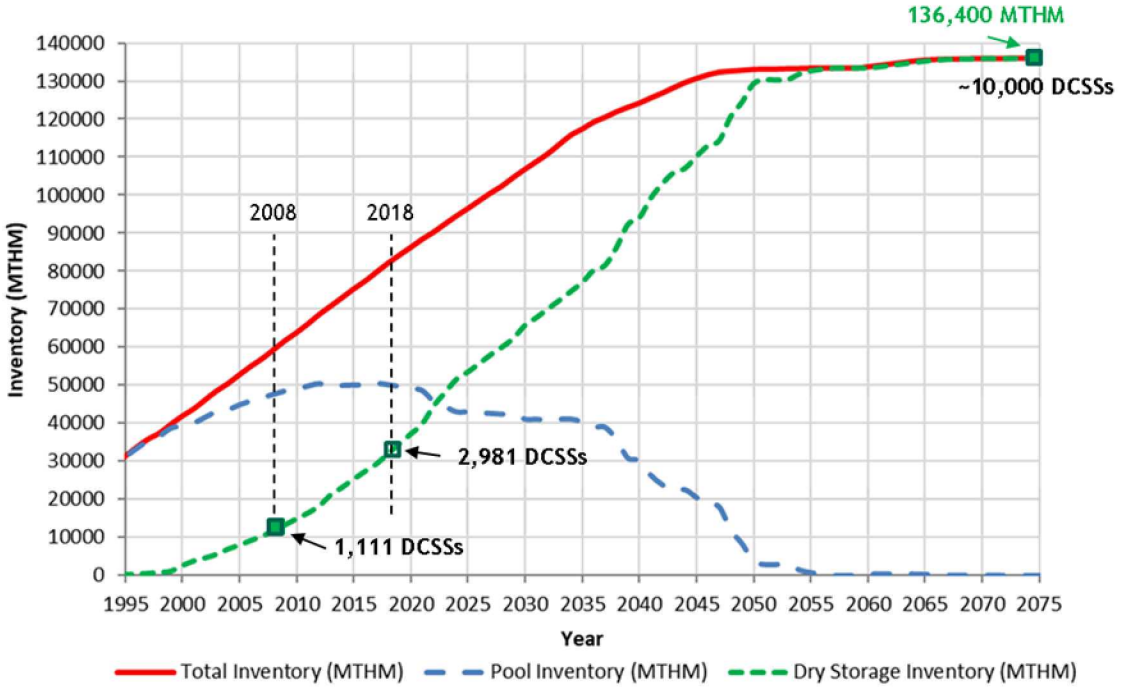
SNF continues to accumulate in dry storage at commercial reactor sites; HLW remains in storage at DOE sites

Current Status of the US Program

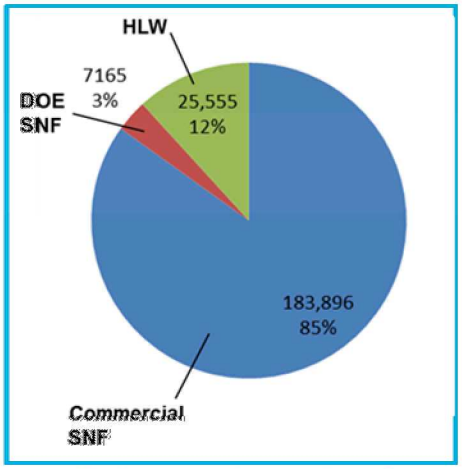
2008	• Yucca Mountain Repository License Application submitted
2009	• Department of Energy (DOE) determines Yucca Mountain to be unworkable
2010	• Last year of funding for Yucca Mountain project
2012	⑩Blue Ribbon Commission on America's Nuclear Future completes its recommendations, including a call for 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 constructio n or disposal (updated from Bonano et al., 2018)



Projected Volumes of SNF and HLW in 2048



Volumes shown in m³ 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

Concluding Remarks

- **International Consensus**:
  - Deep Geologic Disposal is still the preferred alternative to permanent isolate SNF and HLW from humans and environment.

- **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

- **In the US, the lack of an operating repository has forced nuclear utilities to store SNF on site.**
  - SNF is accumulating at a rate of ~2,200 MTHM with ~160 DSSCs being load annually
  - US has three alternative paths (or some combination thereof): repackage fuel, design one more repositories that can accept the DSSCs as disposal packages, or store on site indefinitely (with repackaging as needed).

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