Thermohydraulic R&D for Dry Storage Casks at Sandia National Laboratories

PRESENTED BY

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Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY | NNSA

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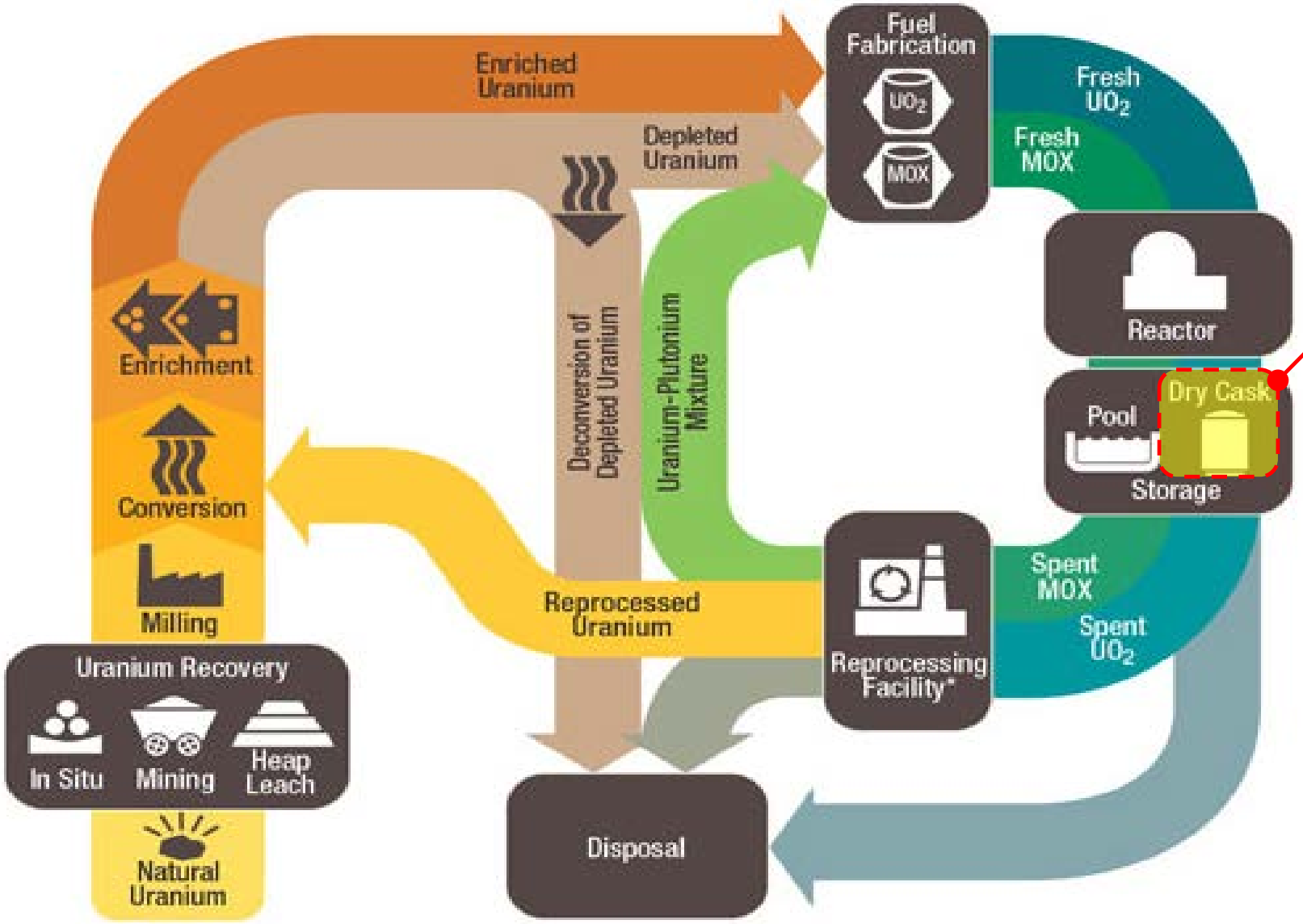
SAND2018-8885PE

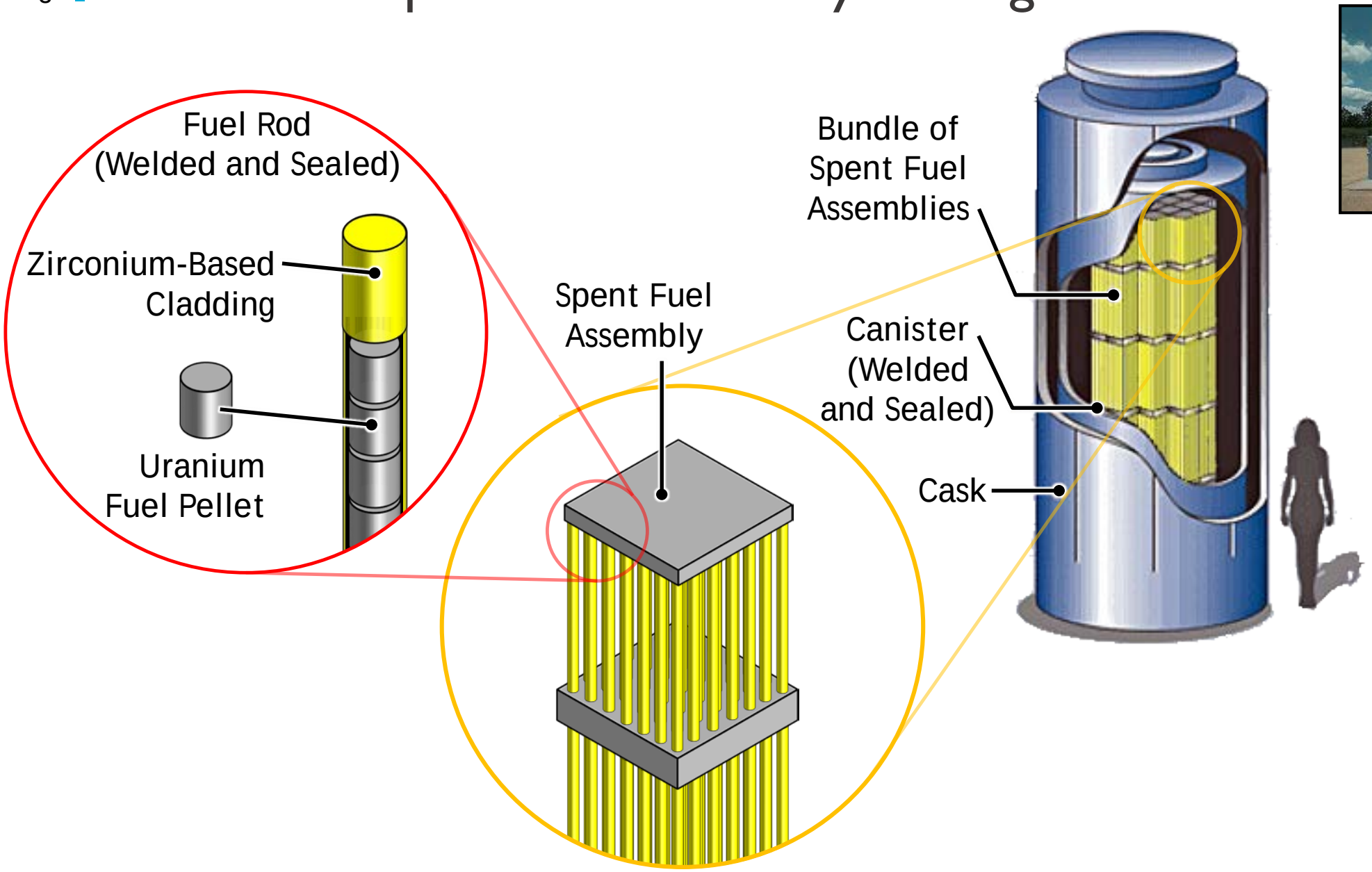
Nuclear Fuel Cycle



Focus of this presentation

* Reprocessing of spent nuclear fuel including MOX is not practiced in the U.S.
Note: The NRC has no regulatory role in mining uranium.

What Are Spent Fuel and Dry Storage Casks?

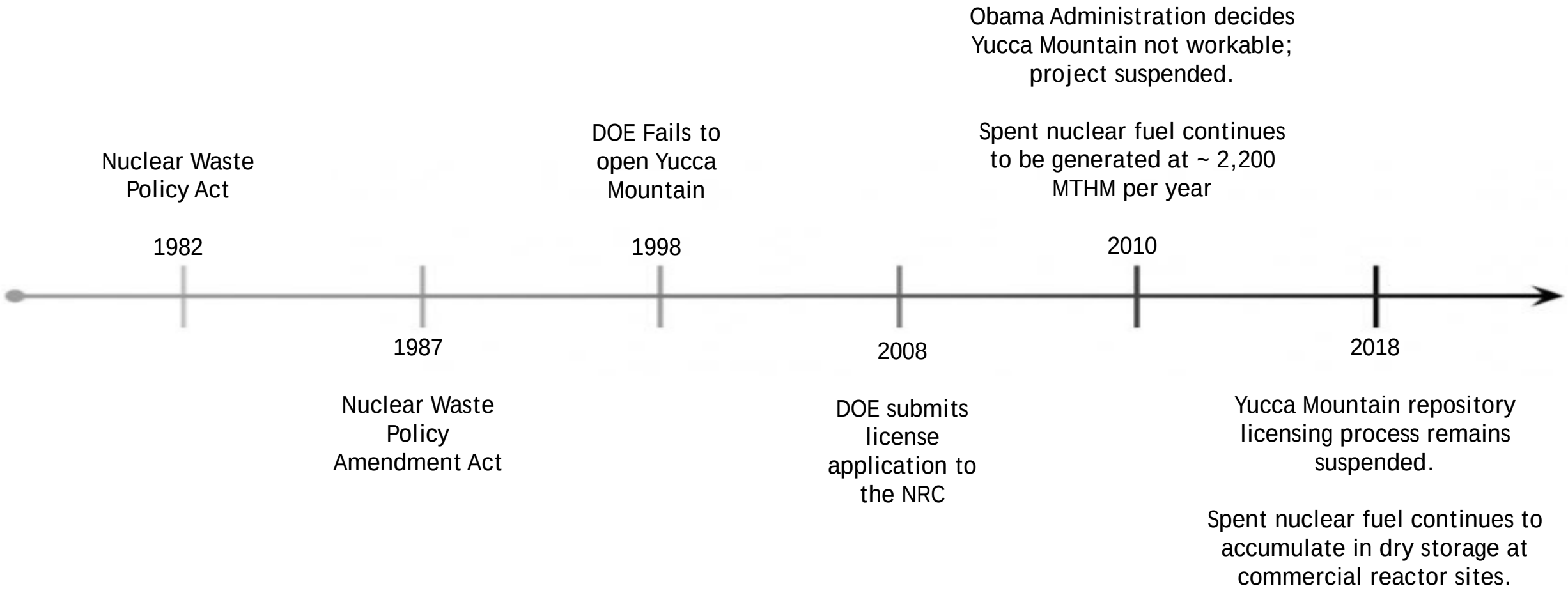


Aboveground

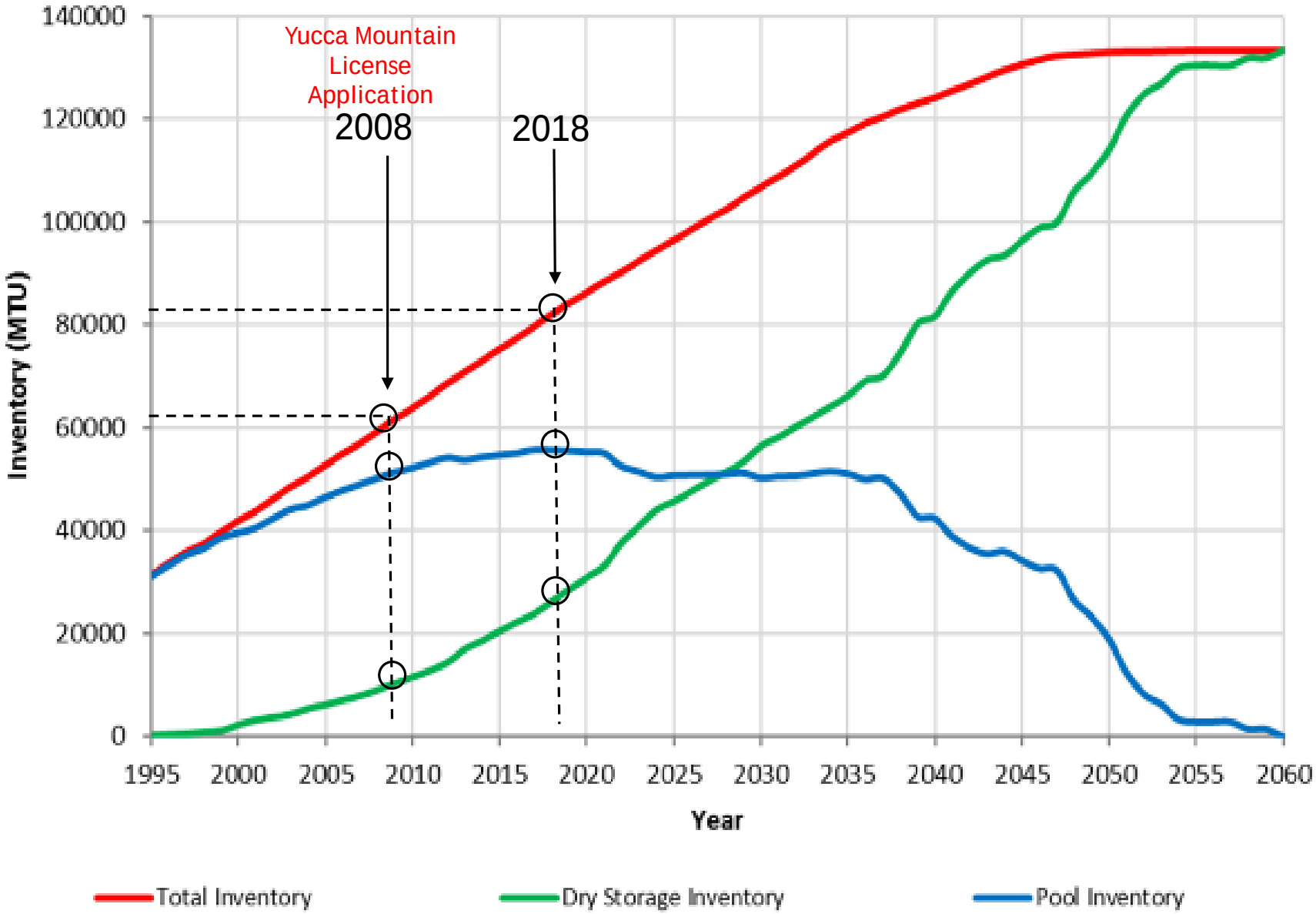
Belowground

Horizontal

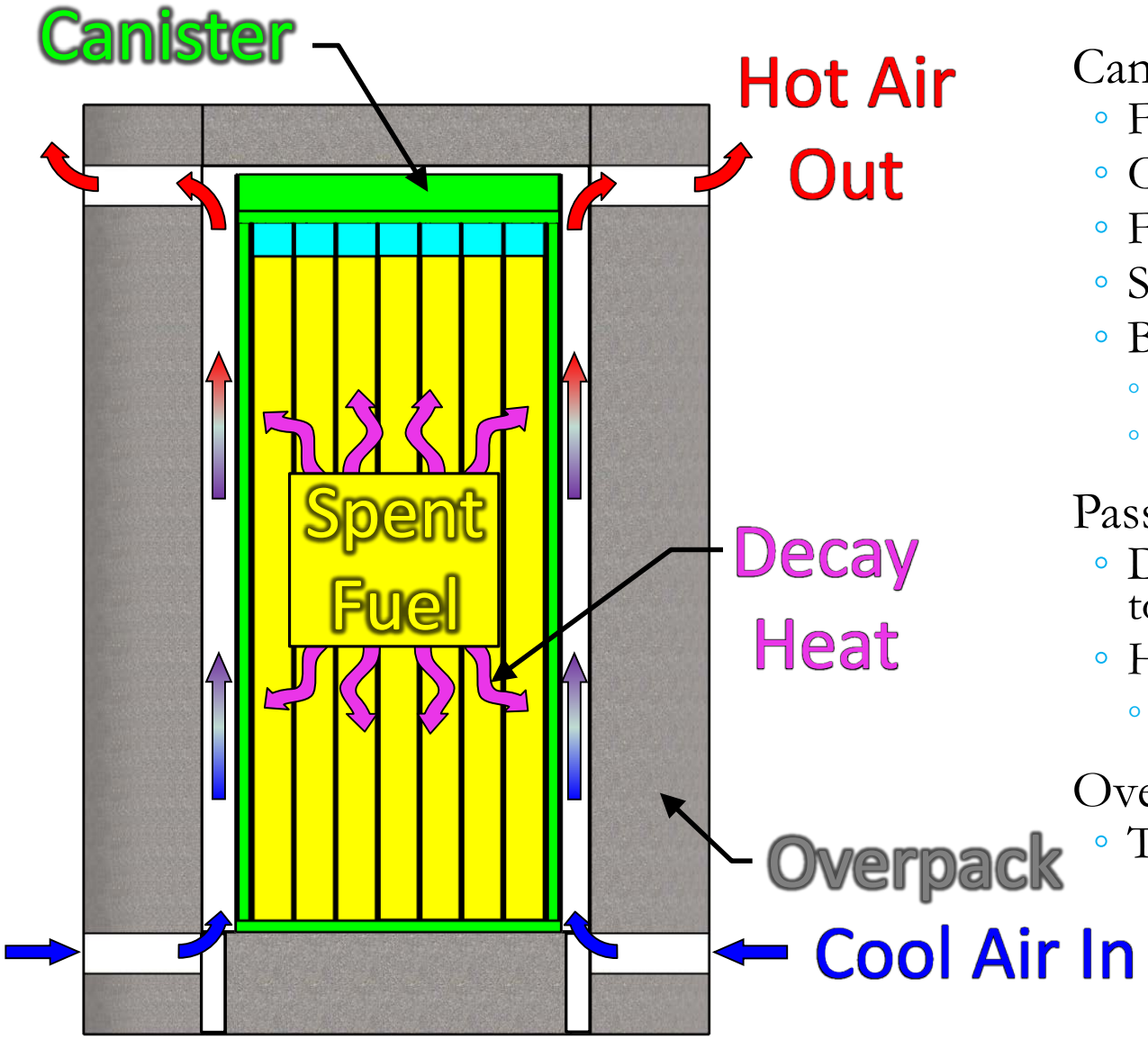
Timeline of U.S. Spent Nuclear Fuel Management



Commercial Spent Nuclear Fuel Inventory In Storage



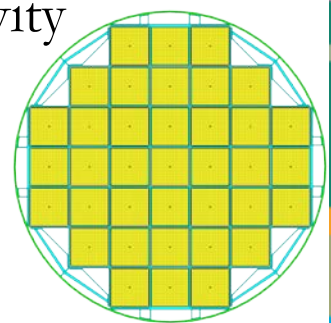
How Storage Casks Work



Canister holds spent fuel assemblies
- Fuel rods individually sealed (welded)
- Canister also sealed (welded or bolted)
- Fuel gives off heat from radioactive decay
- Stainless steel cylinder with regularly spaced compartments
- Backfilled with inert helium
  - No chemical interaction
  - Good thermal properties

Passively cooled storage
- Decay heat conducted, convected, and thermally radiated to canister wall
- Heat externally removed by natural air flow
  - Air not in contact with spent fuel

Overpack provides shielding from radioactivity
- Typically made from reinforced concrete



Motivation for Current Research

Modern, vertical casks loading with larger decay heats and greater pressures of helium backfill

- No testing for similar conditions in previous investigations
- Need capability for:
  - Pressurizing helium to modern, real-world values
  - Mimicking broad range of fuel ages (fresh out of the pool to decades old)

Simultaneous measurements of interior and exterior (of canister) responses needed for full system characterization

- Aboveground and belowground configurations of interest

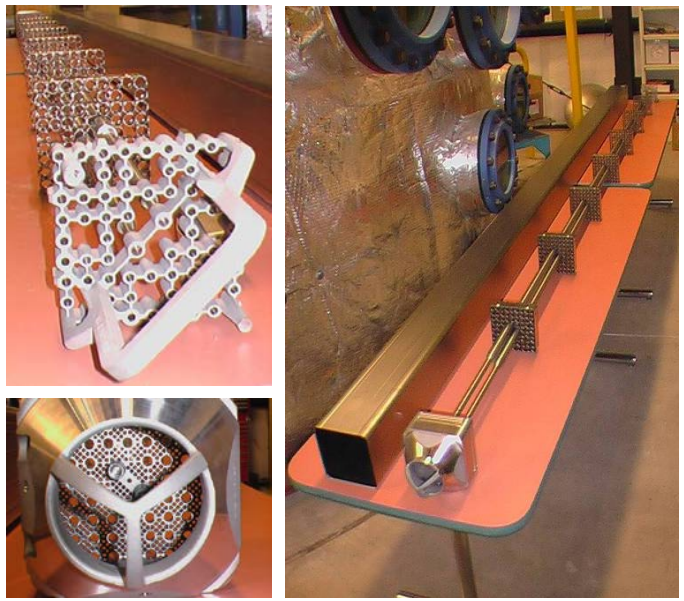
Current Sandia Cask Simulator Testing

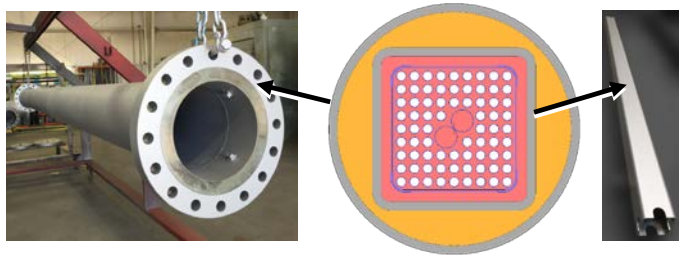
Sandia Dry Cask Simulator (DCS)

- Collect data for model validation
  - Simplified geometry based on real-world systems
- Co-funded by U.S. Department of Energy and U.S. Nuclear Regulatory Commission
  - Office of Nuclear Energy (DOE)
  - Office of Nuclear Material Safety and Safeguards (NRC)
- Wide range of parameters
  - Decay heat and internal pressures
  - Different above and below ground storage configurations
  - Facility undergoing redesign for horizontal testing configuration by end of calendar year 2018.
- Better confidence in predictive modeling to understand fuel behavior

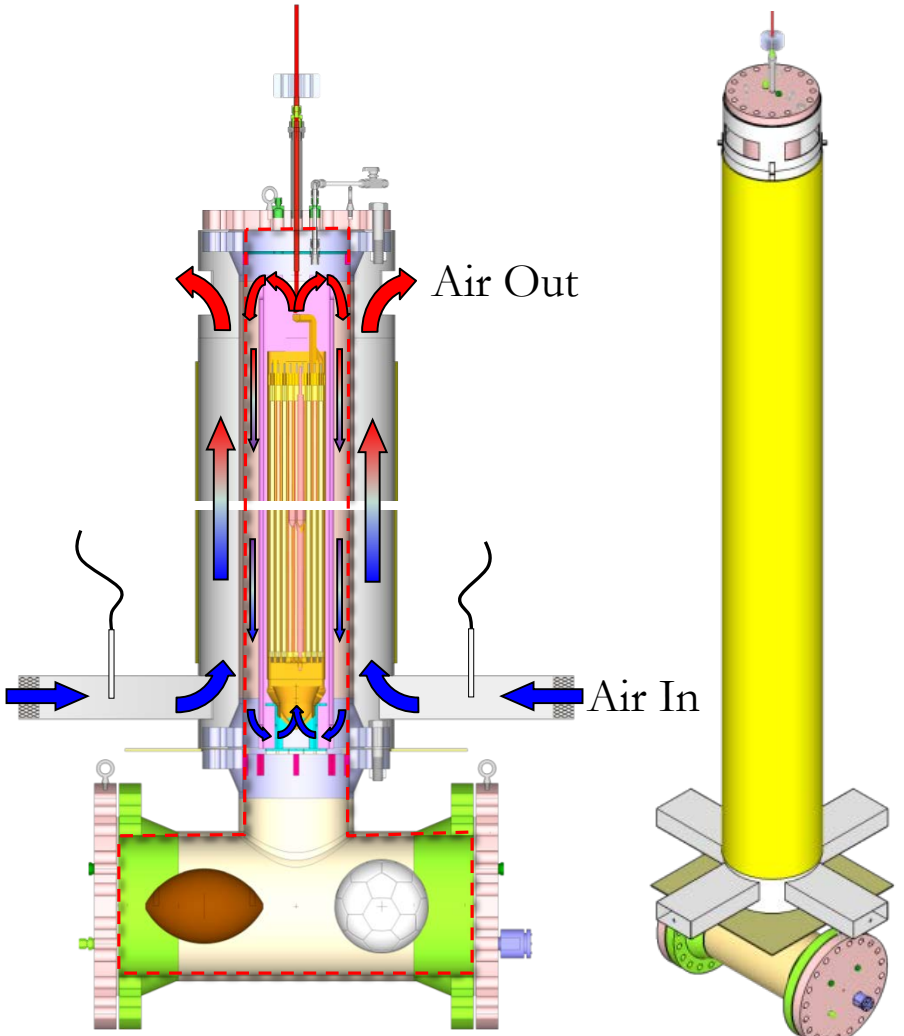
Sandia Test Assembly

Real-world hardware with electrical heaters for spent fuel

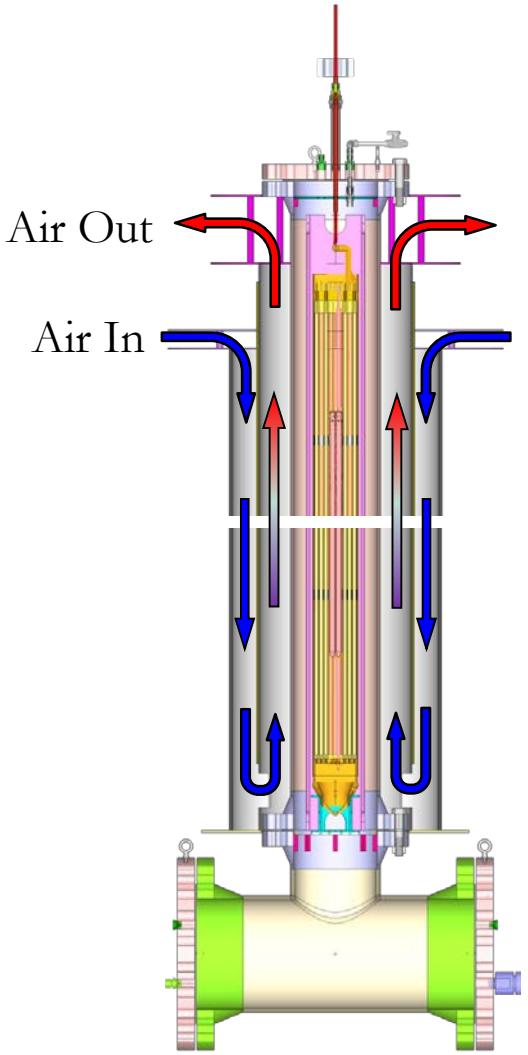


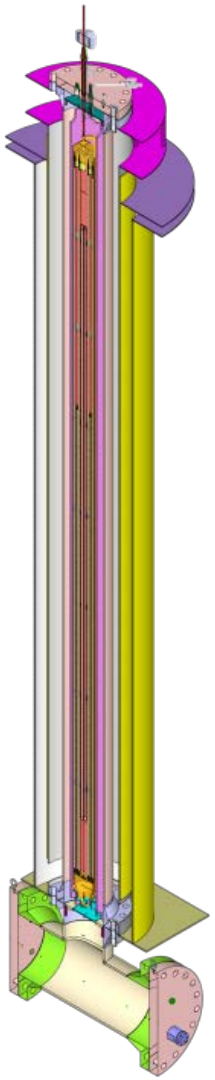


"Canister" Test x-section "Basket"



Aboveground





Belowground

Summary

Dry cask simulator testing complete for all above and below ground configurations

- Over 40 unique data sets collected
- 14 each for two primary configurations
- 13 additional data sets for cross-wind testing
- Main results will be reported in an NRC contractor report by end of 2018

Comparisons with computational fluid dynamics simulations show good agreement between models and experimental data

Draft report describing results to date subjected to both internal Sandia technical review as well as independent NRC review

References

Bonano, Evaristo J., et al. "The Need for Integrating the Back End of the Nuclear Fuel Cycle in the United States of America." Cambridge, MRS Advances, DOI 10.1557/adv.2018.231, Feb. 2018.

Durbin, Samuel G., and Eric R. Lindgren. "Thermal-Hydraulic Results for the Boiling Water Reactor Dry Cask Simulator." Sandia, U.S. Department of Energy Spent Fuel and Waste Science and Technology, DOI 10.2172/1398335, Sept. 2017.