U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Spent Fuel and Waste Science and Technology (SFWST)

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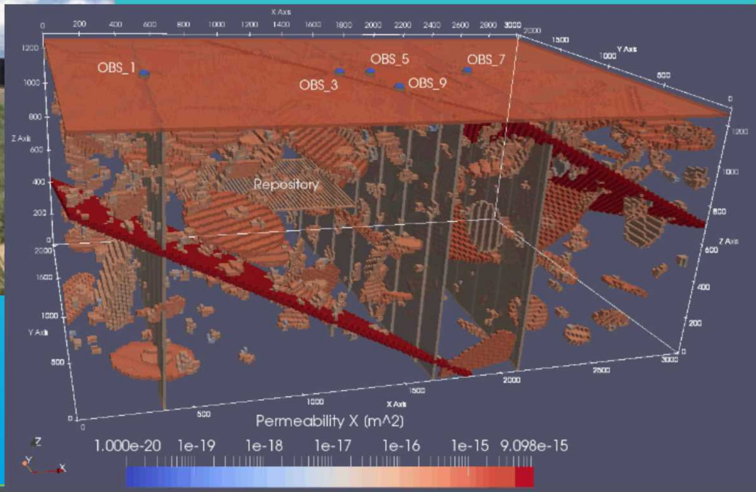

History and Overview of Past Studies on Technical Feasibility of Dual-Purpose Canister Direct Disposal

U.S. Nuclear Waste Technical Review Board Virtual Meeting

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This is a technical presentation that does not take into account contractual limitations or obligations under the Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (Standard Contract) (10 CFR Part 961). For example, under the provisions of the Standard Contract, spent nuclear fuel in multi-assembly canisters is not an acceptable waste form, absent a mutually agreed to contract amendment.

To the extent discussions or recommendations in this presentation conflict with the provisions of the Standard Contract, the Standard Contract governs the obligations of the parties, and this presentation in no manner supersedes, overrides, or amends the Standard Contract.

This presentation reflects technical work which could support future decision making by DOE. No inferences should be drawn from this presentation regarding future actions by DOE, which are limited both by the terms of the Standard Contract and Congressional appropriations for the Department to fulfill its obligations under the Nuclear Waste Policy Act including licensing and construction of a spent nuclear fuel repository.

Outline

- Dual-Purpose Canister (DPC) background
- Examples of DPCs in current use
- Projected inventory of DPCs
- History of DOE’s R&D program for DPC direct disposal
- Ongoing and planned R&D activities

Background

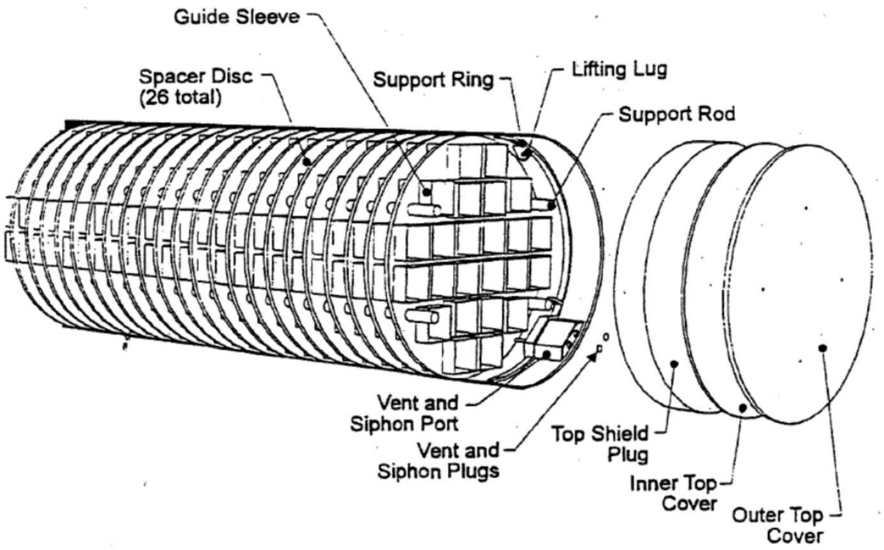
- Dual-purpose canisters (DPCs) were designed, licensed and loaded for storage and transportation of Spent Nuclear Fuel (SNF), but not with consideration for ultimate geologic disposal.
  - Fuel baskets are designed to control criticality for short-term operations (fuel pools) or transportation accidents
  - After disposal, some packages could eventually breach and flood
  - Aluminum-based neutron absorbing materials readily corrode from long-term exposure to ground water
- There are currently more than 3000 DPCs containing SNF across the United States.

Background (cont.)

- Repackaging of SNF loaded in DPCs into specialized disposal canisters would be financially and operationally costly with radiological, operational safety, and management risks.
- The cost avoidance associated with direct disposal of SNF in DPCs could be up to $20 billion.
- The significant contributors to cost avoidance are
  - Elimination of disposal canister procurement costs
  - Reduction in the number of disposal overpacks
  - Elimination of repackaging operations
  - Elimination of disposal of DPC hulls and baskets as low-level waste

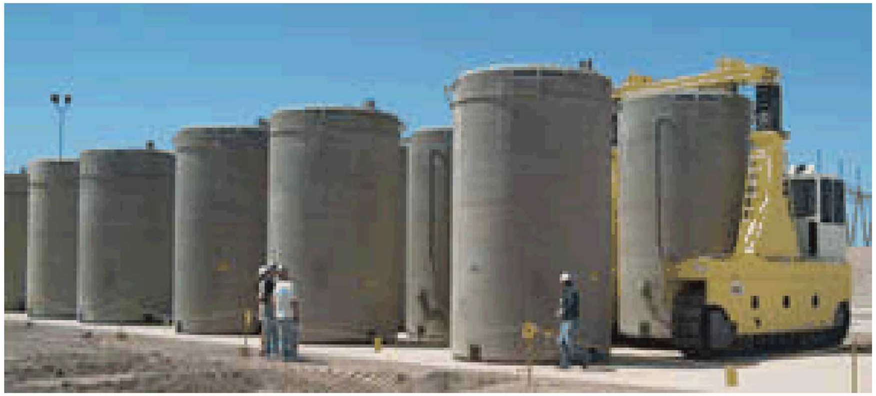
Typical DPC Canister/Cask System – NUHOMS®

- NUHOMS® (TransNuclear/Orano) horizontal storage systems
- ~1/3 of existing U.S. DPC fleet
- NUHOMS line varies with capacity, PWR & BWR fuel types
- Shell is welded SS304; basket and plug materials vary



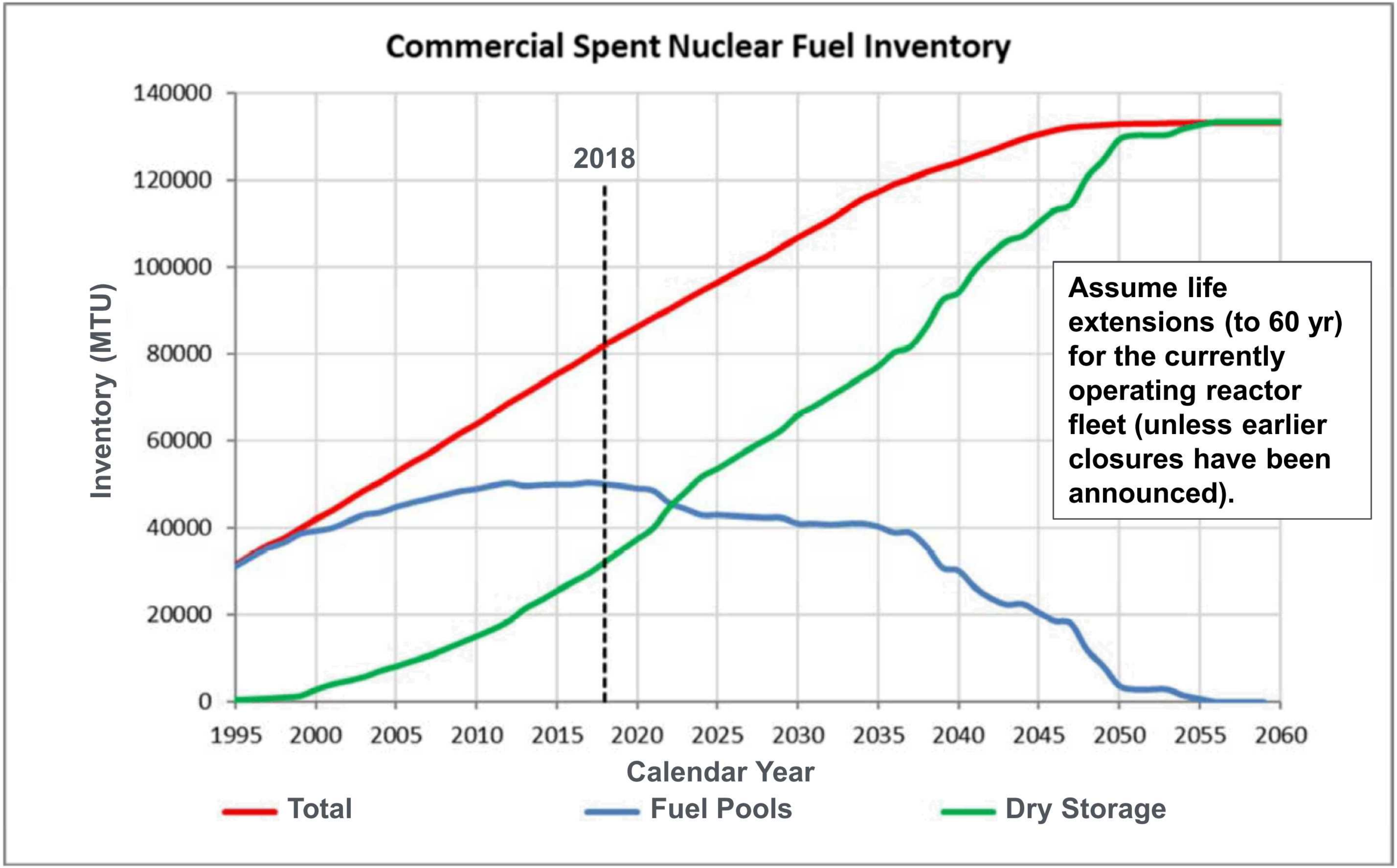
Typical, Recent Large DPC System Designs – Magnastor®

- Magnastor® DPC system (NAC International)
- Capacity 37-PWR (or BWR equiv.)
- Thermal limits: 35.5 kW storage/24 kW transport
- Fuel cool time >4 yr out-of-reactor
- Design basis: burnup credit analysis, heat rejection features, transport needs.



Pictures and data from NAC International website

Spent Fuel Projection – Accumulation in Pools and DPCs (MTU)



Brief History of Storage-Transportation-Disposal Canister Investigations

- DPC Investigations starting in the 1990's
  - Disposability was recognized as an issue for storage canisters by the DOE and the NWTRB, as early as 1992 [A]
  - Large waste package capacity was established by *MPC Conceptual Design Report* [B] (21-PWR/40-BWR) and later modified by a 1996 Westinghouse design study (21-PWR/44-BWR). [C]
  - International programs have demonstrated subcriticality using certain burnup and enrichment characteristics without neutron absorbers, for small waste packages (up to 4-PWR/12-BWR) [D]
  - The U.S. concept is larger than for international programs (e.g., Swedish KBS-3 concept: 4-PWR/12-BWR) which leads to the need for reactivity control for disposal, but reduces the number of packages from >70,000 to <16,000.

A Williams, J. "Multi-Purpose Canister Study," Presentation to the NWTRB, January 6, 1993.

B CRWMS M&O 1994a. Volume II.A – *MPC Conceptual Design Report*, Revision 0A. A20000000-00811-5705-00002 REV 0A. July 27, 1994.

C Westinghouse 1996. Lar*ge MPC Assembly Subsystem Preliminary Design Report*. MPC-NC-02-020 Rev.3. MOV.19990717.0140.

D SKB 2016. Criticality effects of long-term changes in material compositions and geometry in disposal canisters. TR-16-06. (https://www.skb.com/publication/2485117/)

Brief History of Storage-Transportation-Disposal Canister Investigations

- Triple-Purpose Canister for the 2008 License Application
  - The Transport-Aging-Disposal (TAD) canister was a multi-purpose, disposable concept.
  - Neutron absorption for the TAD would be provided by 11-mm thick basket plates of borated stainless steel (304B4; ASTM A887-89).
  - Corrosion performance of 304B4 was validated experimentally [A] and received regulatory safety review [B]
  - Direct disposal of commercial SNF in DPCs was considered [C] but not implemented
  - Proposals for direct disposal of SNF in DPCs using the LA disposal concept were introduced concurrently [D]

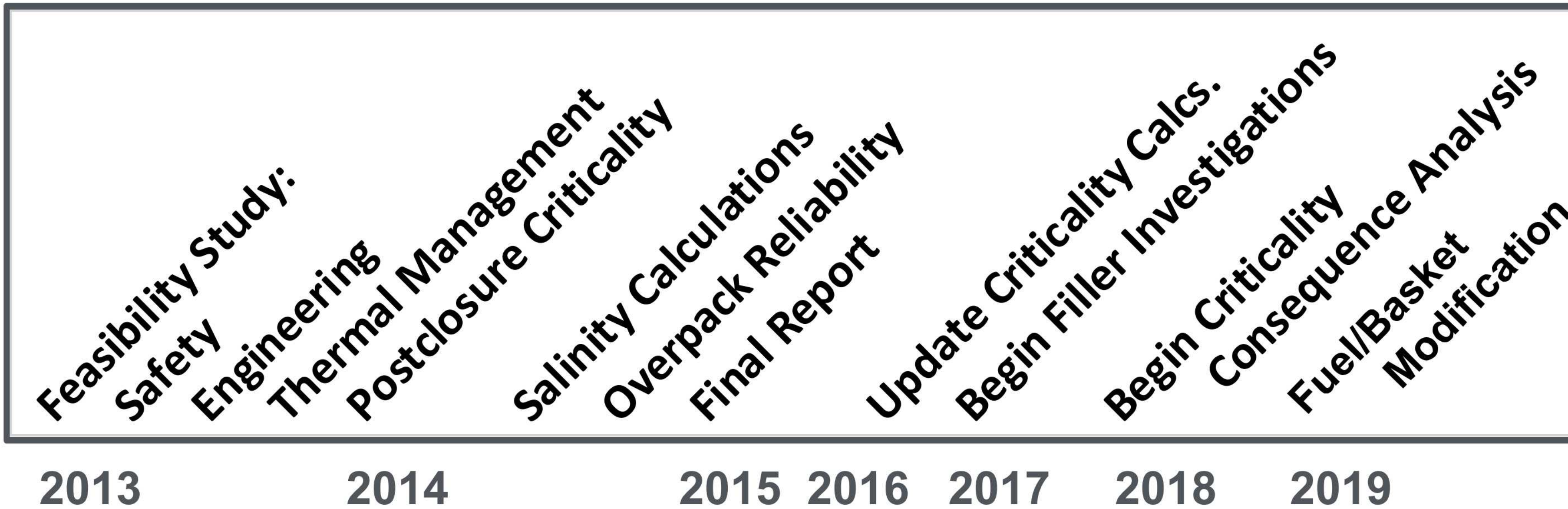
[A] Orrell, S.A. 2007. Letter to J.R. Dyer, Subject: Updated Lead Laboratory Recommendation for the Neutron Absorber to be Used in the Performance-Based Requirements Document for the Transport, Aging and Disposal (TAD) Cansiters. #07_772_YMP-LL_07-09-2007.

[B] NRC 2014. Safety Evaluation Report Related to Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada Volume 3: Repository Safety After Permanent Closure. NUREG-1949 Vol. 3.

[C] BSC (Bechtel SAIC Company) 2003. The Potential of Using Commercial Dual Purpose Canisters for Direct Disposal. TDR-CRW-SE-000030, Rev. 0, Office of Civilian Radioactive Waste Management, Las Vegas, NV: Bechtel SAIC Company.

[D] EPRI (Electric Power Research Institute) 2008. Feasibility of Direct Disposal of Dual-Purpose Canisters: Options for Assuring Criticality Control. #1016629

SFWST Campaign DPC Direct Disposal R&D



- **DOE/SFWST began R&D on direct disposal of DPCs in 2013**
- **Initial approach: technical feasibility with low-probability screening of criticality**
- **Expanded approach: include fillers, criticality consequence studies, and fuel/basket modification options**

R&D Roadmap Update for DPC Disposition R&D

- R&D Roadmap Update (M2SF-19SN010304042, Rev. 1)
- DPC disposition priority
- Included among 23 highest priority R&D activities:
  - Probabilistic post-closure DPC criticality consequence analyses
  - DPC filler and neutron absorber degradation testing and analysis
  - Coupled multi-physics simulation of DPC postclosure (chemical, mechanical, thermal-hydraulic) including processes external to the waste package.
  - Source term development with and without criticality

Current R&D Program for DPC Disposition

- Follow on preliminary technical feasibility investigation (2013-2015)
- General approach: Research the availability of technical solutions for safe, timely, cost effective disposition of commercial spent fuel in DPCs
- Added starting in 2018: fillers, fuel/basket modification, and criticality consequence investigations
- Current R&D:
  - DPC fillers for criticality control
  - Potential future DPC modifications (fuel/basket modification)
  - Postclosure criticality consequence analysis
  - As-loaded DPC criticality modeling

Strategies

- Strategies for disposal of DPCs could combine different options:

  1) Direct disposal without modification (a disposal licensing strategy that addresses the risk [probability and consequence] from postclosure criticality events);

  2) Modification of already-loaded DPCs with injectable filler material;

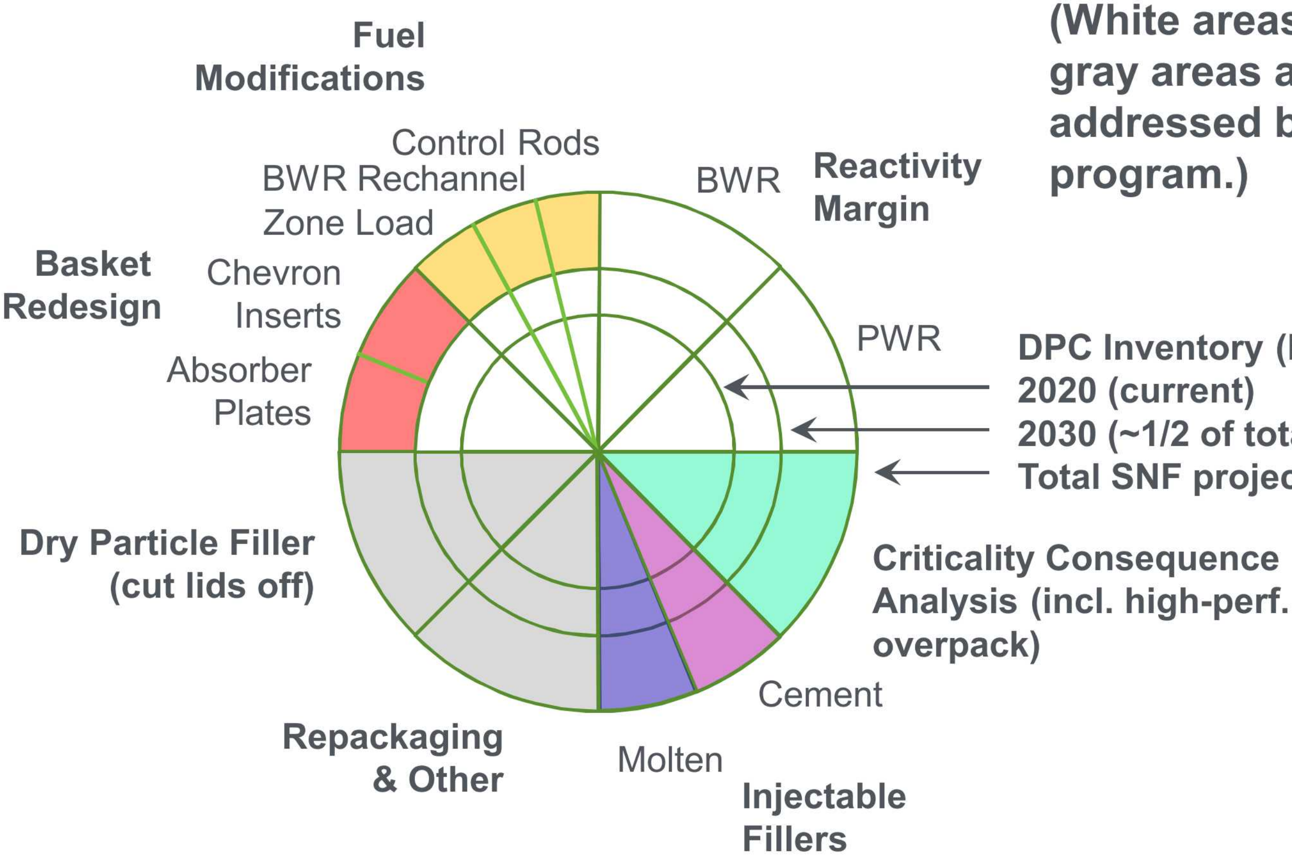
  3) Modification of DPCs to be loaded in the future, or the fuel they contain, by changing loading maps, adding disposal criticality control features, or basket redesign.

Summary of SFWST R&D on Direct Disposal of DPCs

Goal for DPC disposition:

Expand one or more solutions to provide *radial* (not circumferential) coverage of the full inventory circle.

(White areas cannot be expanded; gray areas are not currently addressed by the DOE SFWST R&D program.)

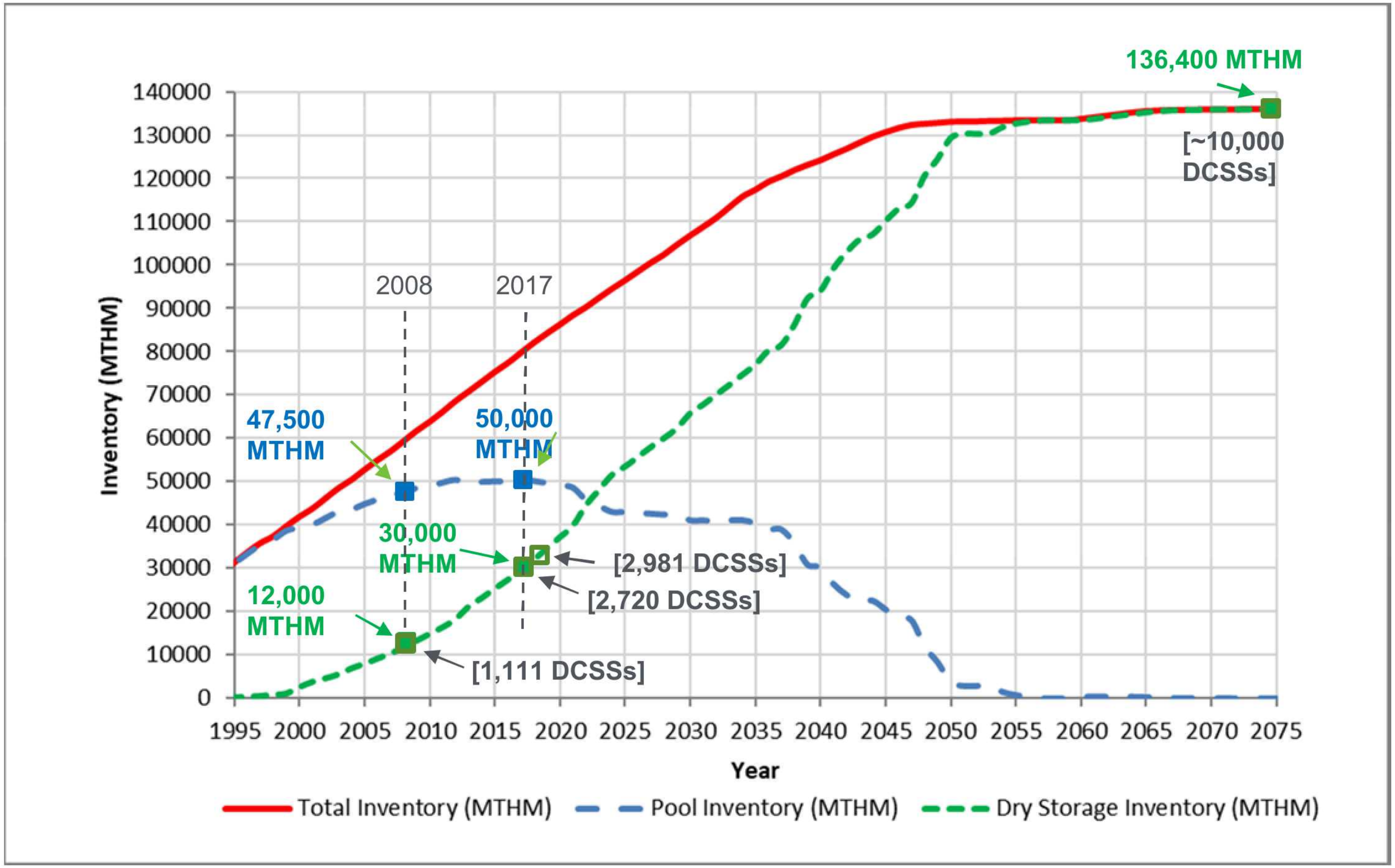


References

- SNL (Sandia National Laboratories) 2019. *Comparative Cost Analysis of Spent Nuclear Fuel Management Alternatives.* SAND2019-6999 Revision 1. June 2019.

Questions?

Projected Inventory of Commercial SNF in Storage



Source: Figure 1-5 from "Comparative Cost Analysis of Spent Nuclear Fuel Cost Alternatives, Sandia Report SAND2019-6991 Rev 1, June 2019