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Fuel Cycle Technologies

Compatibility of Commercial Storage Containers with the Waste Management System

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Outline

- **Background**
  - Location and amount of used nuclear fuel (UNF), present and future
  - Types of dry storage casks currently in use
  - Constraints on disposal
- **Examples of approaches available for integrating storage, transportation, and disposal**
  - Direct disposal of dual purpose canisters (DPCs)
  - Repackaging of UNF, i.e., can-in-can concepts
- **System-level analyses to inform decision-making**
  - Past work
  - Present work being conducted by the Used Fuel Disposition Campaign

Background

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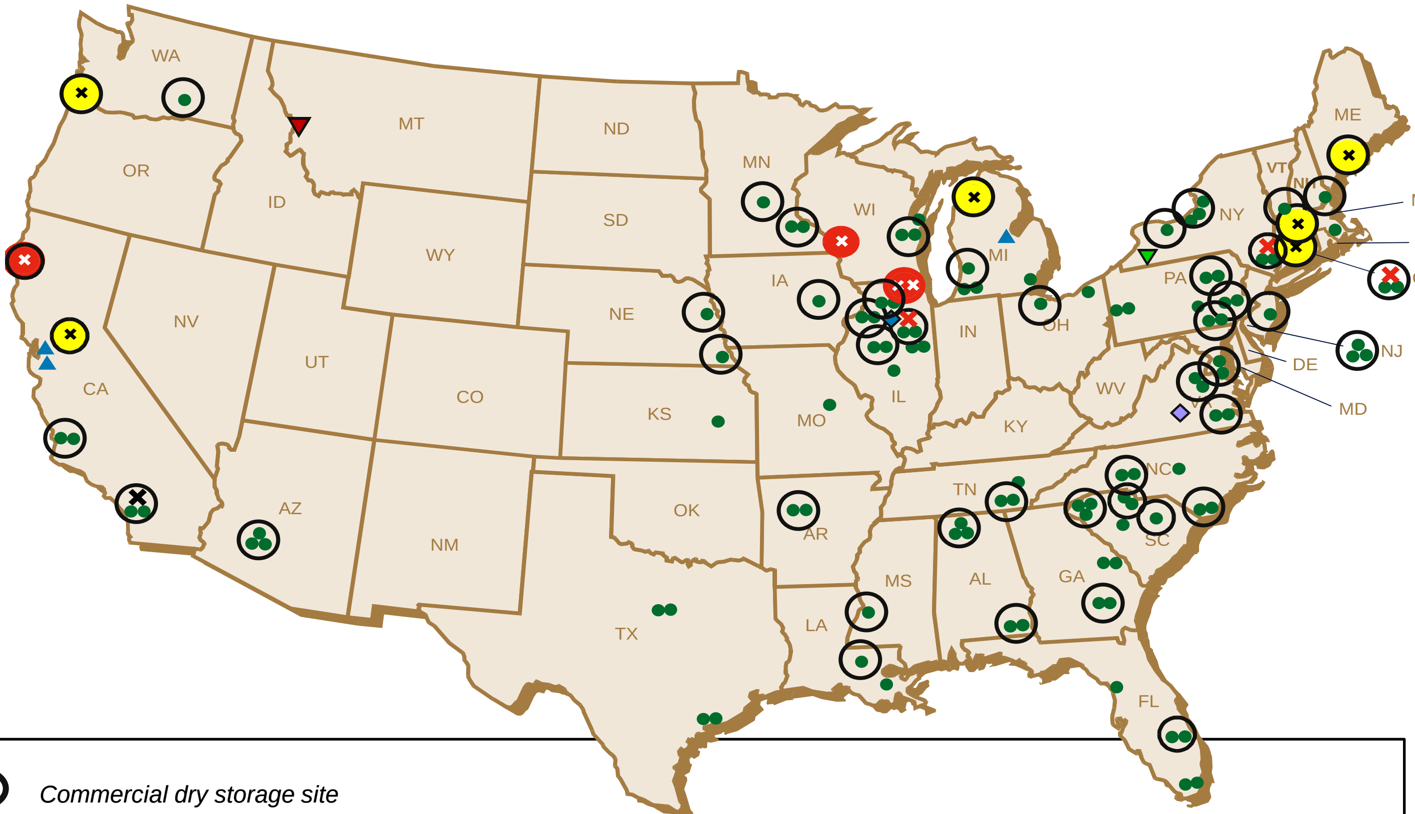
Location of Spent Nuclear Fuel and High-Level Radioactive Waste



- Commercial dry storage site
- Shutdown reactor site undergoing decommissioning
- Shutdown reactor site largely decommissioned except ISFSI
- Nuclear fuel fabrication/test facility
- Operating reactor
- Shutdown reactor
- SNF from shutdown reactor at operating reactor site
- Operating commercial research reactor
- Commercial HLW
- Commercial SNF from research reactor
- Commercial SNF pool storage (away from reactor)

January 2011

[1] ***Locations reflect non-federally owned SNF and HLW covered by the Nuclear Waste Policy Act***

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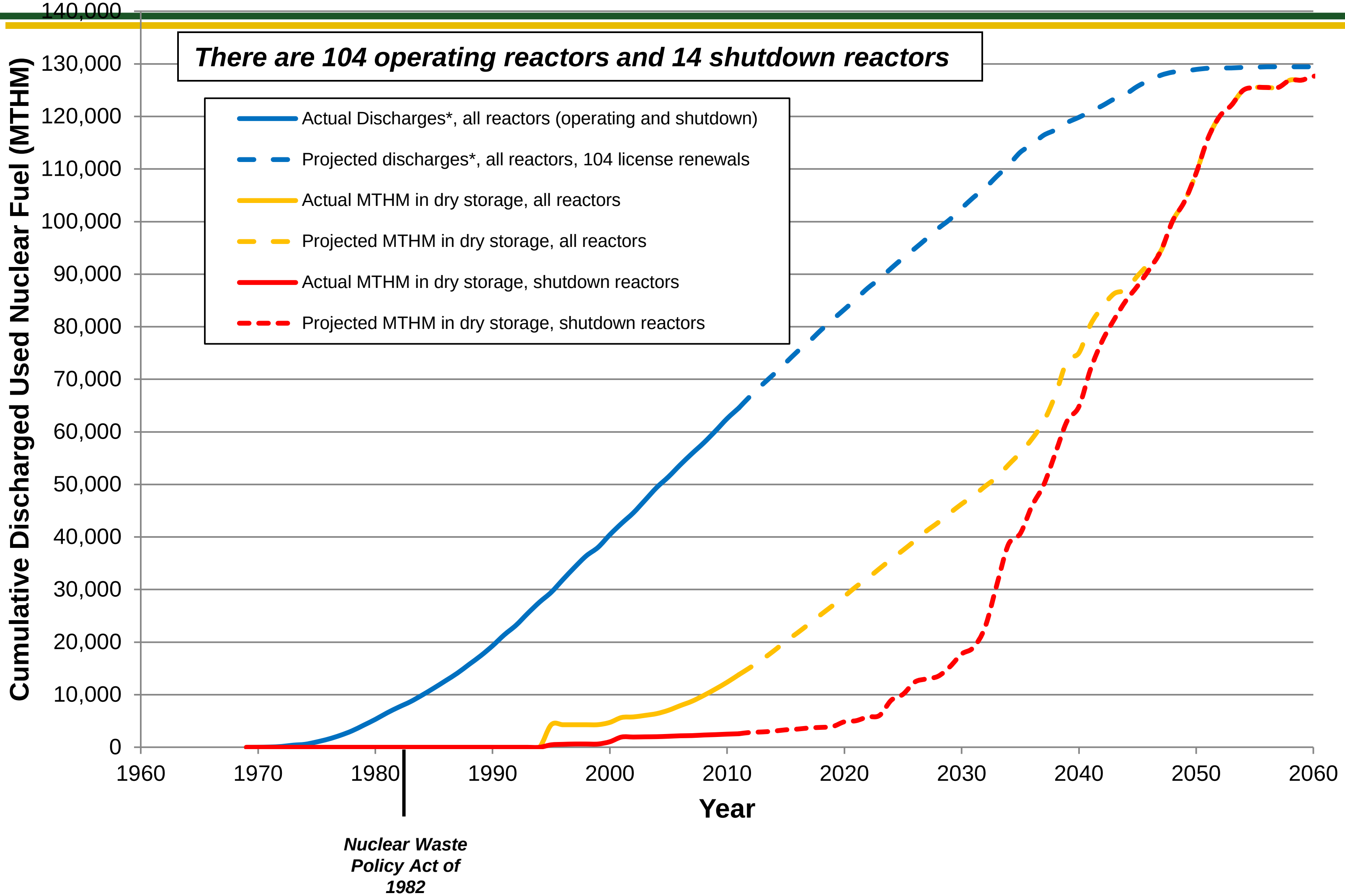
Historical and Projected Commercial Spent Nuclear Fuel Discharges



Source: *Based on actual discharge data as reported on RW-859s through 12/31/02, and projected discharges, in this case for 104 license renewals

DRY FUEL CANISTER CASKS

CASK VENDOR	CANISTER Type	NUMBER OF CANISTERS (12/2011)	TRANSPORT CASK(S)	NUMBER OF FABRICATED TRANSPORT CASKS
FUEL SOLUTIONS	W150	8	TS-125	0
	VSC-24	58	None-Storage Only	-
TN (NUHOMS)	24PT1, 24PT4 24PT	68	MP-187/MP-197HB	1 / 0
	7P, 12T, 24P **24PHB[1], 32P[1]**, 52B	258	None-Storage Only	-
	24PTH, 32PT, 32PTH 61BT, 61BTH	263	MP-197/MP-197HB	0 / 0
NAC	MPC-26, MPC-36	59	NAC-STC	2[2]
	UMS-24	204	NAC-UMS	0
	TSC-37	0	NAC-MAGNATRAN	0
HOLTEC	MPC-24[3], MPC-32 MPC-68, MPC-80	439	HISTAR 100	12

[1] Still being loaded as of 12/2011. All others "Storage Only" canisters have not been loaded in at least the last five years
[2] NAC-STC Casks Fabricated for Offshore Use Only
[3] Includes Trojan 24E/EF

BARE FUEL DRY STORAGE CASKS

	VENDOR	CASK	NUMBER OF CASKS (12/2011)	TRANSPORT LICENSE	LOCATION
ACTIVE CASKS (STILL LOADED)	TN	TN-68	53	71-9239	Peach Bottom
		TN-40	29	71-9313	Prairie Island
LEGACY CASKS (NO LONGER LOADED)	TN	TN-32	63	NO	Surry, McGuire, North-Anna
	GNB	CASTOR V21&X33	26	NO	Surry
	NAC	I-28	2	NO	Surry
	Westinghouse	MC-10	1	NO	Surry

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Current Used Fuel Management Systems are Designed to meet On-site Safety and Cost Considerations

- **Spent fuel disposal in salt, clay, and crystalline geologic media may need smaller package capacities than currently loaded storage and transportation containers**
  - Deep borehole disposal concepts require substantially smaller packages
- **Repackaging fuel after extended storage creates liabilities and uncertainties**
  - Financial
  - Operational
  - Radiological
  - Regulatory
- **Options: modify disposal concepts or develop an integrated cask system that can address storage, transportation, and disposal issues**

Cask capacity comparison (# of assemblies)			
PWR		BWR	
Existing Dry-Storage Cask Systems			
24 – 37		52 – 89 assemblies	
Yucca Mountain TAD			
21		44	
Generic Repository Design Concepts*			
Mined Crystalline	Mined clay/shale	Mined bedded salt	Deep Borehole
4 PWR/ 9 BWR	4 PWR/ 9 BWR	4+ PWR/ 9+ BWR	1 PWR / 1 BWR

* *Generic Repository Design Concepts and Thermal Analysis (FY11)*, FCRD-USED-2011-000143 Rev. 0, August 2011.

Comments on Standardization

- **NWTRB (June, 2011)**
  - The TAD canister program and the previous MPC program were significant steps forward in recognizing the benefit of preventing repetitive handing of bare fuel. The programs also introduced the concept of standardizing container designs.
  - Future programs should consider the TAD canister concept carefully because of its potential safety, handling, system-simplification, and cost advantages. However, the programs should ensure that the sizes of the canisters are compatible with fuel dimensions and the sizes of dual-purpose canisters.
- **Blue Ribbon Commission (July 29, 2011)**
  - promote the better integration of storage into the waste management system, including standardization of dry cask storage systems.
  - include development of the systems analyses needed to provide quantitative estimates of the system benefits of utility actions such as the use of standardized storage systems …
  - The rulemaking should … incentivize actions by contract holders (e.g. use of standardized storage systems) that would reduce overall waste management system costs.
- **BRC, December 2 , 2011 meeting**
  - “While the value is real,” said Meserve, “it is unclear what should be standardized and how. The subcommittee recommended modifying the report to state that standardization is desirable and that voluntary effort should be encouraged.

Comments on Standardization (con't)

- **EPRI (October 31, 2011 to the Blue Ribbon Commission)**
  - EPRI disagrees that the case for "standardizing" dry storage systems has strengthened. Useful "standardization" can only be done with details of the storage and disposal designs in hand.
  - EPRI recommends that the current industry approach of independently selecting storage and transportation systems be maintained.
- **NEI (July 1, 2011 to the Blue Ribbon Commission)**
  - "We do not agree that standardization will necessarily improve the waste management system and reduce overall system costs."
  - "We do not think that dry cask storage systems can be standardized until the requirements for the disposal waste package are specified."
  - "We recommend that the subcommittee provide a recommendation that a new waste management organization strive to dispose of the existing canisters before designing a new standardized canister.
- **FY 2012 Omnibus Budget**
  - Within available funds, $10,000,000 is for development and licensing of standardized transportation, aging, and disposition canisters and casks.
- **NWTRB (December 30, 2011)**
  - The lack of a standardized container design can result in additional complexity at later stages of the waste management system.

Examples of Approaches to Integrating Storage, Transportation, and Disposal

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Direct Disposal of Large Dual Purpose Canisters (DPCs)

- **Direct disposal of DPCs is attractive from the storage and transportation perspective, but…**
- **Direct disposal of 24-37 PWR-assembly DPCs is currently beyond the domestic and international experience base**
  - DPCs are much larger than the 4 PWR-assembly waste package designs under consideration by mature repository programs in saturated geologic media
  - DPCs are larger than the 21 PWR-assembly waste package designs proposed for repositories in unsaturated geologic media
- **Larger size means either substantially higher temperatures or much longer surface storage coupled with alternative repository designs (e.g., open-drift emplacement in unsaturated media)**
  - See following presentation on thermal load management analyses
- **Direct disposal of DPCs represents a potentially significant engineering and scientific challenge**

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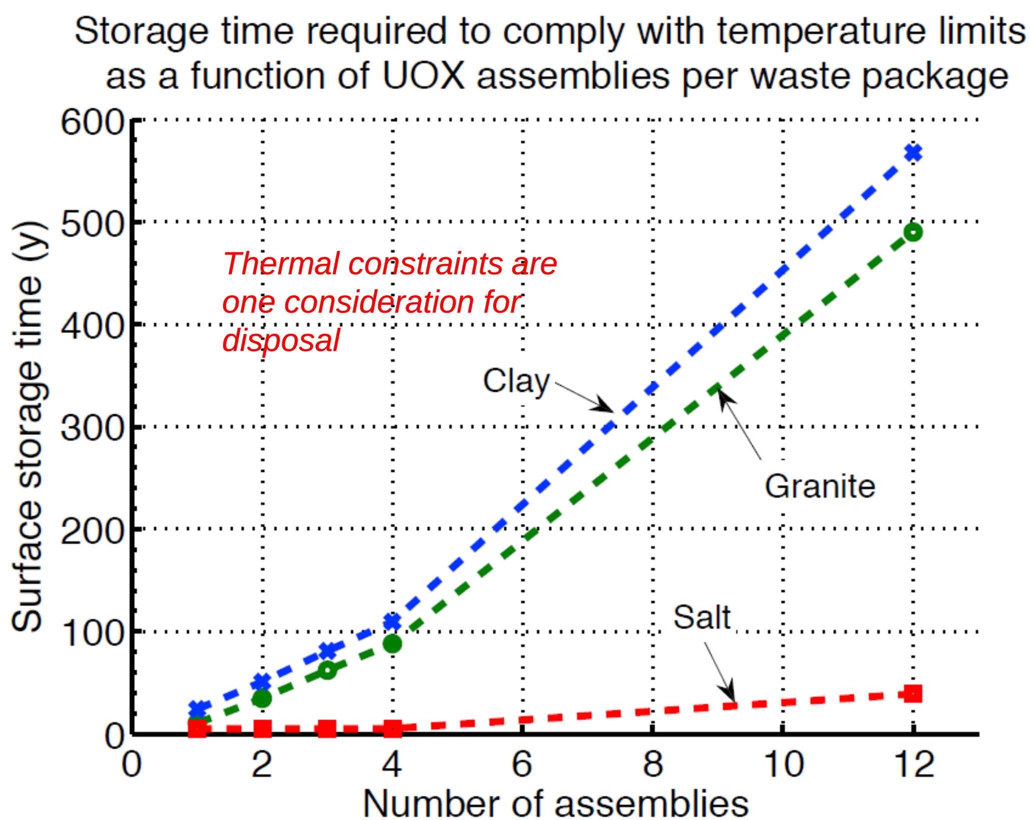
Work Needed to Support Direct Disposal of DPCs

- **Engineering and design work related to handling and emplacement of larger, heavier packages**
  - Ramps vs. shafts
  - Cranes, hoists, transport/haulage mechanisms
  - Hazard and risk assessments to identify safety and regulatory issues
- **High temperature materials R&D**
  - Both engineered and natural materials
- **High temperature geochemistry R&D**
- **Development of coupled T-H-C-M models valid at elevated temperatures**
- **Re-evaluation of approaches for criticality evaluation in performance assessments**
- **Iterative integrated performance assessments and performance allocation to support design evolution**

An Example of Possible Thermal Constraints on Geologic Disposal

- **Potential geologic disposal media have thermal constraints that could limit waste package size and require lengthy decay storage**
  - Presentation by Dr. E. Hardin to follow
- **This will have system-level impacts**
  - Large storage canisters may not be “disposable” without different disposal concepts
    - *Need to analyze “what it would take”*
  - Potential need to re-package
    - *When, where, how*



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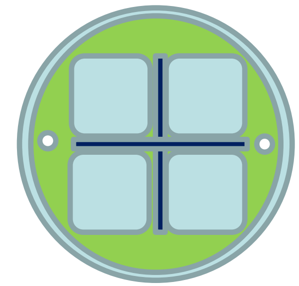
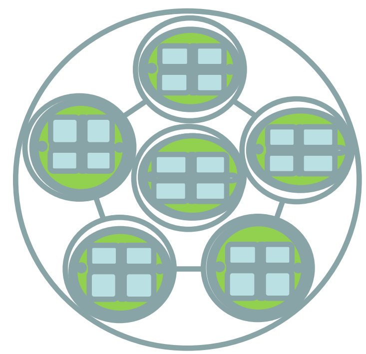
Integrated Canister-in-Canister Concept (representative example from ORNL)

Flexible Integrated Modular Nuclear Fuel Storage, Transportation, and Disposal Canister System (FIRST)

- Multi-modal use and flexibility in all operations while working within existing utility framework
- Unique design features to accommodate future, current, and past proposed disposal concepts
- Allows direct disposal (similar to YMP TAD concept)
- Many secondary benefits
  - *Including improved characteristics to accommodate extended storage*
- Repackaging could be done at a consolidated interim storage facility

Small canister provides flexible disposal options





Small canisters in larger canister for storage and transportation

Effort Initiated in FY12 in UFDC to Evaluate Integrated Canister Concept

- **Multiple national laboratories involved, led by ORNL**
- **FY12 activities**
  - Develop drawings for design iterations
  - Evaluate operational aspects
    - *Design and operational options will be explored to minimize impact on current cask loading processes, durations and cost*
      - Welding versus bolting lids
      - Drying process
  - Perform initial evaluations to demonstrate compliance and, where applicable, benefits relative to criticality, shielding, thermal, confinement, and structural requirements
  - Develop cost basis analysis
- **The concept is not proposed as "the solution": it's input to the decision-making process**

System-level Analyses to Inform Decision-Making

DOE's UNF Management System Architecture Evaluation

- **The BRC's July 29 draft report to the Secretary of Energy recommends prompt efforts be undertaken to develop one or more consolidated storage facilities and one or more geological facilities**

- **The Nuclear Waste Technical Review Board has provided input and comments to the BRC recommending that a "systems" approach to radioactive waste management be undertaken both when considering consolidated interim storage of used nuclear fuel and for evaluating advanced nuclear fuel cycles**
  - June 30, 2011 correspondence to the BRC
  - October 31, 2011 correspondence to the BRC

- **The U.S. DOE has initiated system-level analyses of the back-end of the nuclear fuel cycle pertaining to the management of used nuclear fuel from the current LWR fleet**

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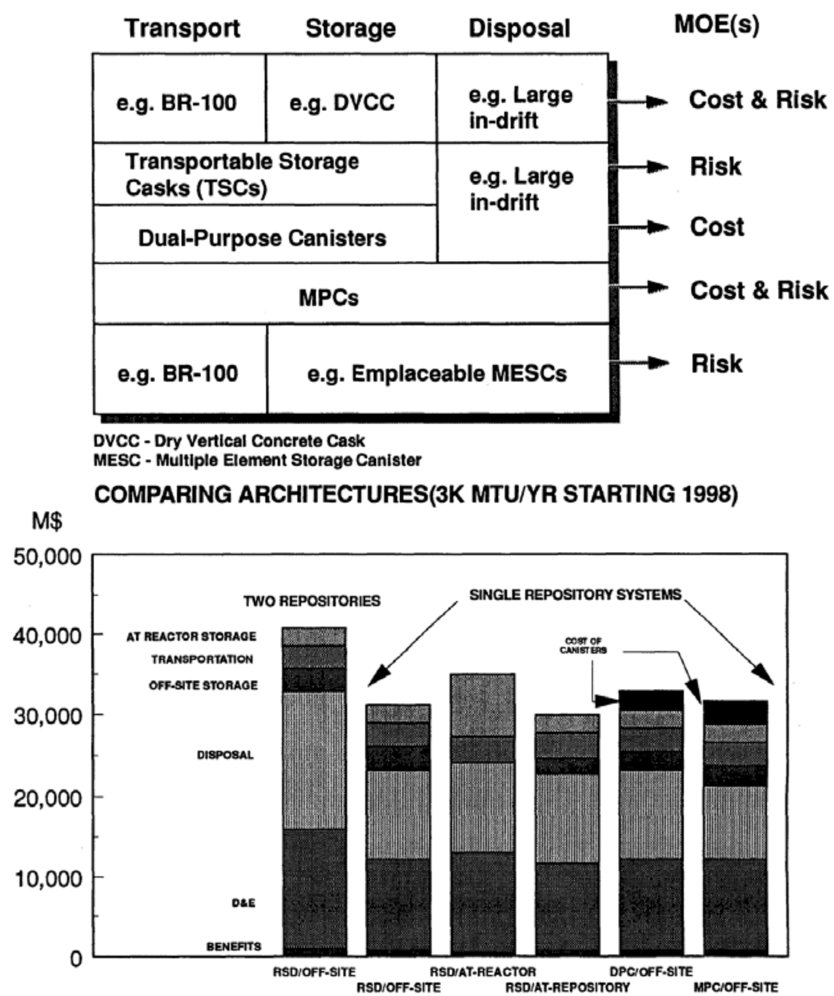
UNF Management System Architecture Evaluation – Past Work

- **In the 1990s the U.S. DOE completed a number of systems analyses investigating consolidated interim storage as part of the waste management solution**
- **These analyses are "dated" and conditions have changed**
  - Utility evolution and progress loading dry storage systems
  - Consideration of different geologic disposal environments
- **Need to update back-end system architecture studies**
- **Need to update tools for evaluating the back-end of the fuel cycle**



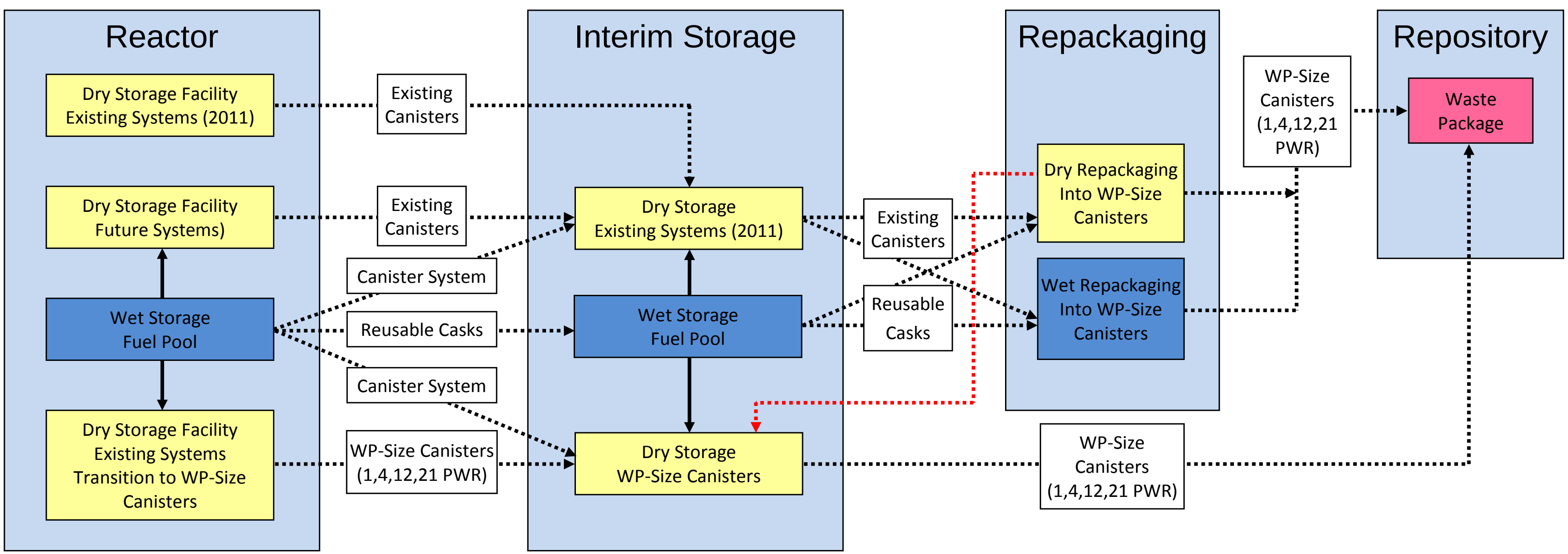
System Architecture Study, July 26, 1994.

UNF Management System Architecture Evaluation – Current Work

- Evaluate an integrated approach to transportation, storage, and disposal in the waste management system with an emphasis of providing flexibility to respond to unknown situations and developments
- Evaluate the implications of the current strategy for on-site storage of used nuclear fuel in large dry storage systems on the subsequent direct disposal of the stored used nuclear fuel in salt, clay/shale, and crystalline mined geologic repositories and in deep boreholes
- Alternative strategies and approaches for managing the used nuclear fuel will be identified and evaluated to identify potential benefits in cost and flexibility
- Factors including emplacement capability, thermal constraints, the need for re-packaging techniques, storage alternatives, transportation, impacts on utility operations, etc. will be considered
- Measures for flexibility and rough order of magnitude cost factors associated with each alternative included in the evaluation

Architecture Study will utilize Logistic Simulation Tools

- Transportation-Storage-Disposal Logistics Model (FY12)
  - Combine features of existing codes CALVIN & TSM (OCRWM) and TOM (ORNL)
  - Support system engineering and resource estimation scenarios



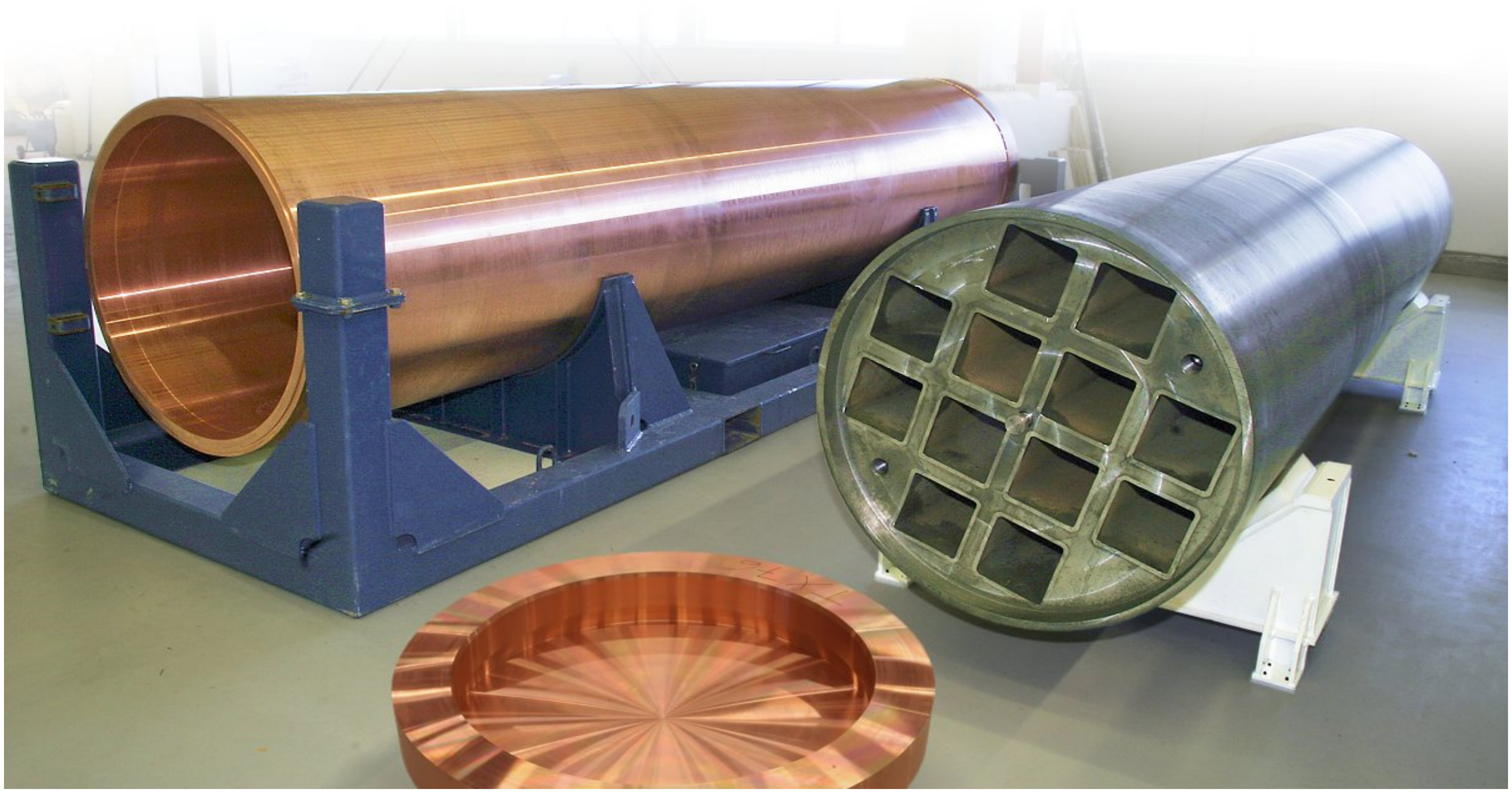
Summary

- **Current approaches to the management of used nuclear fuel may not provide the optimal solution for efficient storage, transportation, and disposal options**
  - Large casks are effective for storage
  - Small waste packages provide more disposal options
- **Reliable analyses that integrate across storage, transportation, and disposal are needed to support decision-making**
  - a system architecture study will evaluate options for operating a waste management system
- **The DOE Office of Used Fuel Disposition has initiated thermal load management analyses to evaluate disposal options for used nuclear fuel and high-level radioactive waste**
  - Discussed in detail in the next presentation
- **Agreement on an approach to standardizing storage containers that are compatible with transportation and disposal requires integration**

Backup Graphics

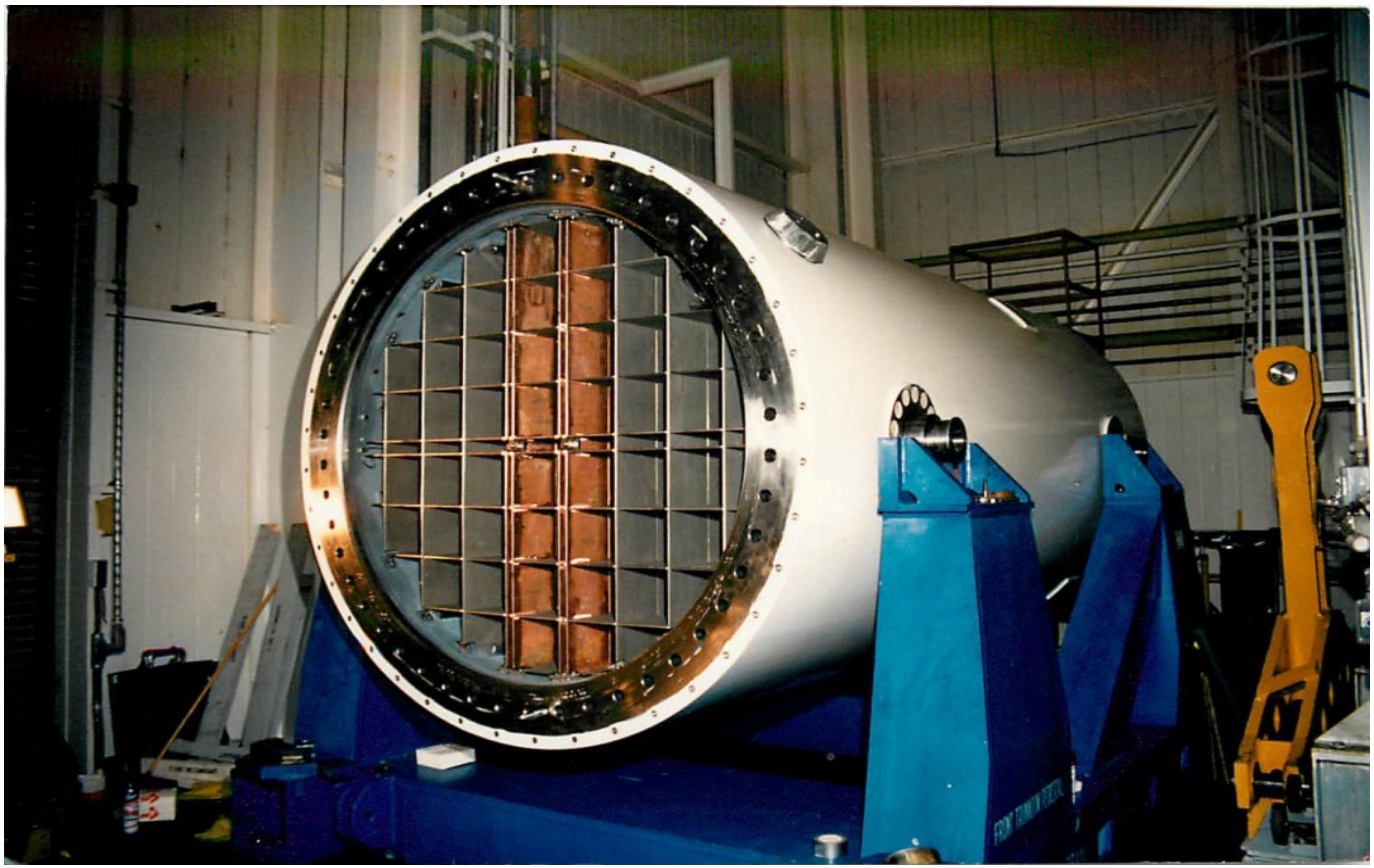
Swedish Disposal Container

12 BWR/9 PWR
SNF assemblies



NAC Transportation Cask

TN-40
Transportation/Storage Cask



Fort St. Vrain Storage Vault

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Nuhoms Storage Canister

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Nuhoms transfer cask and storage modules