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Nuclear Fuels Storage & Transportation Planning Project
Office of Fuel Cycle Technologies
Nuclear Energy

Considerations for Disposition of Dry Cask Storage System Materials at End of Storage System Life

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Nykopiong Sweden
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Caveat lector: Standard Contract between utilities and DOE (10 CFR 961)

- ***This is a technical presentation that does not take into account the contractual limitations under the Standard Contract***

- ***Under the provisions of the Standard Contract, DOE does not consider spent fuel in canisters to be an acceptable waste form, absent a mutually agreed to contract modification***

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End of life dry cask/canister storage system disposition: Why, Where, When, and How all Matter

- **Canister repackaging could be required for several reasons (why):**
  - Some storage systems in use are not certified for transportation (see Williams' presentation)
  - Repository constraints (e.g., thermal, criticality)
- **Repackaging is complicated (how):**
  - Increases total fuel-handling operations
  - Complicates pool operations and increases worker doses if performed at reactor sites
  - Requires development and deployment of on-site repackaging systems if performed at shut-down reactor sites
  - Will generate additional low-level waste including discarded dry storage canisters
  - Repackaging facility as part of an integrated waste management system may be appropriate
- **Repackaging could be reduced or eliminated provided (when, where):**
  - Direct disposal of existing dry storage canisters is proven acceptable
  - Standard storage, transportation and disposal canisters are developed and deployed

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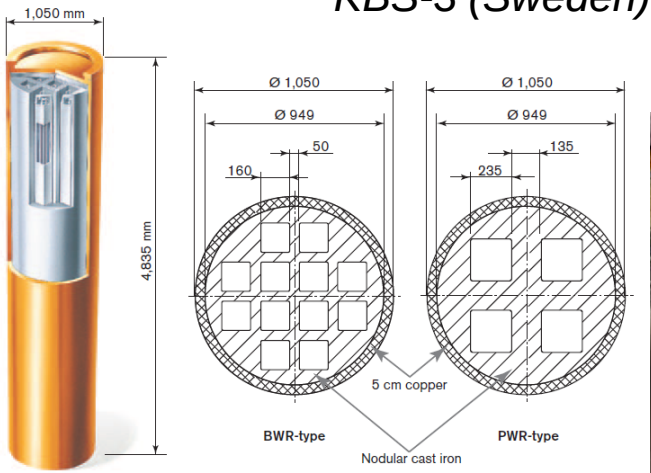
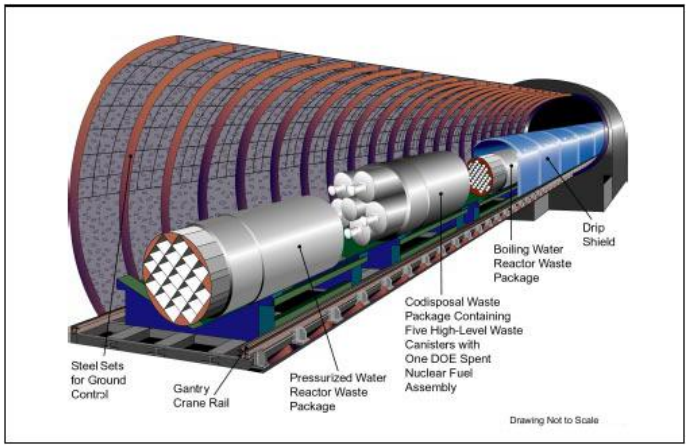
Canisters Considered in International Disposal Programs are Considerably Smaller than US Dual-Purpose Canisters

KBS-3 (Sweden) waste package
12 BWR / 4 PWR



Empty 64 BWR Dual Purpose Canisters

Swiss disposal concept (Nagra) mockup at the Mont Terri URL
4 PWR



Volcanic Tuff TAD
21 PWR / 44 BWR

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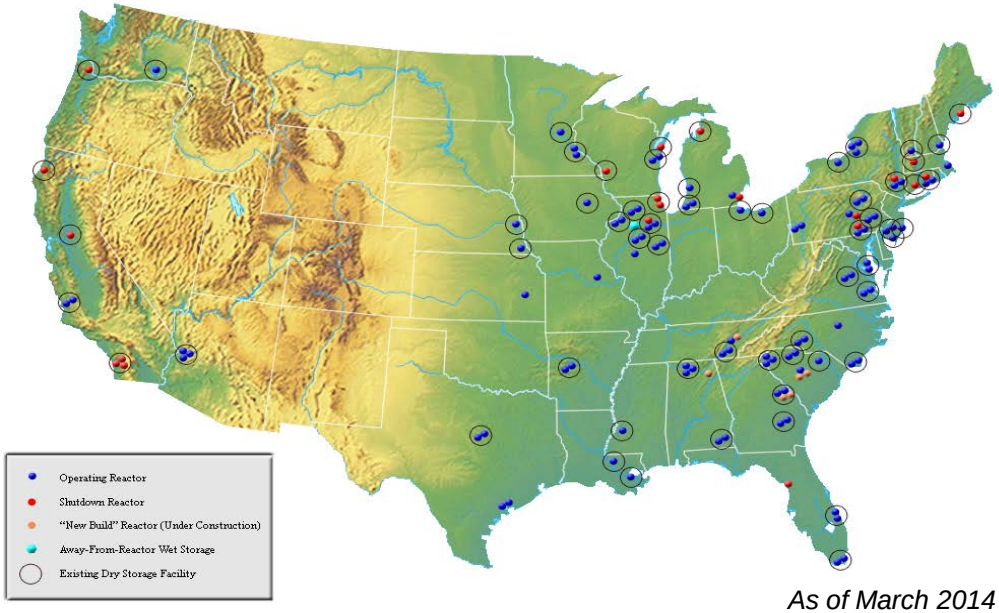
U.S. Commercial Nuclear Reactors History and Location – bases for inventory projections



As of March 2014

- **120 Nuclear Power Reactors (NPR) Built and Operated (incl. Shoreham)**
- **100 in Operation as of November, 2013**
  - *2 Operating NPR have announced "Early Shutdown" dates of 2014 and 2019*
- **2 NPR Nearing Completion**
- **4 New Build NPR**

- **10 NPR on 9 sites shutdown prior to 2000 with only fuel management activities on site and some decommissioning activities ongoing**
- **1 NPR disabled and UNF owned by DOE (Three Mile Island unit 2)**
- **3 NPR permanently shutdown on sites with continued nuclear operations**
- **4 NPR on 3 sites ceased operations or restart activities in 2013**
  - 5 NPR total are shutdown on these sites

NFST NUCLEAR FUELS STORAGE & TRANSPORTATION

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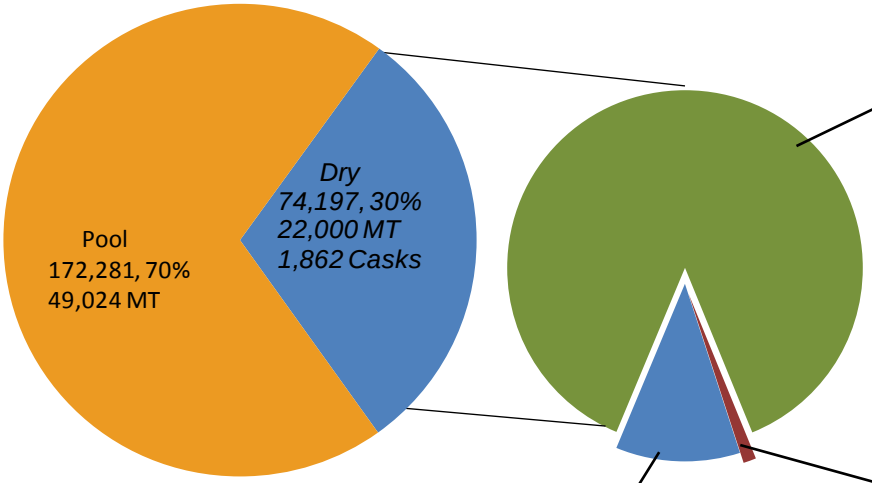
The current inventory of dry storage systems in the United States is large



1,687 Welded Metal Canisters In Vented Concrete Overpacks
65,102 Assbly,
87.5% of Dry

Transnuclear (34%)
Holtec (41%)
NAC (10%)

13 Welded Metal Canisters in Transport Overpacks
866 Assbly, 1.2% of Dry

191 Bare Fuel Cask
8,406 Assbly , 11.3% of Dry

Transnuclear TN-32

Holtec HiStar 100

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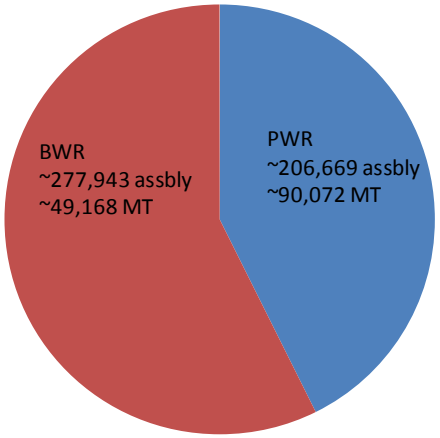
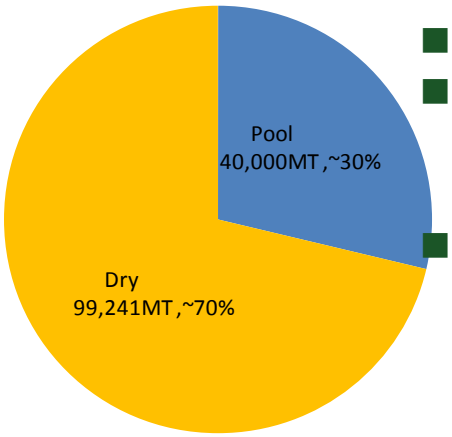
Potential Inventory Estimated at 2060, Reference Scenario, No NPR Replacement

Potential Inventory at 2060
No NPR Replacement Reference Scenario



Potential Inventory at 2060
Storage Method



- Current pool storage is ~50,000MT
- Early reactor shutdowns assumed to reduce the combined pool capacity to ~40,000MT
- Balance of fuel moved to dry storage
  - Assumes no incentive to reduce the pool Inventory

- Reference Scenario No Replacement NPR – Potential Inventory Includes:
  - Shutdown reactor UNF
  - Announced “early shutdown” reactor UNF for NPR not planning to operate 60 years
  - Remaining NPR assumed to get a single license extension and operate for 60 years
  - New builds are not included

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The number of canisters that have to be have to be dispositioned depends on UNF management strategy and facility availability

- **Potentially package or re-package ~206,000 BWR and ~277,000 PWR fuel assemblies**
- **Earlier facility availability (when) and higher acceptance rates and use of bare fuel transporation systems will mitigate the issue**

	Acceptance Rate (MT/yr)	Acceptance Start	PWR Canisters	BWR Canisters	Total Canisters
Canistered Fuel Transport	1500	2020	6998	4210	11208
	3000	2020	6974	4190	11164
	6000	2020	6964	4183	11147
	1500	2035	7017	4223	11240
	3000	2035	7001	4216	11217
	6000	2035	7000	4208	11198
Bare and Canistered Fuel Transport	1500	2020	5145	3051	8196
	3000	2020	3190	1916	5106
	6000	2020	1712	1056	2768
	1500	2035	6326	3728	10054
	3000	2035	5315	3232	8547
	6000	2035	4094	2535	6629

Need to open, empty, and disposition these canisters to re-package fuel into these disposable canisters

	4-PWR/9-BWR	12-PWR/24-BWR	21-PWR/44-BWR
PWR Waste Packages	52,250	17,417	9,952
BWR Waste Packages	30,333	11,375	6,205
Total Waste Packages	82,583	28,792	16,157

Repository constraints and timing drive size

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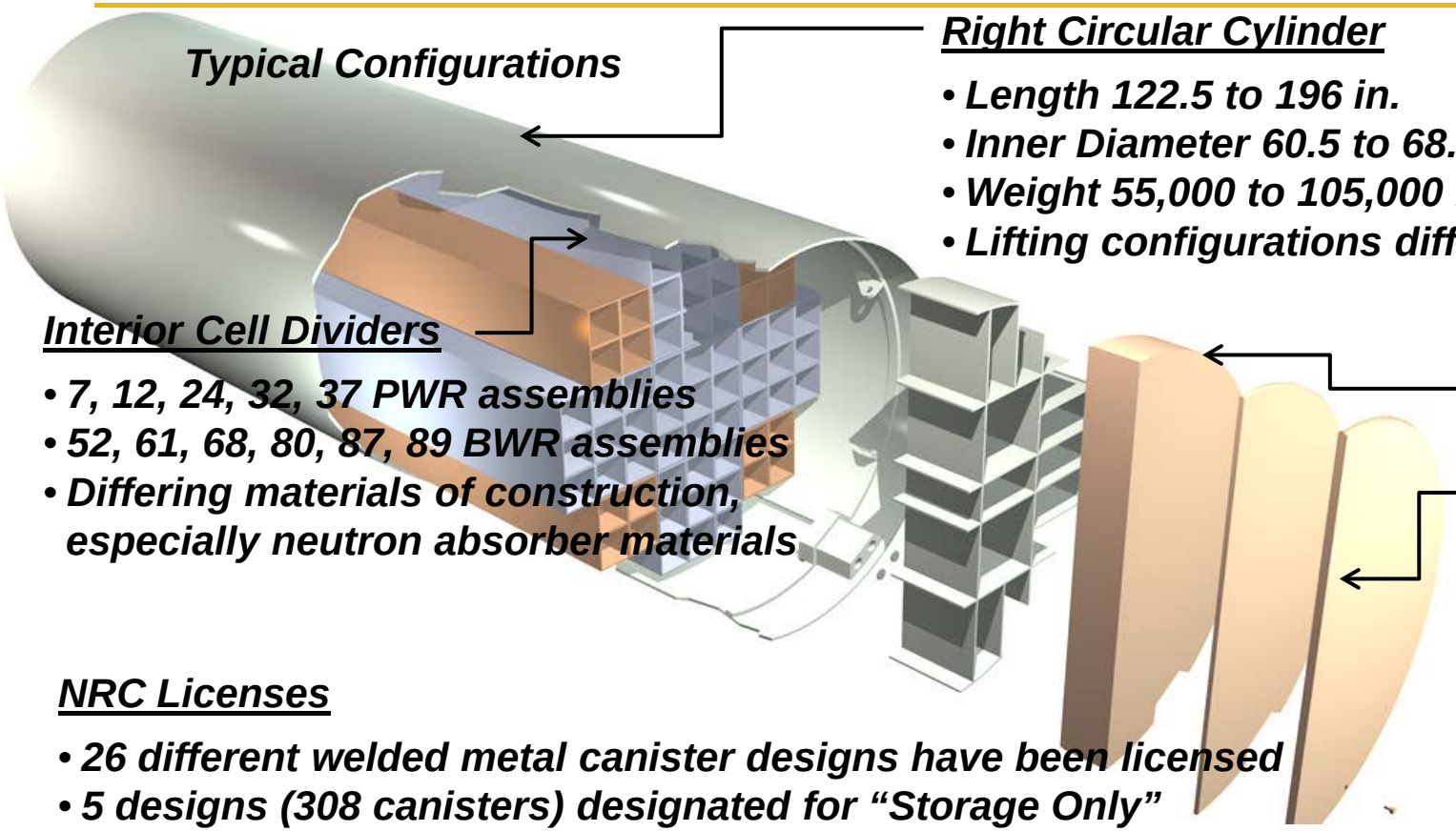
The canister configurations and materials that must be dispositioned is diverse



Typical Configurations

Right Circular Cylinder

- *Length 122.5 to 196 in.*
- *Inner Diameter 60.5 to 68.75 in.*
- *Weight 55,000 to 105,000 lbs.*
- *Lifting configurations differ*

Interior Cell Dividers

- *7, 12, 24, 32, 37 PWR assemblies*
- *52, 61, 68, 80, 87, 89 BWR assemblies*
- *Differing materials of construction, especially neutron absorber materials*

Shield Plug

Welded Cover Plate

NRC Licenses

- *26 different welded metal canister designs have been licensed*
- *5 designs (308 canisters) designated for "Storage Only"*
- *21 designs are "Storage and Transportation"*
- *None are licensed for disposal*
- *Allowable failed fuel canisters varies by design from 4 upwards*

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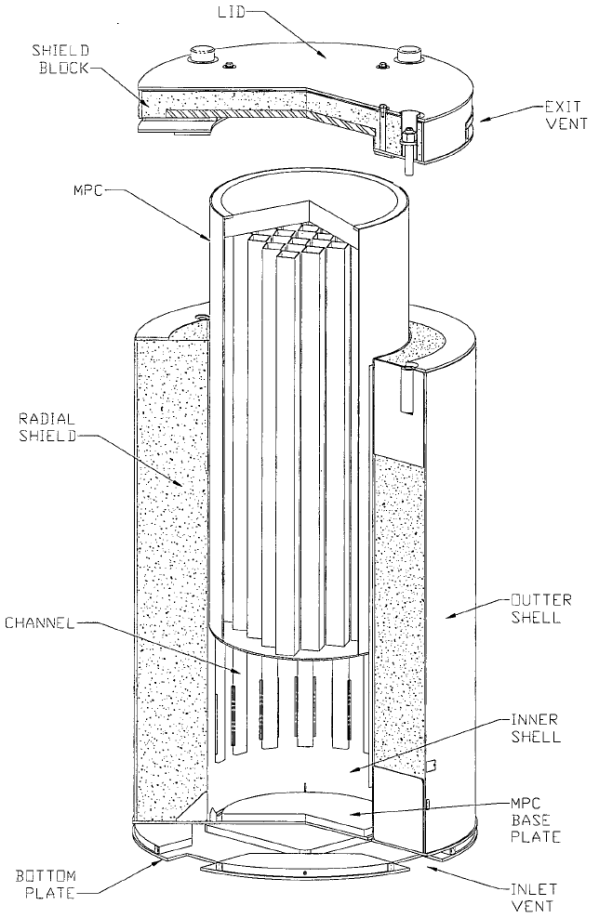
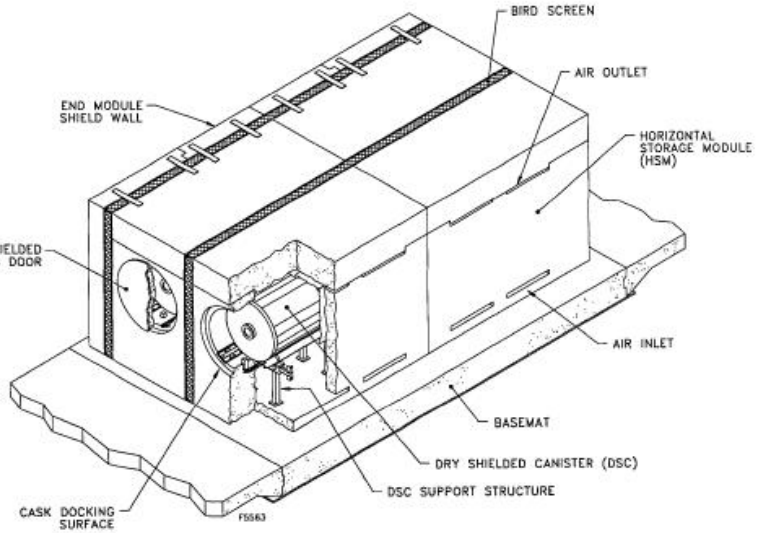
Above grade vented storage overpacks and modules are most widely deployed

Typical vertical cask at grade Holtec and NAC



Holtec HI-STORM

Loaded vertical storage systems at Trojan ISFSI



Transnuclear Horizontal Storage Module

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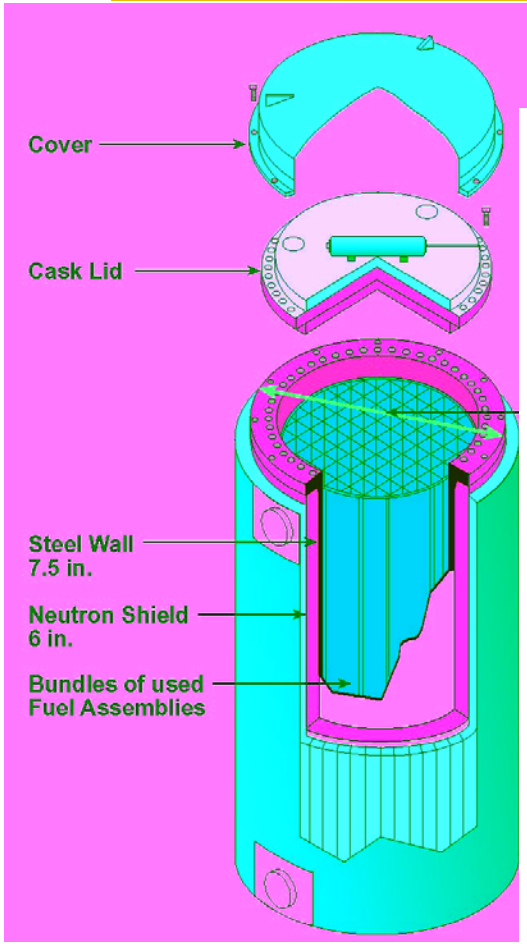
Bare fuel in bolted casks represent a smaller portion of the existing inventory in the United States



TN-68 Configuration

- ***4 Vendors have provided bare fuel casks***
  - *Westinghouse MC-10*
  - *GNB Castor V21/V33 (cast iron body)*
  - *NAC I-128*
  - *Transnuclear TN-32, TN-40, TN-40HT and TN-68*

  Transportation of Legacy Casks is Challenging
- ***Physical configuration varies***
  - *Length from 175 to 215 inches*
  - *OD from 94.8 to 110.25 inches*
  - *Weight from 230,000 to 250,000 lbs*

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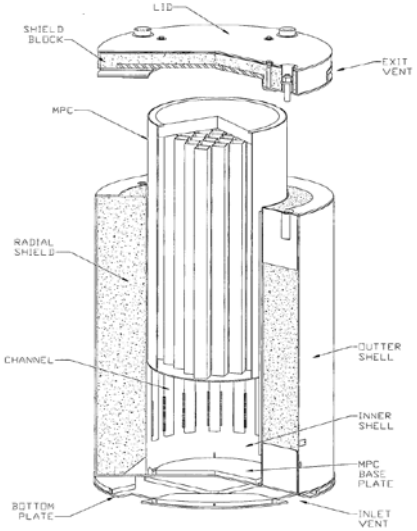
Empty DSC, Storage Overpack, & Repackaging Process Waste and Materials Must Be Managed

- **DSC-Related Materials**
  - Typical Wastes:
    - DPC itself
    - DPC basket and other internals
    - DPC shield plug and lids
  - Characteristics:
    - Low specific activity waste
    - Surface contaminated objects
    - Dependent on fuel characteristics and loading/unloading activities



- **Storage Overpack could be:**
  - Free released for recycling (no contamination expected)
  - Reused for at-reactor UNF storage (in DSC)
- **Process Wastes depend on repackaging method and equipment**

Source: AREVA

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DSC Reuse, Repurpose, Recycle

- **Reuse for packaging of Used Nuclear Fuel, HLW, or Greater than Class C (GTCC) Wastes**
  - Cutting activity must be on lid and not shell
  - DSCs that are certified for transportation (DPCs) can be used again to ship UNF from reactor sites to ISF/repository
  - Requires some decontamination of interior surfaces
  - Requires re-certification after cutting (new or reconditioned lids)
- **Repurpose for disposal of Low Level Waste (LLW)**
  - Cutting activity must allow for DSC to be resealed (e.g., no jagged or diagonal cuts)
  - Likely need to remove DSC basket and reduce for disposal
  - No decontamination would be necessary
- **Recycle for scrap metal or production of STAD**
  - Chemical cleaning (e.g., with oxalic acid)
    - Removes surface contamination
    - Produces cleaning agent waste, which itself can be treated and result in resins
  - Free release criteria needed for recycle to scrap metal
  - Extensive scanning needed to ensure release criteria are satisfied
  - Size reduction necessary and should be performed after decontamination

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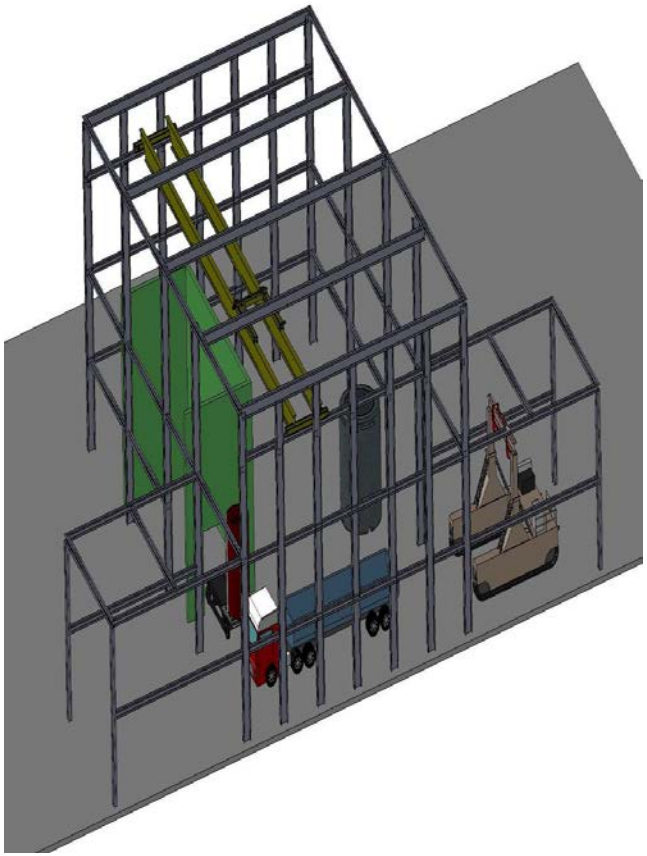
Empty Canisters: Systems will be needed for Material Management

- **Heavy load-handling capability**
- **Radiation dose surveying**
- **Cutting and removal of canister baskets**
- **Decontamination of internal canister surfaces (e.g., CO_2 ice blasting)**
- **Size reduction (wire cutting)**
- **Processing throughput**
- **Transportation interface**
- **Consider remelt and reuse in the fabrication of disposal canister (off site DD)**



Source: CBI

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Disposal without recycle could be costly; costs will increase as the inventory increases over time

Direct Disposal may be necessary

- Reuse: little demand to reuse a non-disposable canister

  Repurpose: must meet free release criteria NRC IE Information Notice 85-95
- Recycle: consider melting down and reusing in the fabrication of disposable canisters

Low Level Waste

- Approximately 350 cubic feet of LLW/ DSC
- Disposal cost range $200-$1000 per cubic foot (Class A LLW)