# Implications of Repackaging Used Nuclear Fuel

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**U.S. Nuclear Waste Technical Review Board Technical Workshop on the Impacts of Dry-Storage Canister Designs on Future Handling, Storage, Transportation, and Geologic Disposal of Spent Nuclear Fuel in the U.S.**

**Washington, D.C.**
**November 18-19, 2013**

# 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***

# Considerations for Repackaging: Why, Where, When, and How all Matter

- **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) (see Bonano presentation)
- **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
  - Generates 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

# Repackaging Requires Substantial Effort and (Possibly) Facility or Facilities

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- **Potentially package or re-package ~206,000 BWR and ~277,000 PWR fuel assemblies**
- **Canisters that would have to be opened depends on UNF management strategy (where), acceptance rates (how), and start dates (when)**

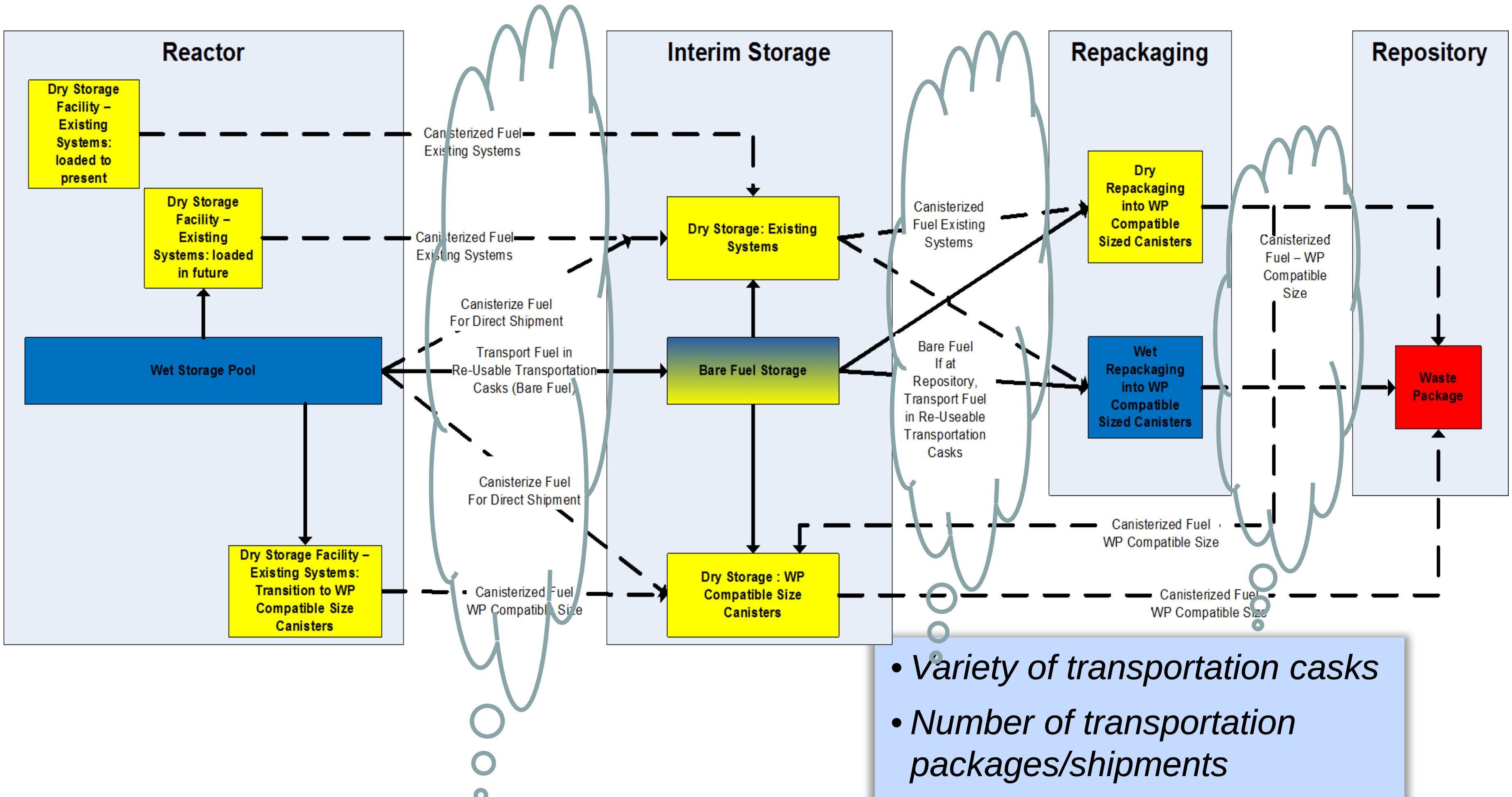
| | Acceptance Rate (MT/yr) | Acceptance Start | PWR Canisters | BWR Canisters | Total Canisters |
|---|---|---|---|---|---|
| Canistered Fuel Transport | 1500 | 2020 | 6998 | 4210 | 11208 |
| | 3000 | 2020 | 6974 | 4190 | 11164 |
| | 6000 | 2020 | 6964 | 4183 | 11147 |
| | 1500 | 2035 | 7017 | 4223 | 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 cut open these dual-purpose 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*

# Where Repackaging Occurs Matters for Transportation System Functions and Requirements




- *Variety of transportation casks*
- *Number of transportation packages/shipments*
- *Fleet makeup and size*

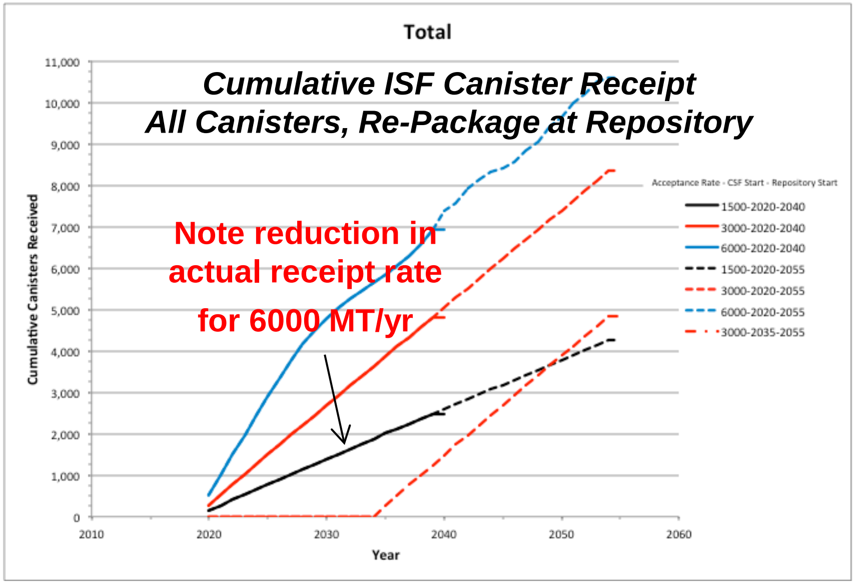
# Where Repackaging Occurs Matters for Regulatory Criteria Imposed on Canister Design and Facility Operations

## Regulations

- **10 CFR 20 “Standards for Protection Against Radiation” (all)**
- **10 CFR 50 “ Domestic Licensing of Production and Utilization Facilities” (at reactors)**
- **10 CFR 72 “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste and Reactor Related Greater than Class “C” Waste” (reactors, ISFSIs, ISF)**
- **10 CFR 71 “Packaging and Transportation of Radioactive Material” (at utility, at CSF, but not at repository)**
- **10 CFR 6X “Disposal…”(at utility, at CSF, at repository)**

# Implications of Repackaging: System Acceptance and Throughput Requirements Matter Everywhere

- **Required system throughput rates may not be achievable at utilities without changing current canister loading and unloading practices**
- **At an ISF or a repository, processing rates and inventories in storage scale with UNF acceptance rate**
  - Larger rates → larger facilities
  - Larger capital and annual operating funding
- **High acceptance rates (i.e., 6000 MT/yr) lead to large facilities and supporting infrastructure**
  - Large capacity storage facilities
  - High processing capability that may only be needed for a relatively short time; under-utilized facilities
    - Available fuel transported relatively quickly; rate then matches discharge



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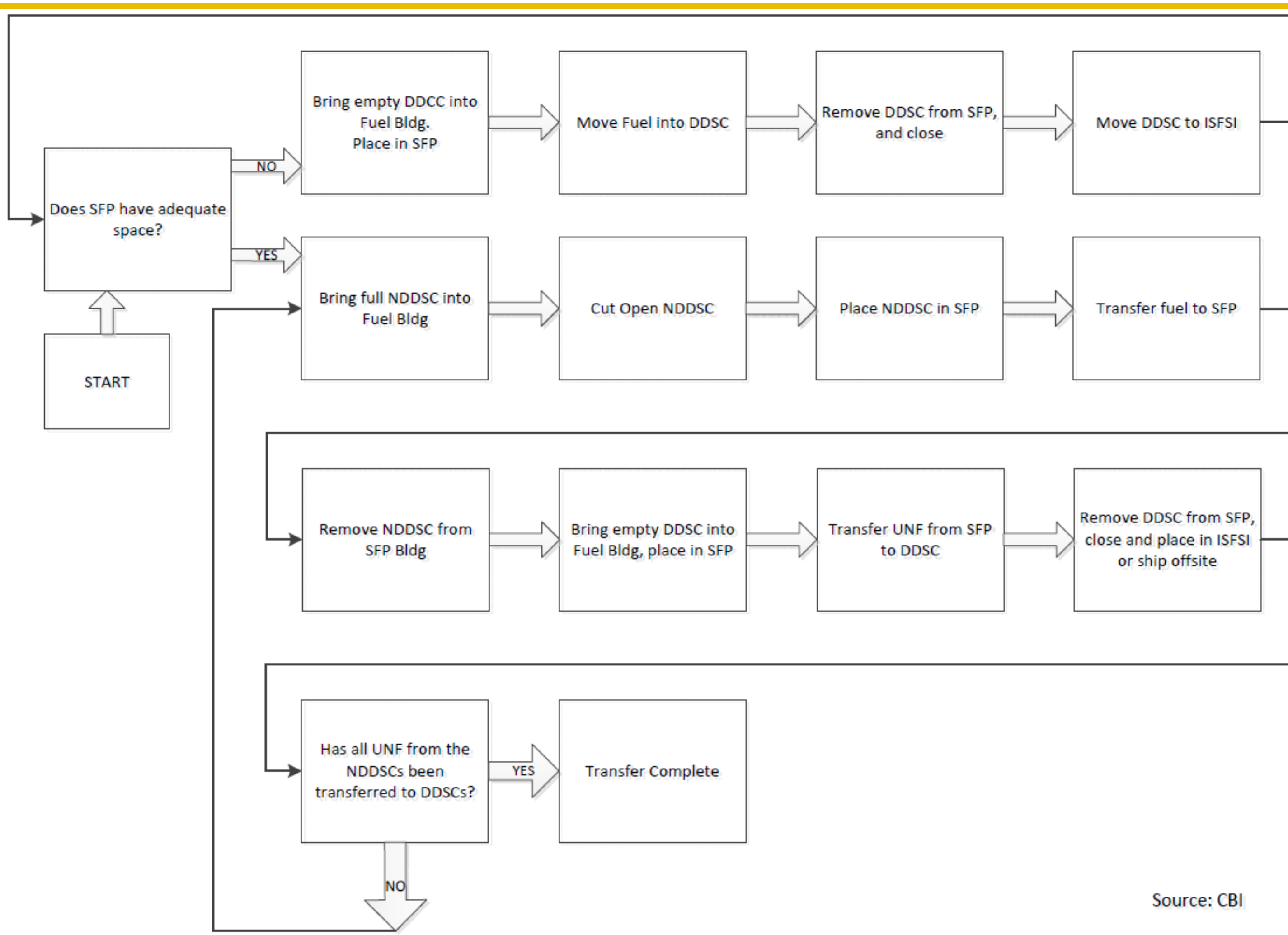
# Repacking Process Flow at an Operating Reactor Site




Source: CBI

# Repackaging at Operating Sites: It will Impact Operations

*Source: CBI*

- Extends Time for Cask Loading Activities
- Impacts Support Personnel Availability
  - Plant Operators (SFP Level Control)
  - Engineers (Technical Support)
  - Security Officers (Cask Movements)
  - Reactor Services Technicians (Fuel Loading, Cask Processing, Cask Transport)
  - Radiation Protection Technicians (Dose Measurements, Contamination Surveys, and Decontamination Services)
- Competition for Space and Resources
  - New Fuel Receipt
  - Refueling Outage Preparation and Execution
  - Spent Fuel Pool Clean-Out Campaigns
  - Nuclear Fuel Inspection
  - Refueling Bridge and Crane Maintenance and Testing
- Increases Low-Level Radwaste Stream
  - Debris Generated by the Cutting Activity
  - Discarded Legacy Canisters and Overpacks
- Increases Collective Radiation Exposure (Dose)
- Increases Training Burden to the Site

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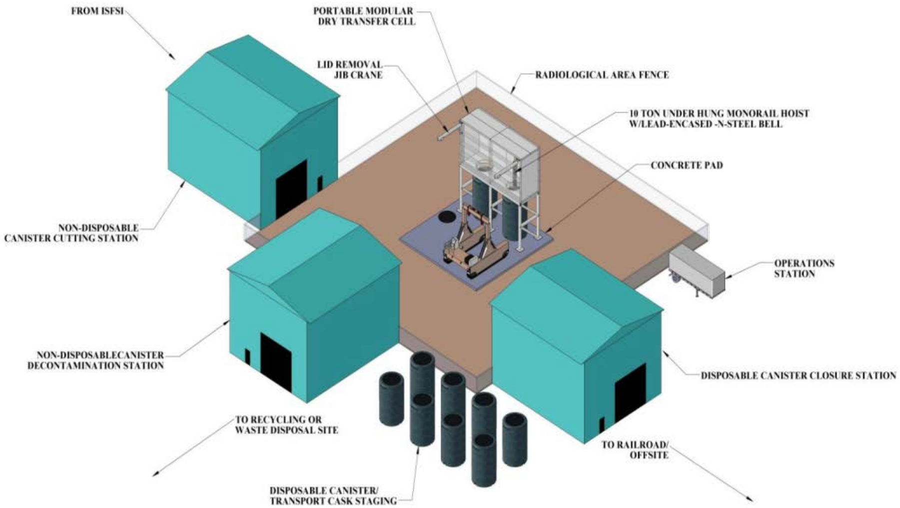
# Repackaging at Shutdown Sites without Pool Access Requires Facility Design and Construction

*Source: AREVA and CBI*




- *Mobile hot cells could be designed and deployed*
- *Facility license needs to cover repackaging operations*
- *Site prep work required for each site*
- *Impacts transportation planning and logistics*
- *Overall system throughput could be an issue*
- *Use of a repackaging facility at an ISF or Repository might be more palatable*



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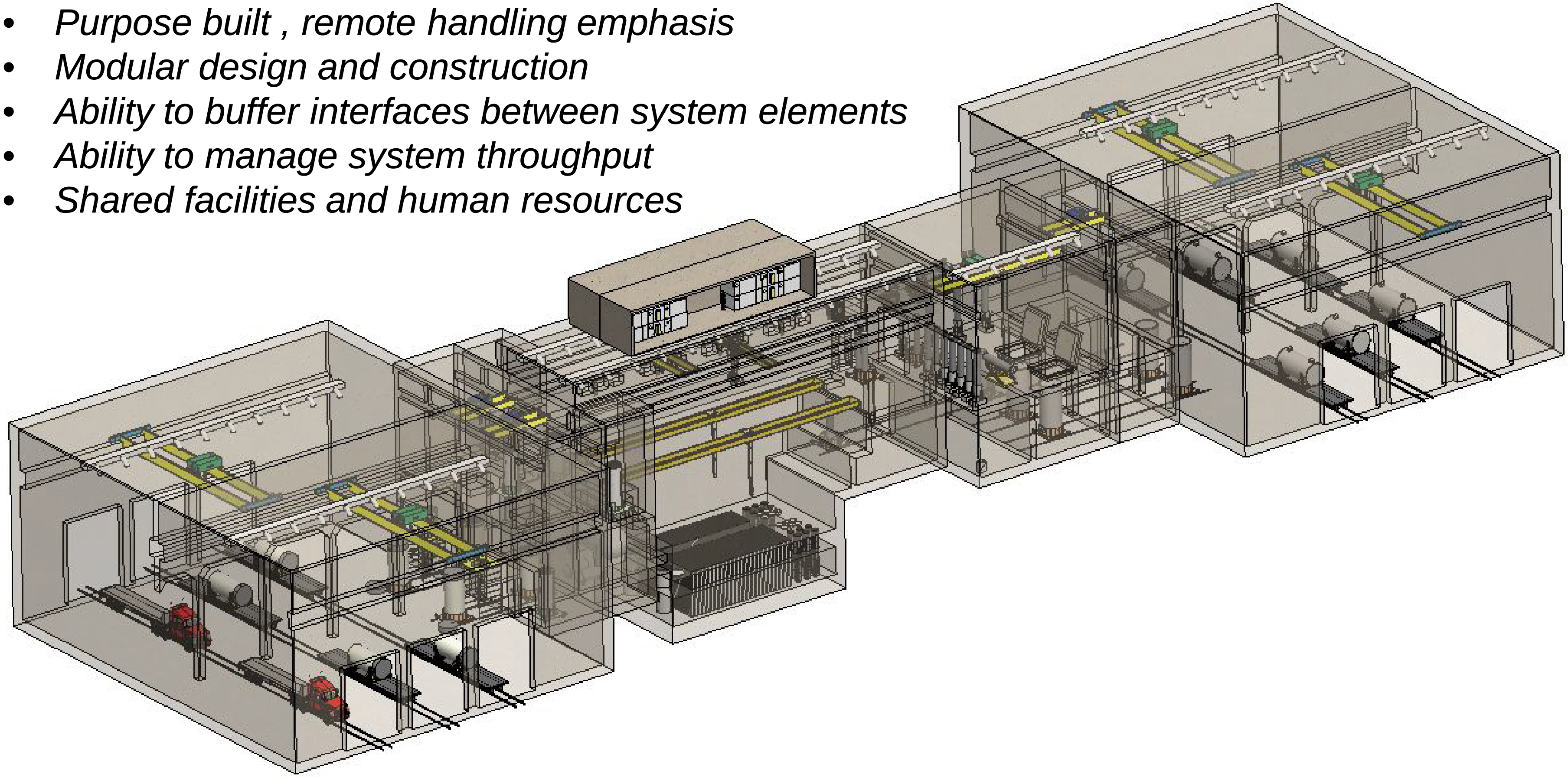
# Repackaging Facilities at an ISF or Repository Offer System Flexibility

- *Design and Ops must conform to Part 72 and/or Part 6X*
- *Purpose built , remote handling emphasis*
- *Modular design and construction*
- *Ability to buffer interfaces between system elements*
- *Ability to manage system throughput*
- *Shared facilities and human resources*



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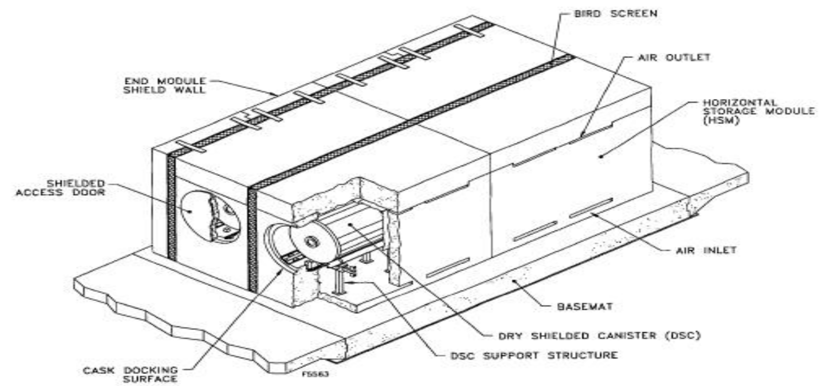
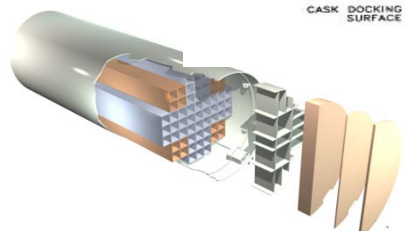
# Empty DSC, Storage Overpack, & Repacking Process Waste and Materials Must Be Managed




## ■ DSC-Related Materials

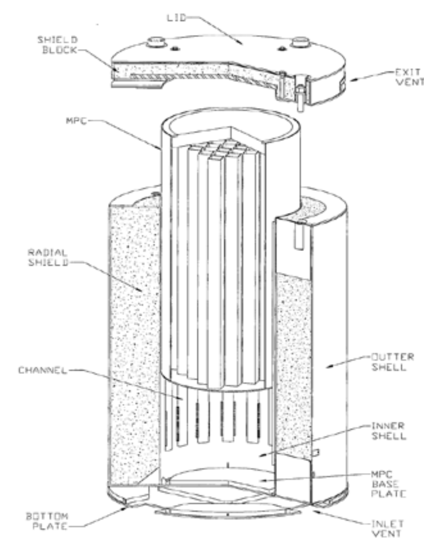
- Typical Wastes:
  - DPC itself
  - DPC basket and other internals
  - DPC shield plug and lids
- Characteristics:
  - Low specific activity waste
  - Surface contaminated objects
  - Dependent on fuel characteristics and loading/unloading activities



## ■ 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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# Empty Canisters: Material Recovery and Waste Management

*Sources: CBI AREVA NFST*

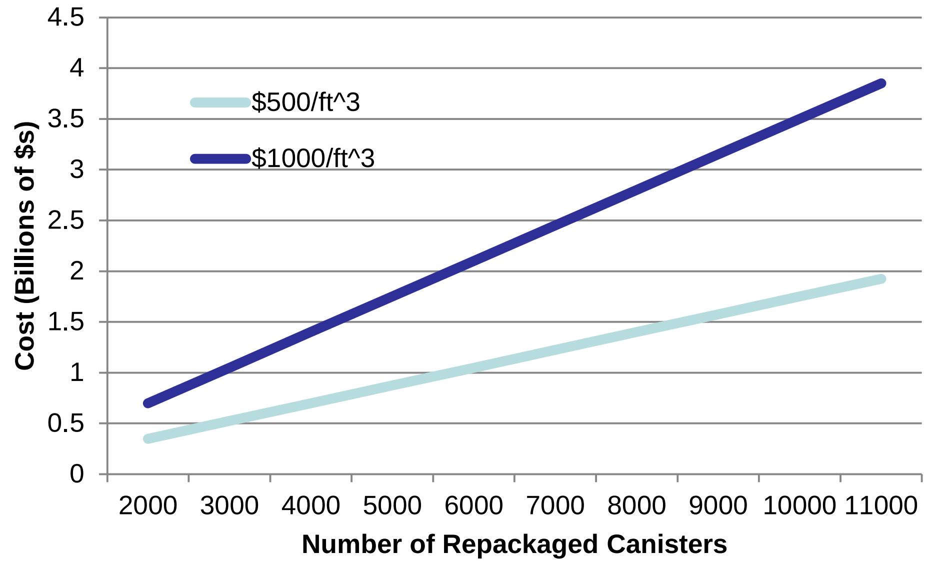
## Reuse, Repurposing, Recycling and Direct Disposal

- 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
- Direct Disposal: portions of the DSC cannot be decontaminated – disposed of as low level waste

## Low Level Waste

- Approximately 350 cubic feet of LLW/ DSC
- Disposal cost range \$500-\$1000 per cubic foot (Class A LLW)



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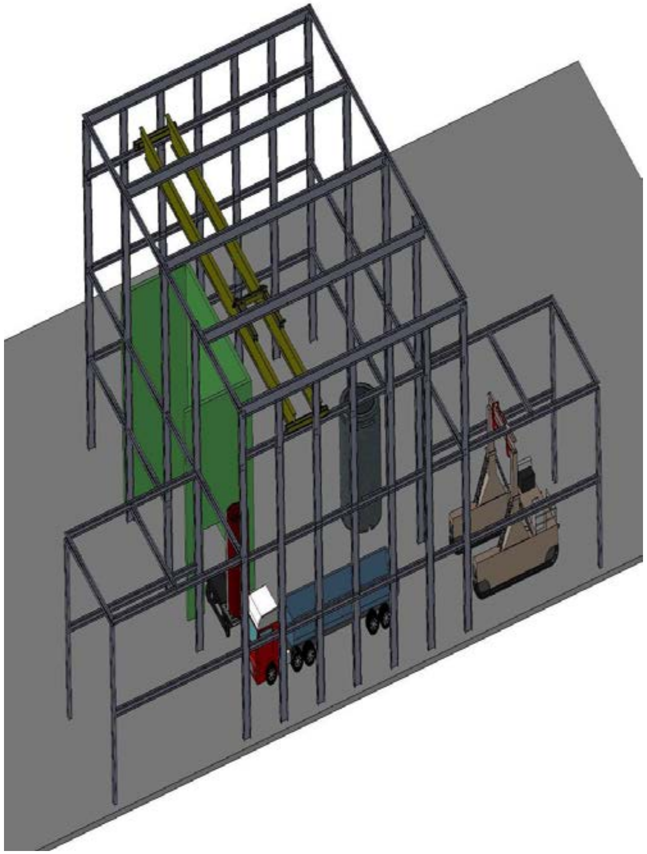
# Empty Canisters: Systems will be needed for Material Management

- 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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# Worker Dose: When, Where and How Matter

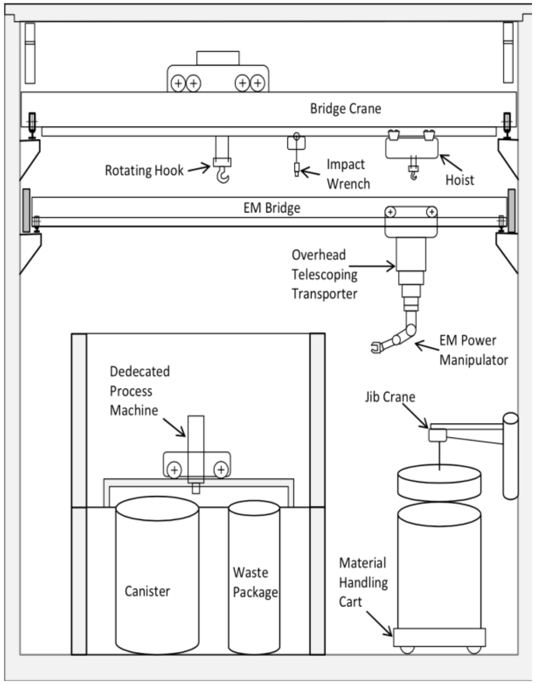
*Source: CBI, AREVA, NFST*

## Worker Dose at Reactors Would Likely be the Highest

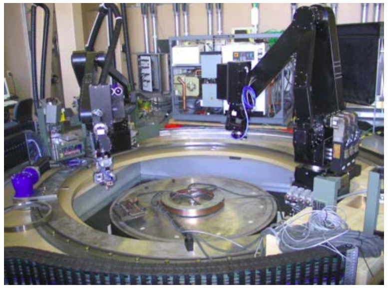
| Dose Estimates (REM) | | |
|---|---|---|
| Plant Type | Load TAD | Unload DSC |
| BWR | 0.441 | 0.441 |
| PWR | 0.198 | 0.198 |

Total per-cask dose estimate at reactor:

- STAD loading dose estimates prepared based on empirical data from 12 Exelon spent fuel loading campaigns at eight (8) plants
- Dataset includes 46 BWR casks loaded and 15 PWR casks loaded




## Worker Dose at an ISF or Repository can be managed by engineering more remote operations

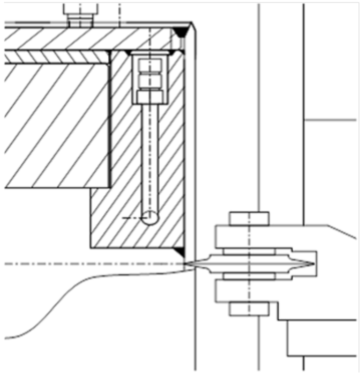


- DPC cutting activities and STAD canister welding can be done remotely

# Cutting Technology Summary

*Sources: AREVA, CBI, NFST*

- **Options**
  - Plasma Torch
  - Skiving/Lathe
  - Water Jet Cutting
  - Wheel Cutting
  - Grinding
  - Diamond Saw Cutting
  - Milling for connected ports (vent/siphon)
  - Hole saw for port covers
- **Recommendations**
  - Use site/vendor preferred methods at reactor sites
  - Consensus : Go dry
    - Skiving for circumferential welds
    - Milling for vent & siphon port covers ("silver dollars")
  - R&D activities for wheel cutting to demonstrate process and improve throughput (e.g., 1 cut instead of 2+)



# How and Where Matters: Summary Relative Cost Comparison

*Source: CBI*

Table 1-1: Summary Cost Comparison

| Transfer Type | Reactor Sites | ISF | Repository |
|---|---|---|---|
| Wet Transfer OR, ISF, R<br>Dry Transfer NOR<br>21PWR / 44BWR | $1.8 | $1.3 | $1.1 |
| Wet Transfer OR, ISF, R<br>Dry Transfer NOR<br>12PWR / 24BWR | $1.9 | $1.5 | $1.1 |
| Dry Transfer All Sites<br>21PWR / 44BWR | $2.0 | $1.2 | $1.0 |
| Dry Transfer All Sites<br>12PWR / 24BWR | $2.1 | $1.4 | $1.0 |

## Assumptions

1. Transfer of UNF will be from Reactor Sites to the CSF and then to the Repository.
2. The average distance between Reactor Sites and the CSF is 1250 miles. The distance between the CSF and Repository is 1250 miles.
3. The total number of assemblies to be transferred from non disposable canisters is 250,000.
4. 3000 MTU/year results in 300 DSCs containing 10,000 assemblies to be unloaded.
5. An on-site D&D facility is required to process empty DSCs.

# Conclusions

- **Repackaging a large number of storage canisters will be a major endeavor and will be complicated:**
  - Increases total fuel-handling operations
  - Complicates system 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
  - Generates additional low-level waste including discarded dry storage canisters
  - Repackaging facility as part of an integrated waste management system offers system flexibility
- **Why, Where, When and How Matter**
  - Choices influence waste management system logistics and operations
- **Repackaging could be reduced or eliminated provided**
  - Standard storage, transportation and disposal canisters are developed and deployed
  - Direct disposal of existing dry storage canisters is proven acceptable

# Acknowledgements

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- **Nuclear Fuels Storage and Transportation Planning Project + DoE, ANL, ORNL, SRNL, SNL**

# Discussion/Questions

- **Why?**
- **When?**
- **Where?**
- **How?**