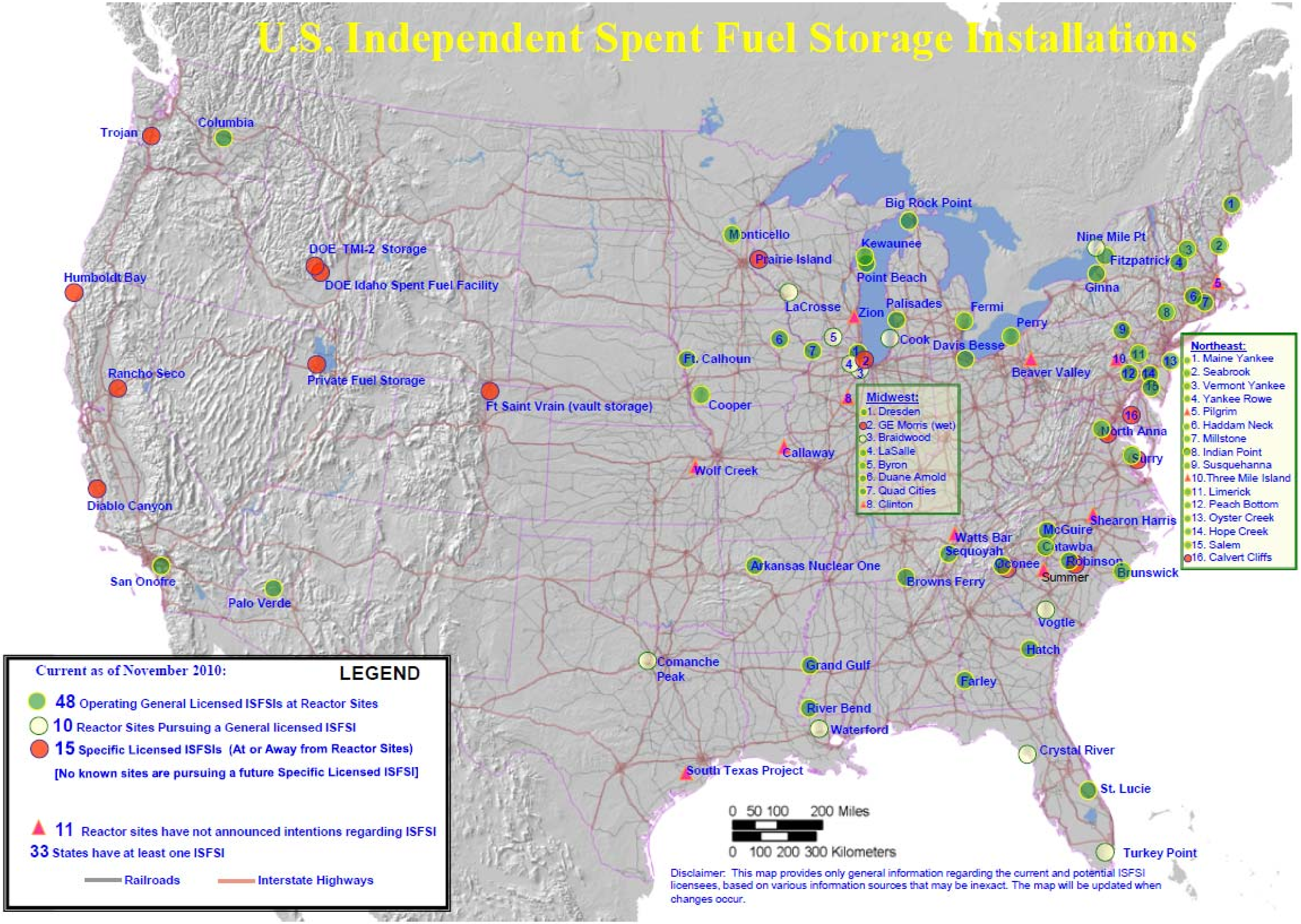
Dry Cask Storage of Nuclear Spent Fuel

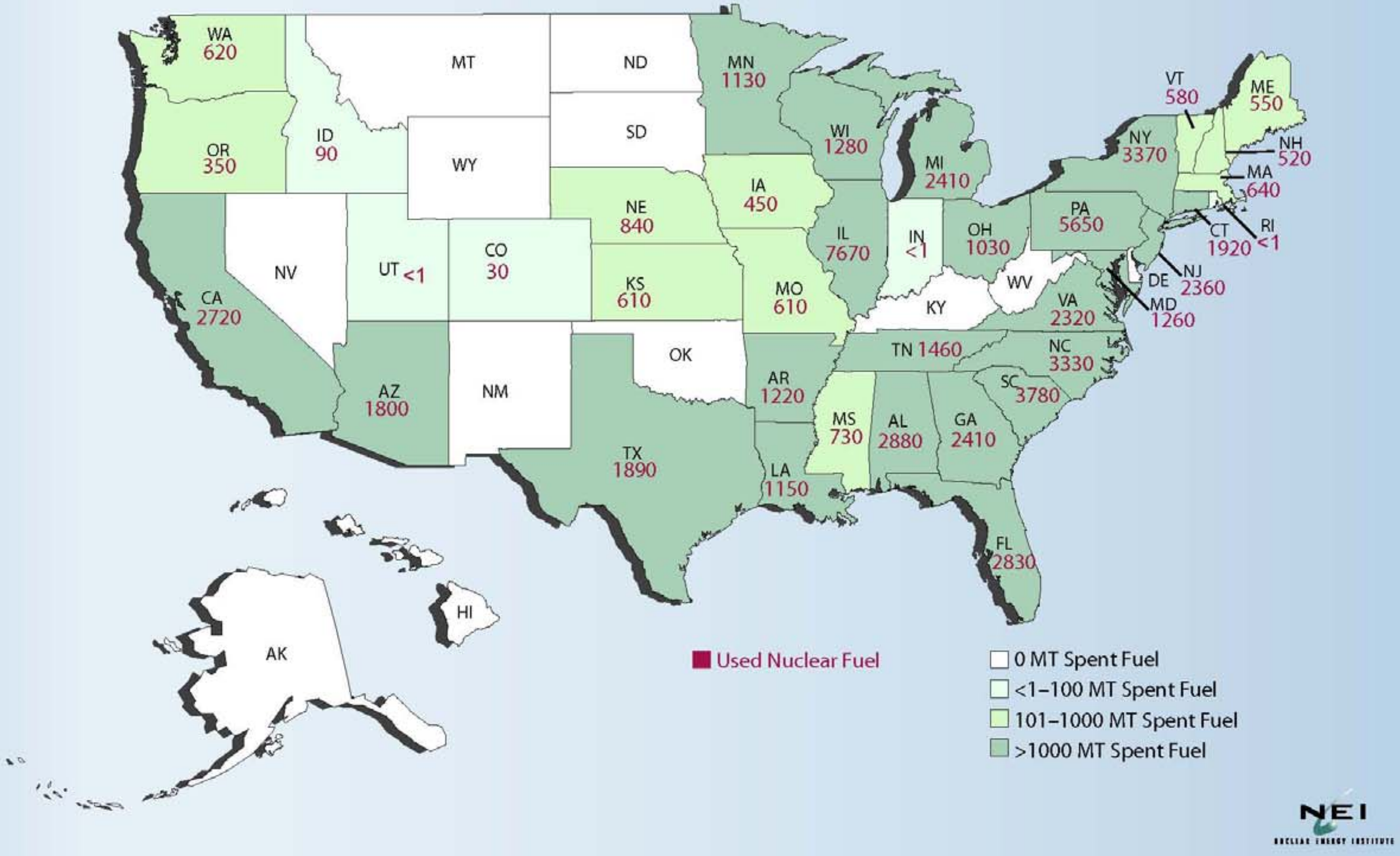
Division of Spent Fuel Storage and Transportation
U.S. Nuclear Regulatory Commission

Overview of Dry Cask Storage

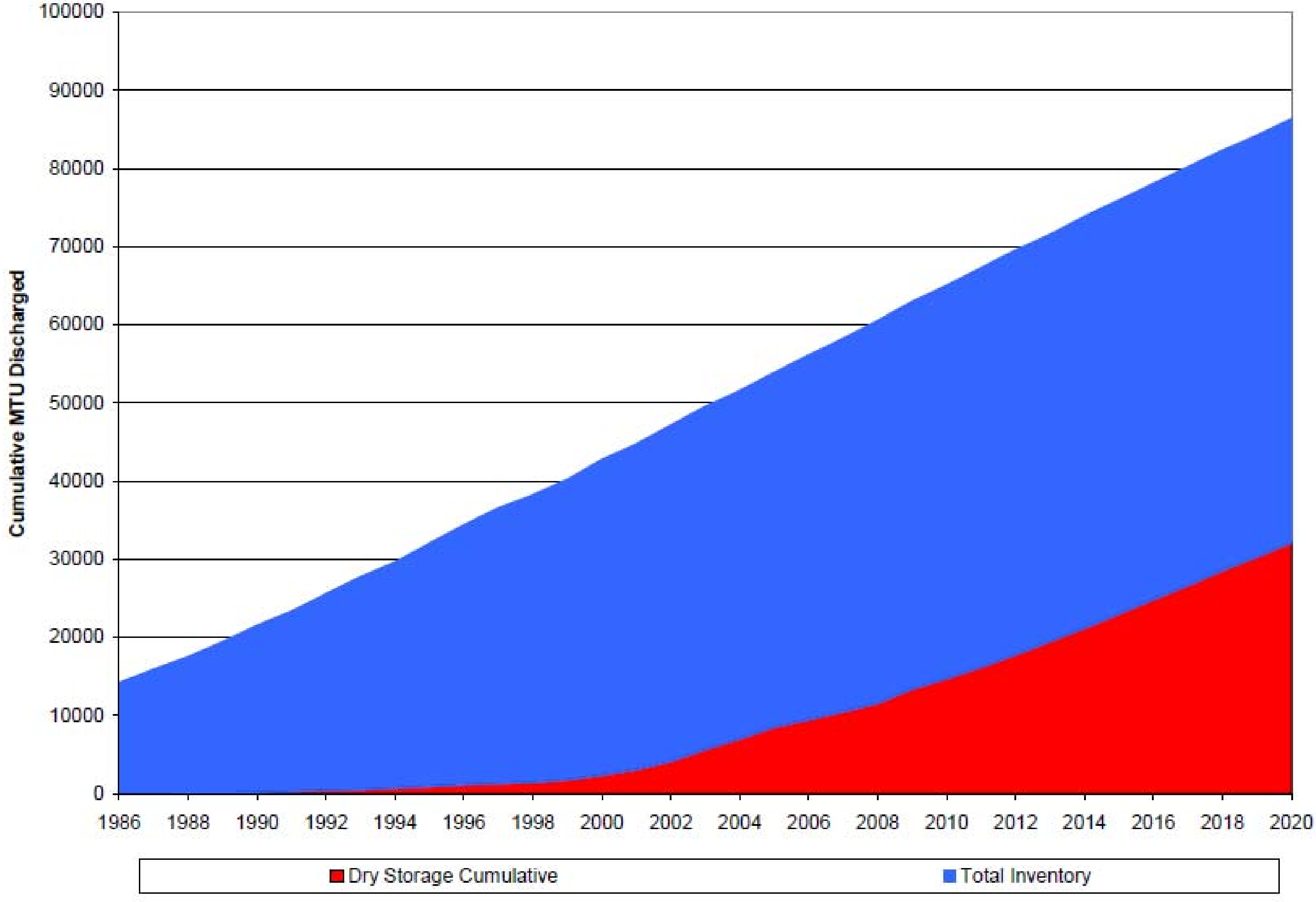

U.S. Independent Spent Fuel Storage Installations
Trojan
Columbia
Humboldt Bay
DOE TMI-2 Storage
DOE Idaho Spent Fuel Facility
Rancho Seco
Private Fuel Storage
Ft Saint Vrain (vault storage)
Diablo Canyon
San Onofre
Palo Verde
Monticello
Prairie Island
LaCrosse
Ft. Calhoun
Cooper
Wolf Creek
Callaway
Big Rock Point
Kewaunee
Point Beach
Zion
Palisades
Cook
Fermi
Davis Besse
Perry
Beaver Valley
Nine Mile Pt
Fitzpatrick
Ginna
North Anna
Surry
Shearon Harris
McGuire
Catawba
Robinson
Summer
Brunswick
Oconee
Watts Bar
Sequoyah
Browns Ferry
Arkansas Nuclear One
Vogtle
Hatch
Farley
Comanche Peak
Grand Gulf
River Bend
Waterford
South Texas Project
Crystal River
St. Lucie
Turkey Point
Midwest:
1. Dresden
2. GE Morris (wet)
3. Braidwood
4. LaSalle
5. Byron
6. Duane Arnold
7. Quad Cities
8. Clinton
Northeast:
1. Maine Yankee
2. Seabrook
3. Vermont Yankee
4. Yankee Rowe
5. Pilgrim
6. Haddam Neck
7. Millstone
8. Indian Point
9. Susquehanna
10. Three Mile Island
11. Limerick
12. Peach Bottom
13. Oyster Creek
14. Hope Creek
15. Salem
16. Calvert Cliffs
Current as of November 2010:
LEGEND
48 Operating General Licensed ISFSIs at Reactor Sites
10 Reactor Sites Pursuing a General licensed ISFSI
15 Specific Licensed ISFSIs (At or Away from Reactor Sites)
[No known sites are pursuing a future Specific Licensed ISFSI]
11 Reactor sites have not announced intentions regarding ISFSI
33 States have at least one ISFSI
Railroads
Interstate Highways
0 50 100 200 Miles
0 100 200 300 Kilometers
Disclaimer: This map provides only general information regarding the current and potential ISFSI licensees, based on various information sources that may be inexact. The map will be updated when changes occur.

Used Nuclear Fuel in Storage

(Metric Tons, End of 2009)



Historical and Projected SNF Discharges

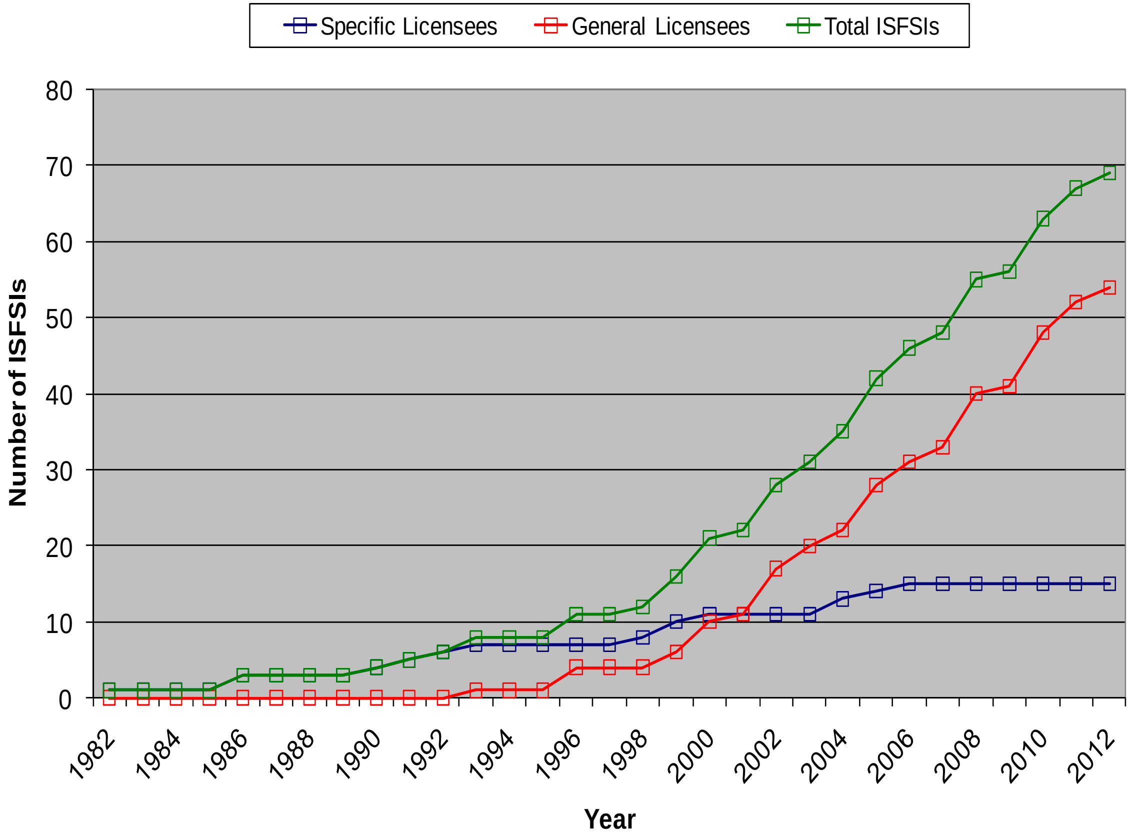


SOURCE:

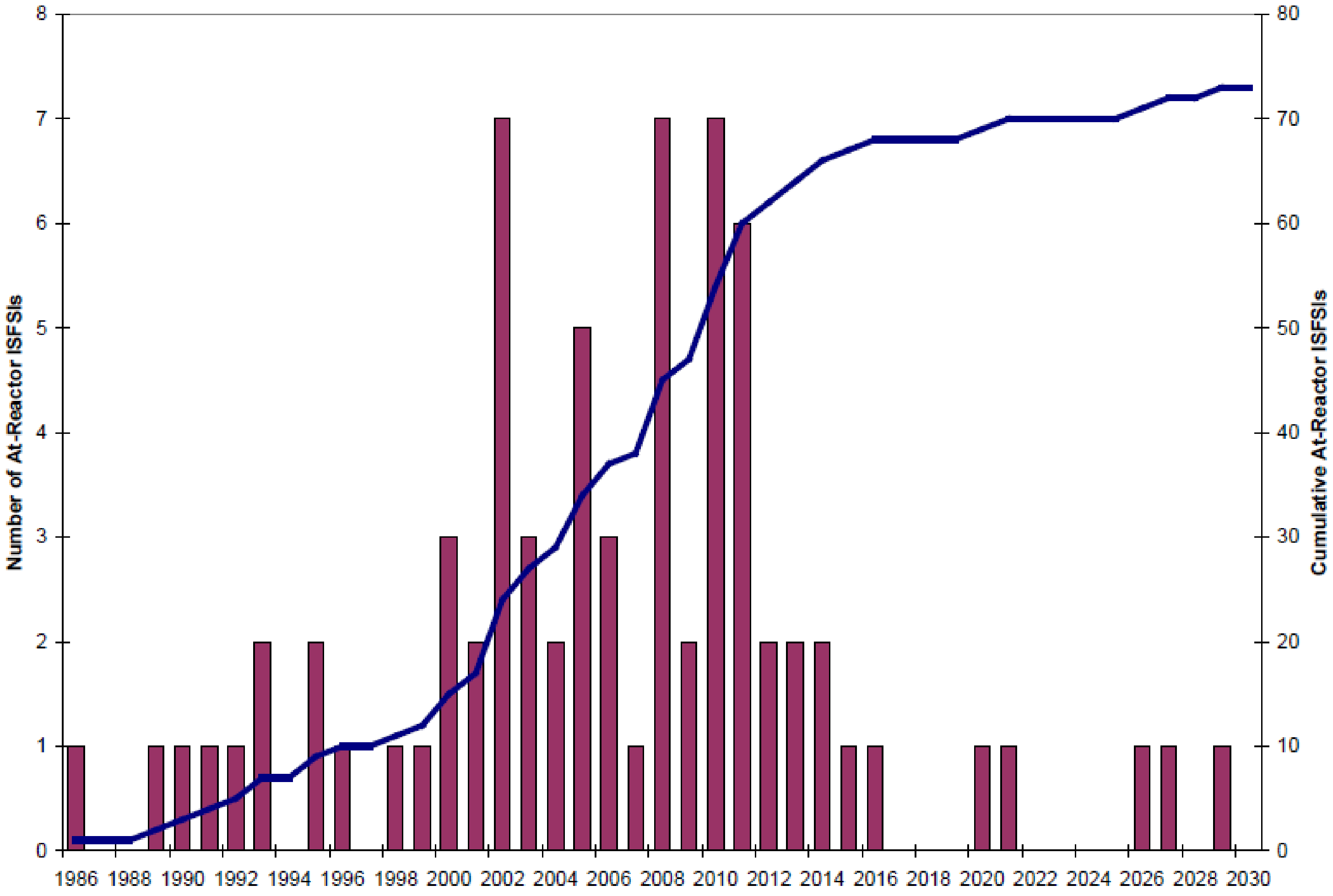
Impacts Associated with Transfer of Spent Nuclear Fuel from Spent Fuel Storage Pools to Dry Storage After Five Years of Cooling, EPRI 11/10

Dry Cask Storage

- 63 licensed ISFSIs (8 more than 2010)
- Expect 10 sites pursuing General License
- Over 1400 loaded storage casks



At-Reactor SNF Dry Storage Facilities



SOURCE:

Impacts Associated with Transfer of Spent Nuclear Fuel from Spent Fuel Storage Pools to Dry Storage After Five Years of Cooling, EPRI 11/10

Examples of Dry Cask Storage

Oconee ISFSI

- Site-Specific License issued to Duke Power January 31, 1990
  - 20 year license
  - Oconee switched to General License NUHOMS in 1998
  - 84 NUHOMS-24P systems loaded under site-specific license
  - 44 NUHOMS-24P systems loaded under general license
- Issued Oconee renewal on May 29, 2009 for 40 years

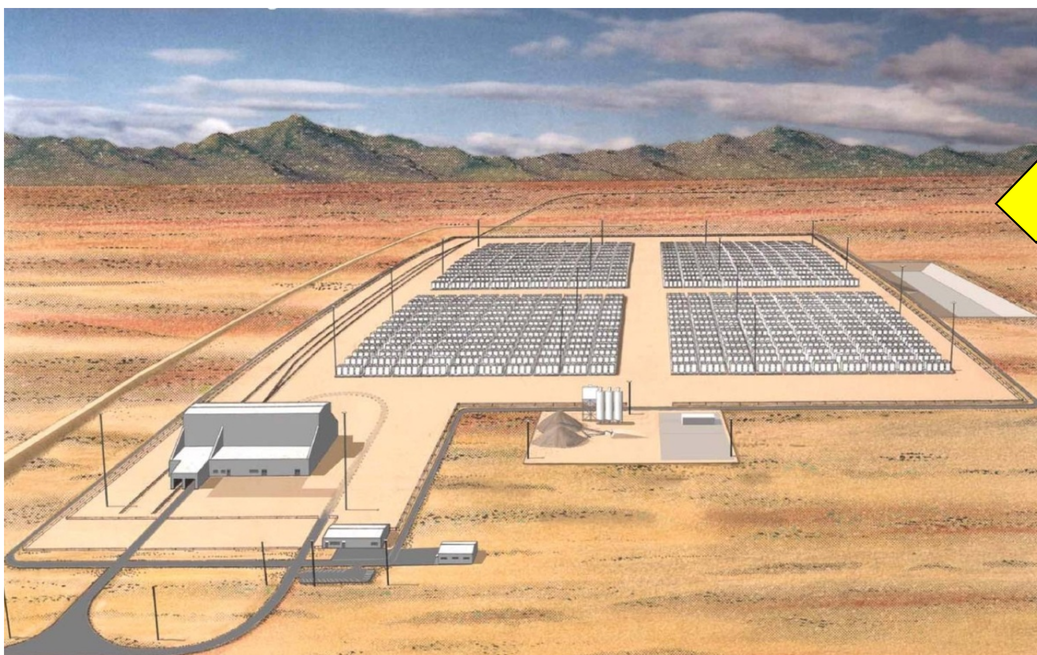
McGuire ISFSI

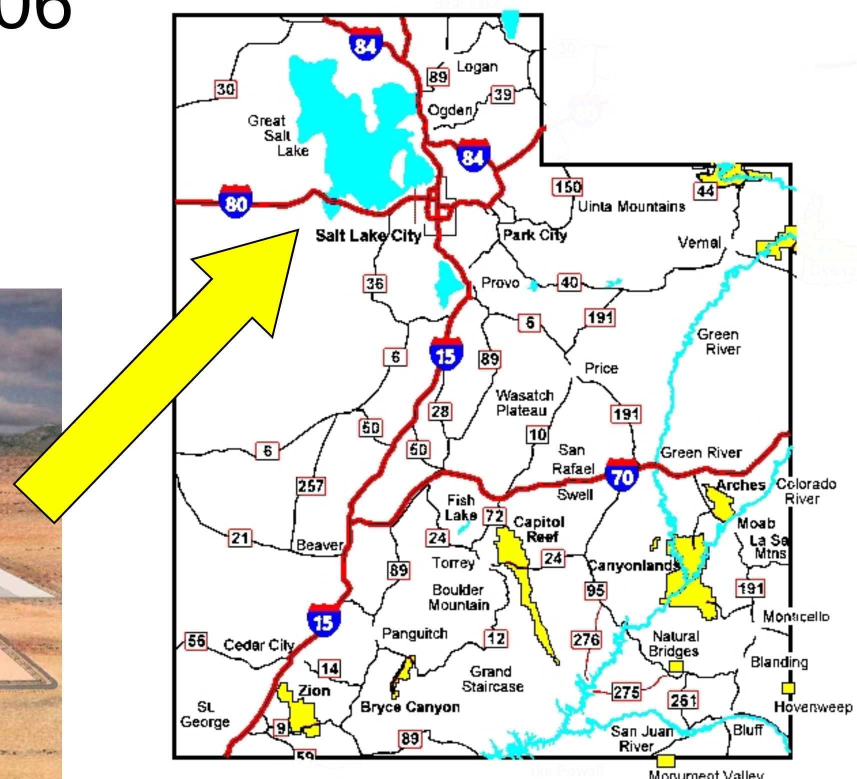
- Initial loading in 2001
- 10 TN-32 casks loaded under site-specific license
- 26 NAC-UMS casks loaded under general license
- In 2010 began using NAC International's MAGNASTOR system under general license

Fort St. Vrain ISFSI

Private Fuel Storage

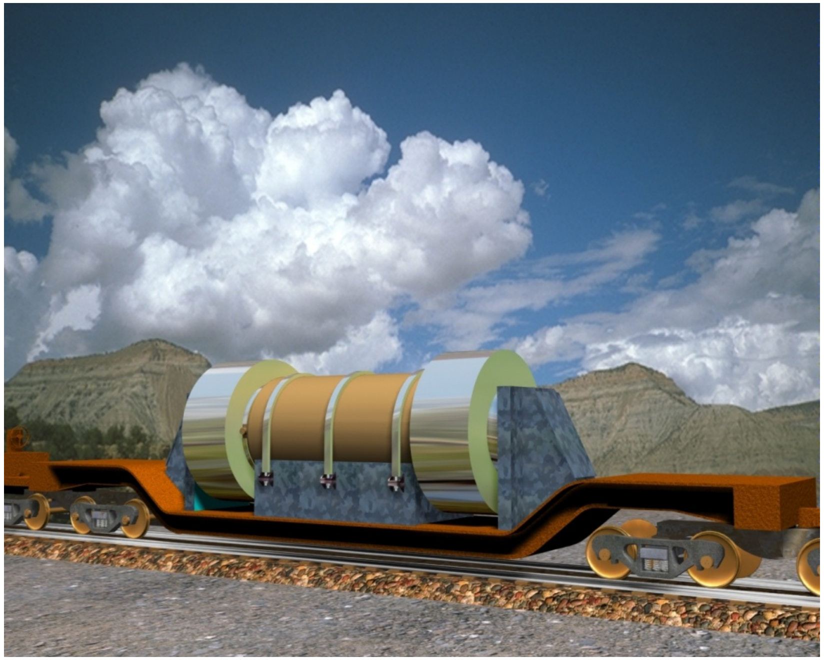
- Application submitted June 1997
- License issued February 2006
- Toole County, Utah





Private Fuel Storage

- HOLTEC Hi-Storm 100 Cask System
- 200 Canisters per Year Average Intake
- 40,000 MTU (4,000 Canisters)



Status of Private Fuel Storage

- PFS has an NRC approved license.
- BIA denied approval of PFS lease and BLM denied approval of right-of-way for rail line.
- Skull Valley Band of Goshute Indians, and PFS sue Department of Interior for review of BLM and BIA decisions.
- U.S. District Court for Utah remands BLM and BIA decisions to DOI for reconsideration (July 2010).

Current NRC Regulatory Framework for Storage Certificates

Renewable Term Licenses

Aging Management Plan

- Time-limited aging analyses
- Design for prevention
- Monitoring – how, how often, in-situ
- Maintenance – what type
- Corrective Actions – when

Technical Review Guidelines

- Standard Review Plan for Dry Cask Storage Systems (NUREG-1536)
- Standard Review Plan for Spent Fuel Dry Storage Facilities (NUREG-1567)
- Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance (NUREG-1927)
- Interim Staff Guidance Documents

A Pilot Probabilistic Risk Assessment of a Dry Cask Storage System at a Nuclear Power Plant - NUREG-1864

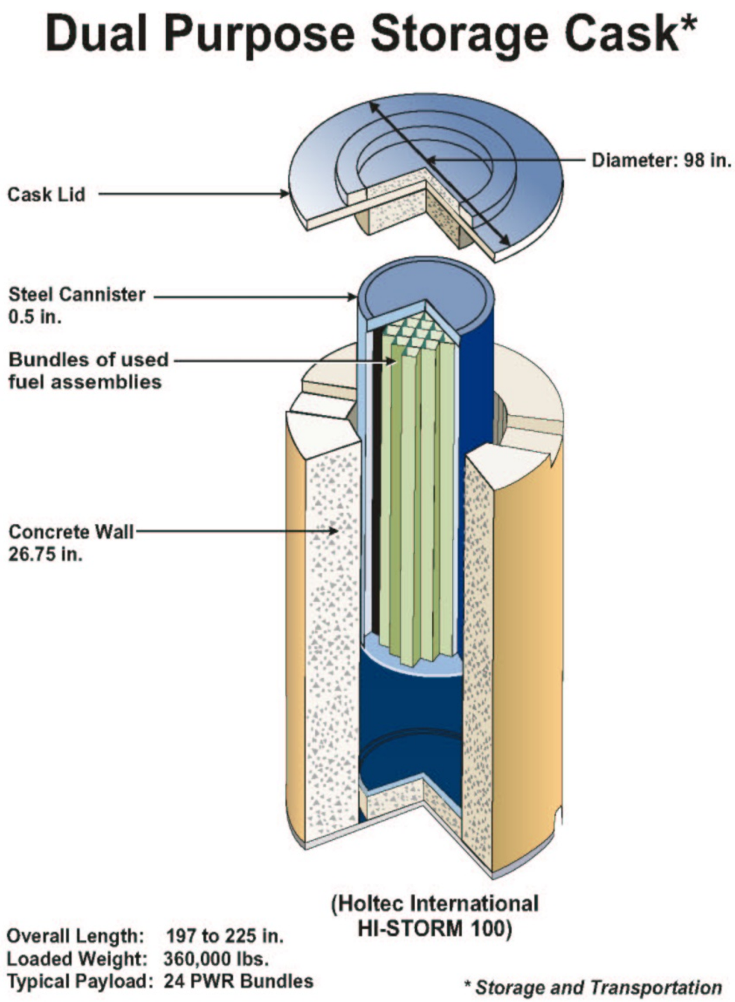
- The overall risk of dry cask storage was found to be extremely low.
- The estimated aggregate risk is an individual probability of a latent cancer fatality of 1.8×10^{-12} during the first year of service, and 3.2×10^{-14} per year during subsequent years of storage.

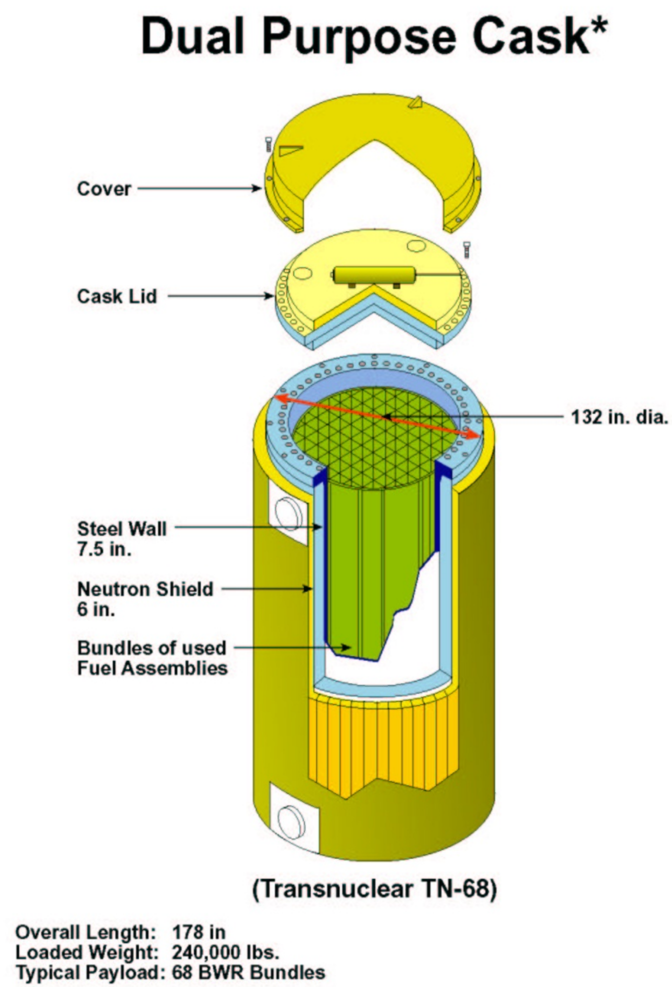
Examination of Spent PWR Fuel Rods after 15 Years in Dry Storage -NUREG/CR-6831

- Based on the Surry fuel rod data, no deleterious effects of 15-years of dry cask storage were observed.
- Creep testing indicated that the cladding retains significant creep ductility after dry-cask storage.
- Creep would not increase appreciably during additional storage because of the low temperature after 15 years.
- Hydrides appear to have retained a circumferential orientation

Typical Dry Storage Cask Operations

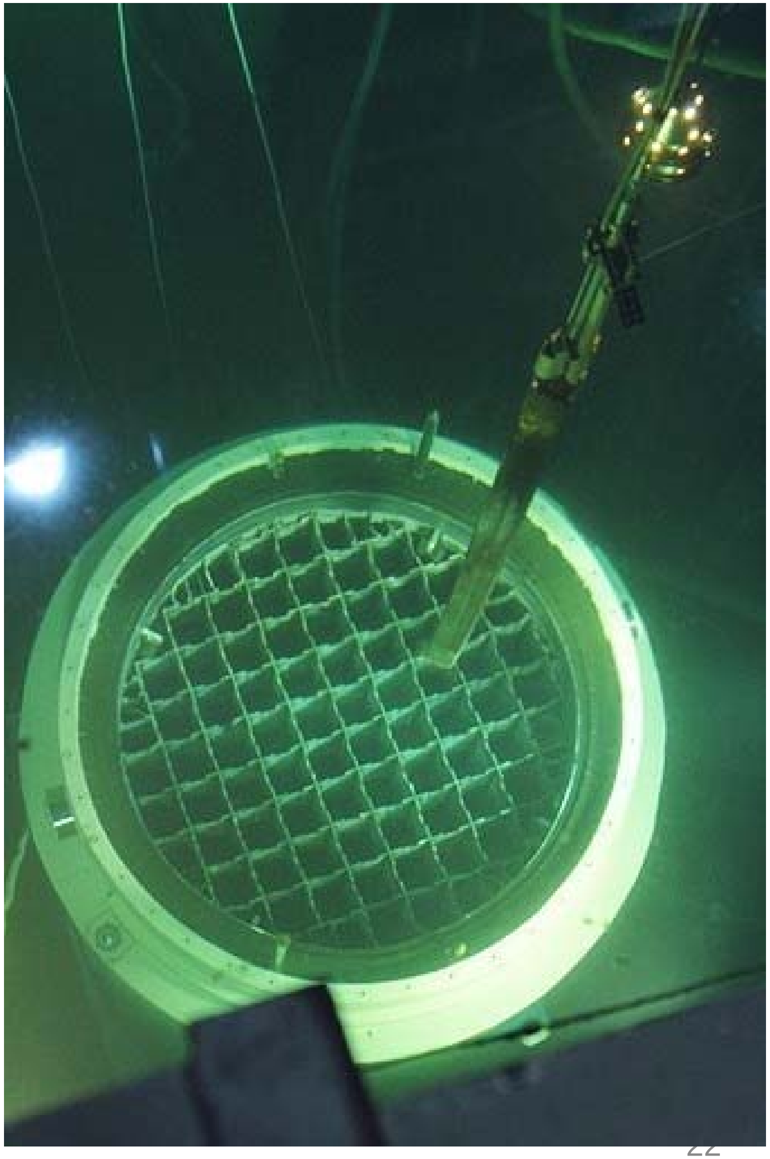
Spent Fuel Storage Casks



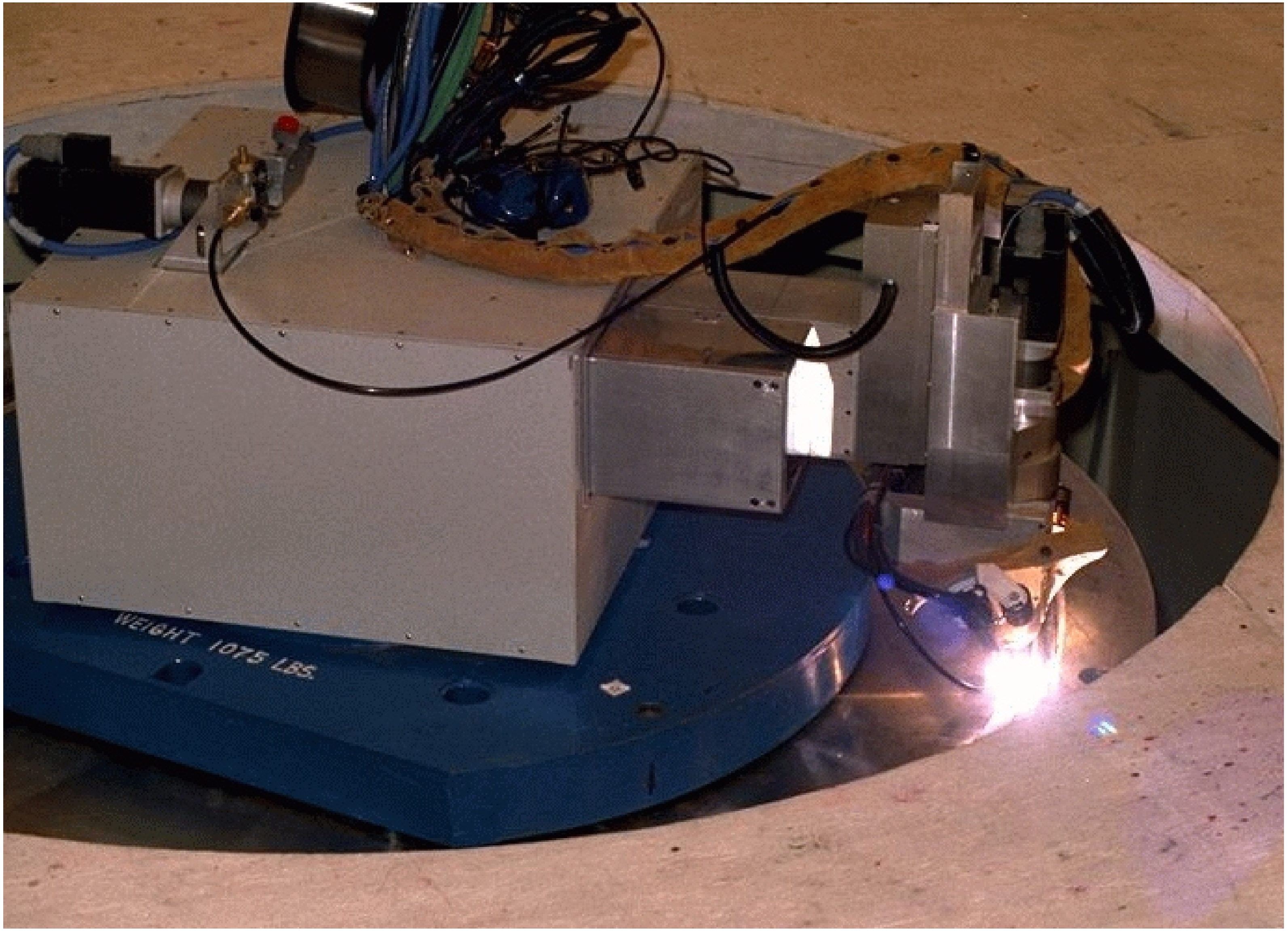


Preparation of Empty Canister

Fuel Loading in Transfer Cask



Welding of Canister Lid



Transfer of Canister into Overpack

Transfer of Overpack to ISFSI Pad

Storage Cask Array on ISFSI Pad

Transfer of Canister into Module

Module Cask Array

How do we get spent fuel out of pools?

PWR Assembly Decay Heat Curve

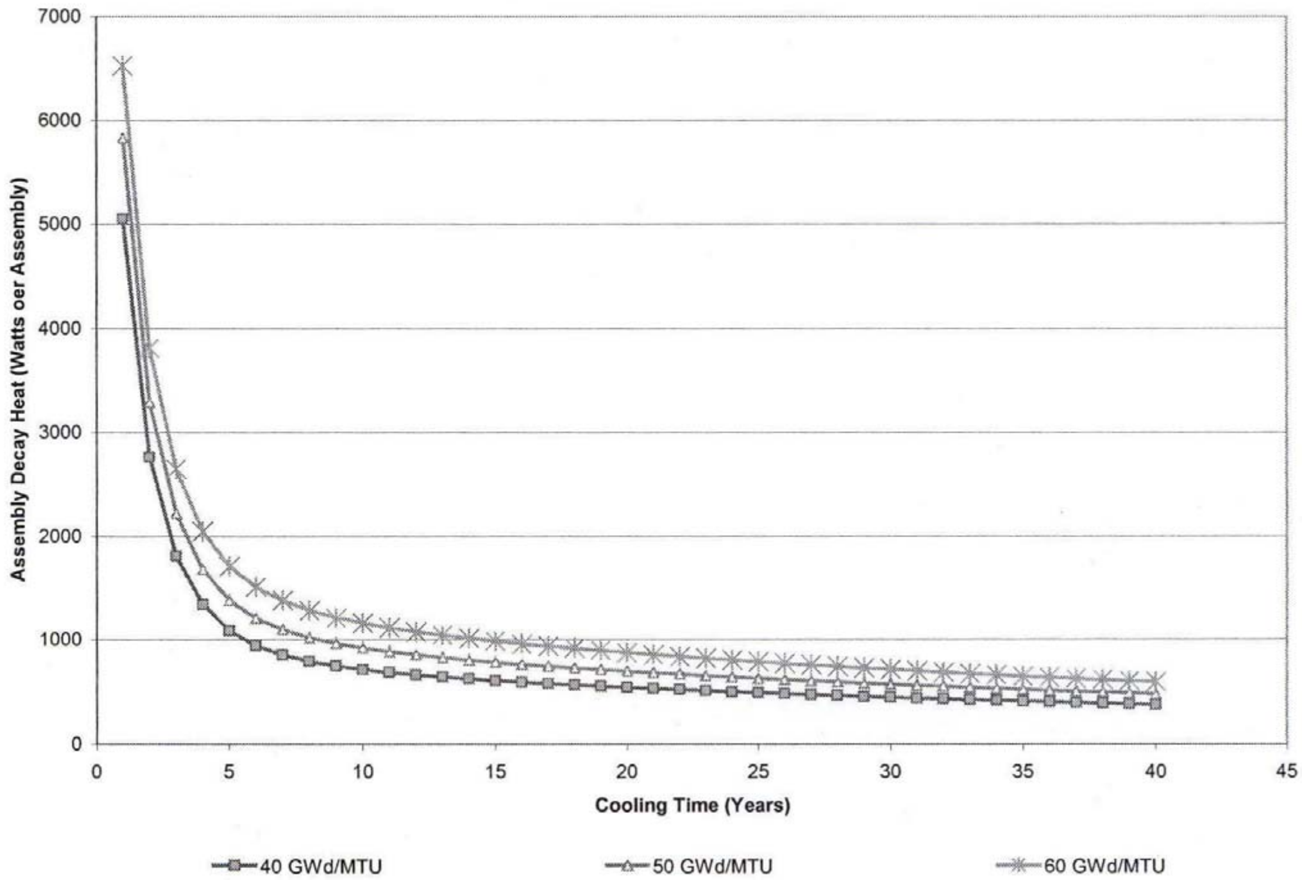


Figure 2-2
PWR SNF Assembly Decay Heat as a Function of Burnup and Cooling Time [BSC 2001, DOE 1992]

EPRI Estimates of Dry Cask Loadings needed to move Spent Fuel into Dry Storage after 5 years

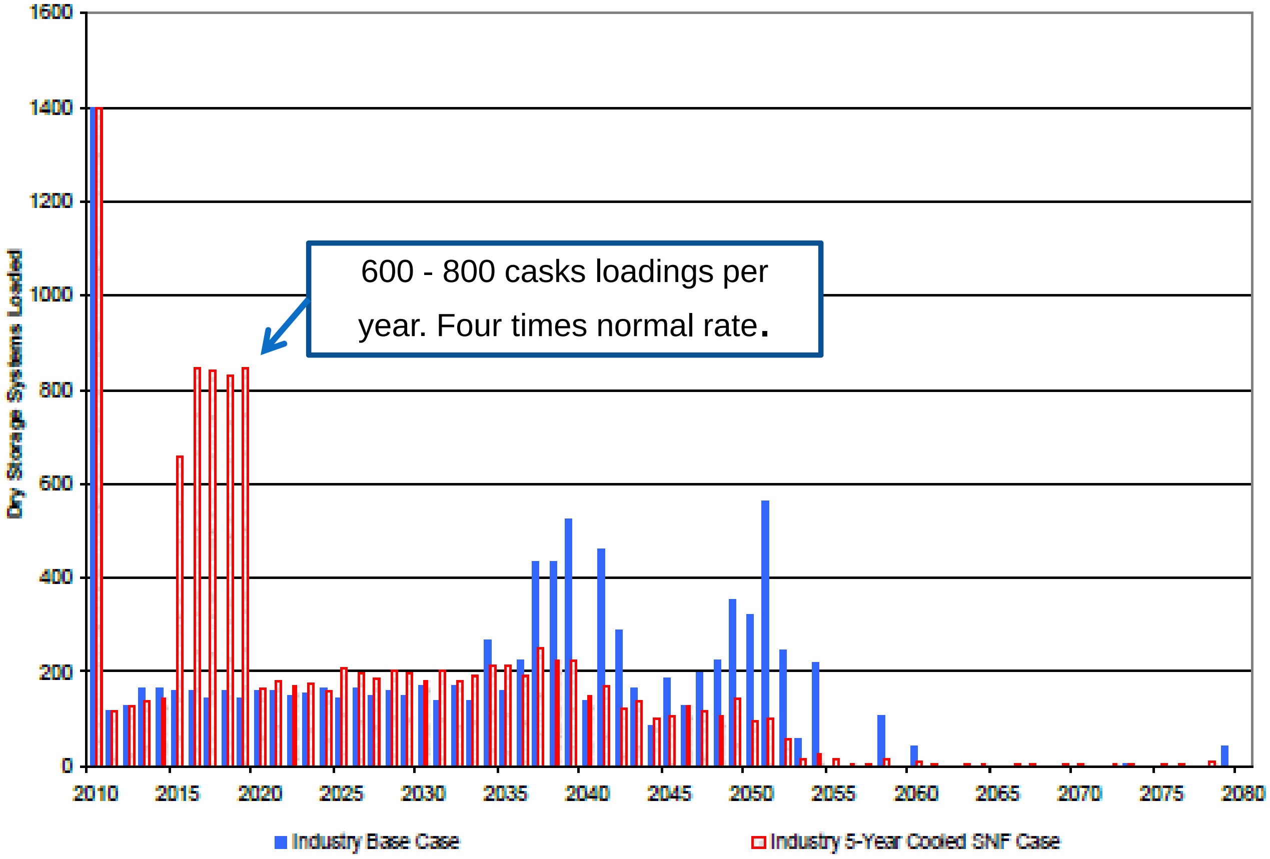


Figure 4-1
Comparison of Dry Storage Systems Loaded Annually Under the Industry Base Case and the Industry 5-Year Cooled SNF Case

EPRI Estimates of Total Dry Cask Loadings resulting from moving Spent Fuel into Dry Storage after 5 years

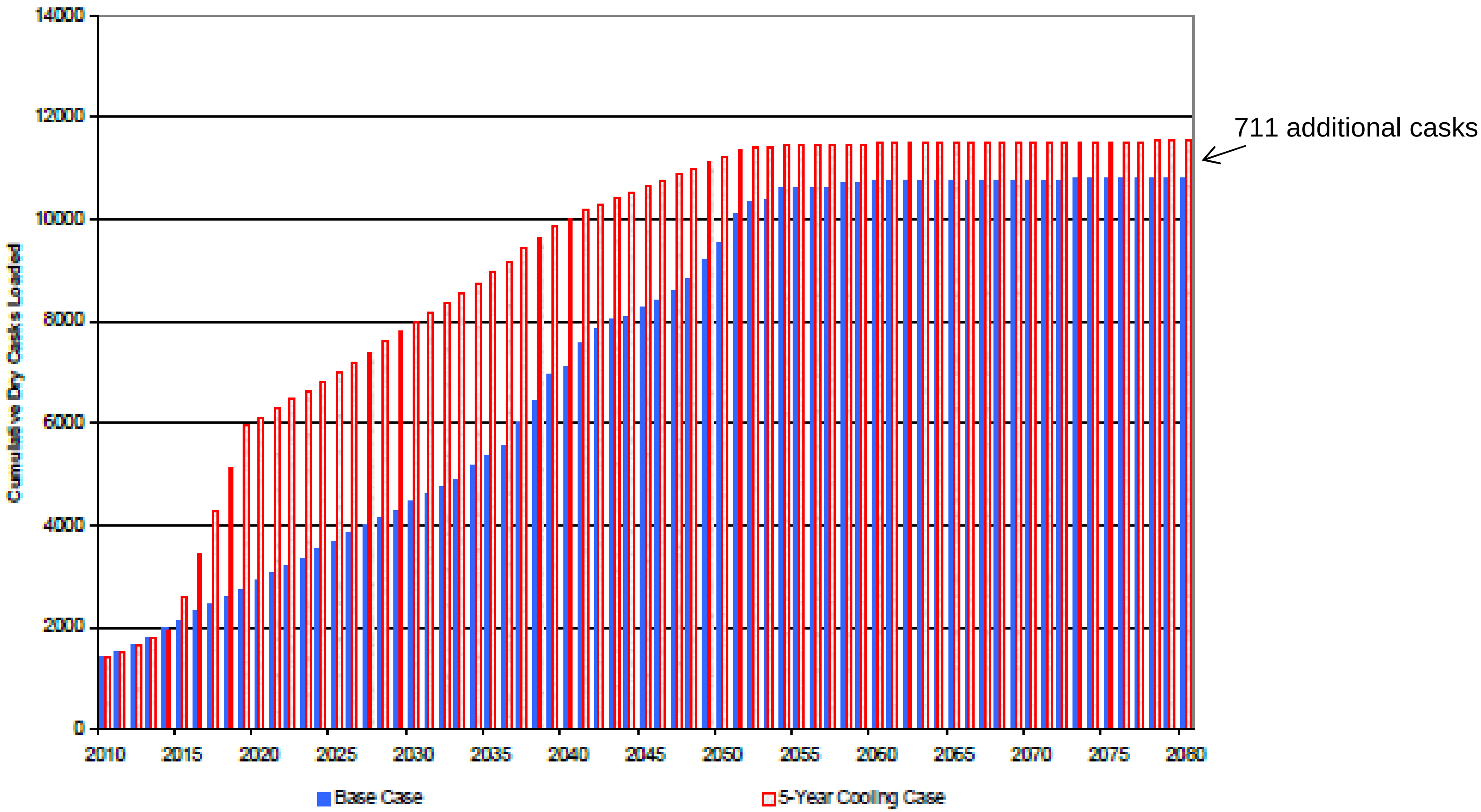


Figure 4-2
Cumulative Dry Storage Systems Loaded Under the Industry Base Case and the Industry 5-Year Cooled SNF Case

How did we get where we are now?

Existing Storage and Transportation Regulations

- Current storage and transportation regulations are flexible enough to :
  - accommodate a wide range of operational and design conditions
  - support future changes in technology/policy (because they are based on performance requirements rather than specific technologies).

- Current storage and transportation regulations permit operational and design conditions:
  - that do not have same end and beginning points
  - that are based on costs or policy optimizations of a single fuel cycle phase
  - may result in extra operations or inconsistencies

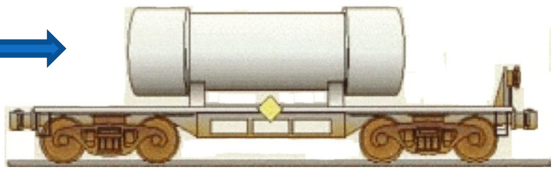
Integration of Storage and Transportation

Storage and Transportation can be integrated by requiring licensees to lay out a proposed transportation strategy before they are granted approval to store. The strategy would replace 72.108. It may look like:

Storage Only → Must maintain wet or dry unloading/loading capability

Dual Purpose Cask → Must have design approved under Parts 71 and 72 and have hardware aging plan for life of storage

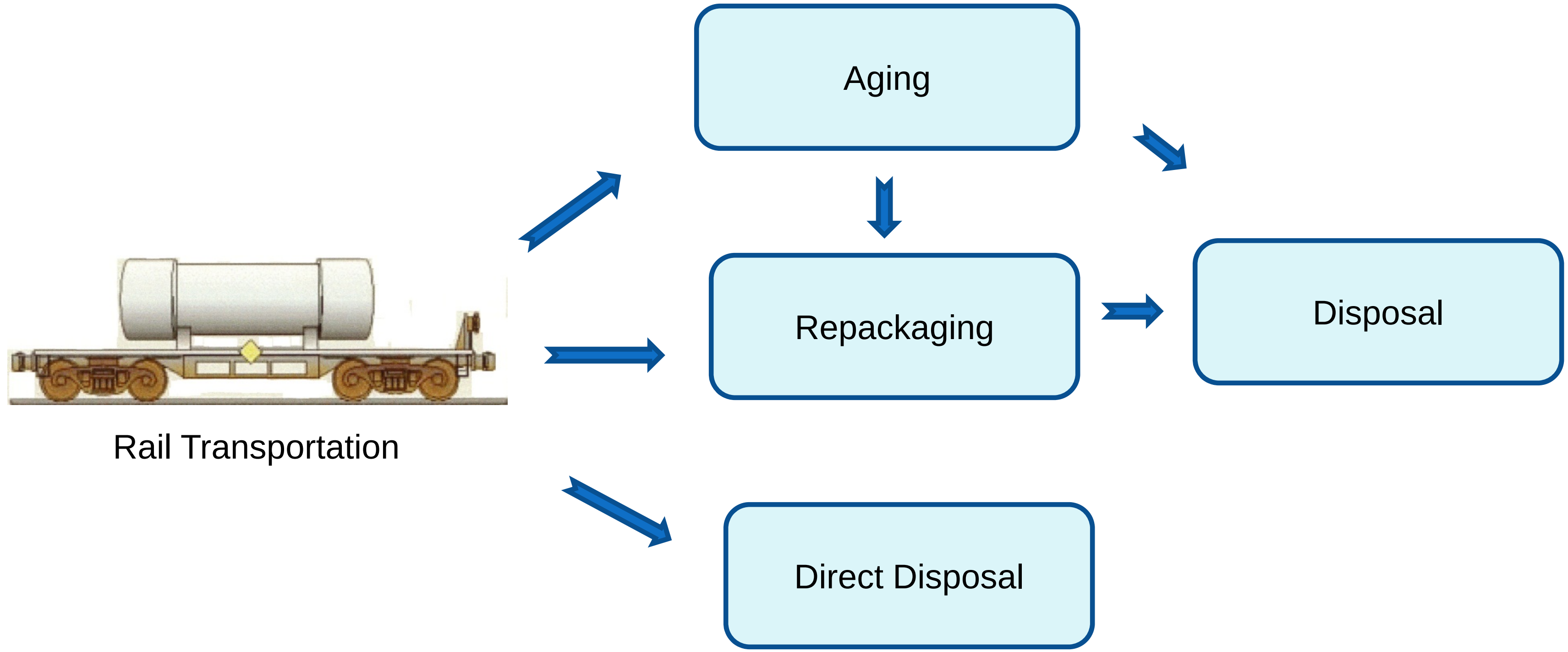
Canister Based System → Must have an approved canister design under Part 72 that can be shown to be transportable in a Part 71 approved overpack at the proposed time of shipment



Rail Transportation

Integrating Storage and Transportation will not directly address disposal.

Integration of Storage/Transportation and Disposal



Need to know repository design parameters such as canister size and heat loads, and role of fuel cladding to integrate regulation of repository operations

Developing a Regulatory Framework for Extended Storage and Transportation

Regulatory Needs

Confidence Decision

- Updated in 2010 for licensed life plus 60 years
- Commission directed staff to prepare separate long-term update for beyond life plus 60 years

Extended Storage and Transportation (EST)

- Potential changes to regulations and guidance
- Opportunity to improve integration of storage and transportation regulations and guidance
- Technical needs
- Risk informing

Technical Basis for EST

- Technical Gap Assessment
  - Component performance
  - System performance
- Implications for Aging Management
- Implications for Transportation and Disposal (or Reprocessing) after Extended Storage
- Coordination with Analysis of Environmental Impacts for Long-term Update of Waste Confidence Decision

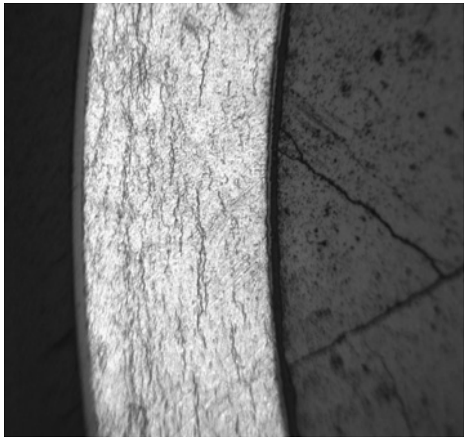
Example: Cladding Integrity

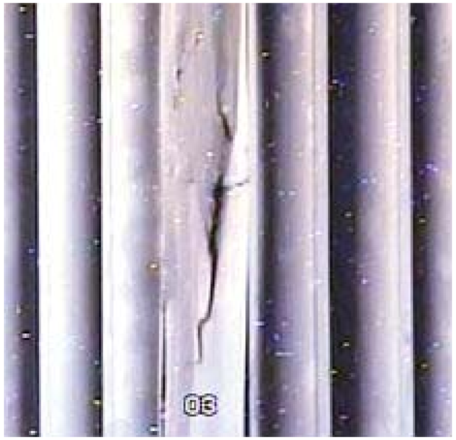
Safety Functions

- Primary fission product barrier
- Geometry control
- Defense in Depth

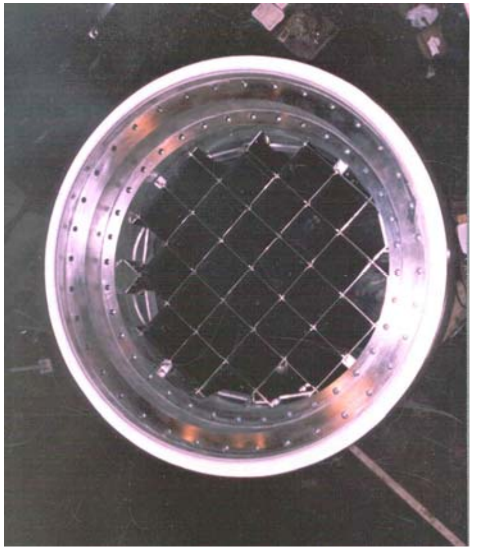
Technical Challenges

- Higher burnup levels
- Temperature effects
- New cladding types
- In-situ monitoring in sealed canisters





Example: Canister Integrity



- Safety Functions
  - Confinement
  - Inert environment
  - Criticality control
- Technical Challenges
  - Long-term corrosion
  - Basket properties
  - Absorber efficiency
  - Monitoring sealed internals

Example: Overpack Performance

Safety Functions

- Shielding
- Heat transfer
- Robustness against severe events

Technical Challenges

- Long-term degradation
- Response to external natural events and external

Path Forward: Phase 1

- Synthesis of Technical Gap Assessments
  - Draft synthesis report for comment, Fall 2011
  - Final synthesis report, Spring 2012
- Regulatory Plan
  - Integration of EST regulatory needs and Waste Confidence long-term update
  - Research plan to address technical gaps
- Cooperative Research (e.g., ESCP)
- Stakeholder Involvement