An Overview of Dry Cask Storage

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NUCLEAR ENERGY INSTITUTE

What is the Nuclear Energy Institute?

- **Industry policy organization in place since 1953 (Atomic Industrial Forum)**
- **Formed in 1994 by merger of:**
  - **American Nuclear Energy Council (Legislative)**
  - **U.S. Council on Energy Awareness (Communications)**
  - **Nuclear Utility Management and Resources Council (Regulatory)**

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Approximately 350 Members in 19 Countries

- All U.S. nuclear utilities
- International nuclear utilities
- Reactor and major component suppliers
- Dry Cask Storage Vendors
- Architect/engineering firms
- Radiopharmaceutical manufacturers
- Fuel suppliers
- Universities
- Labor unions
- Law firms

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Public Web Site

www.nei.org

Used Nuclear Fuel

- **Solid ceramic pellets encased in metal clad rods**
- **40 years of nuclear electricity have produced only a small amount**
  - **entire inventory would cover a single football field approximately 7 yards deep**

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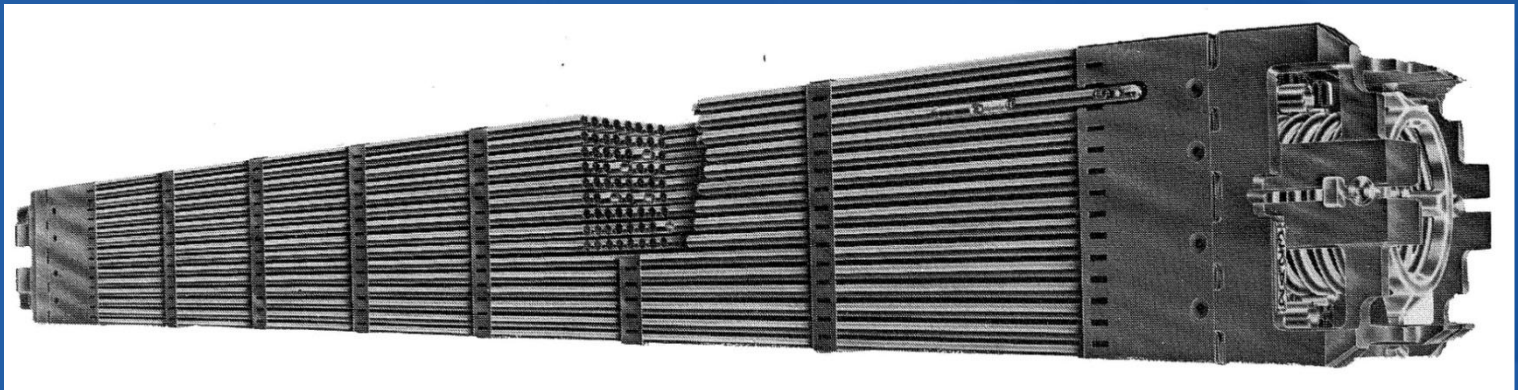
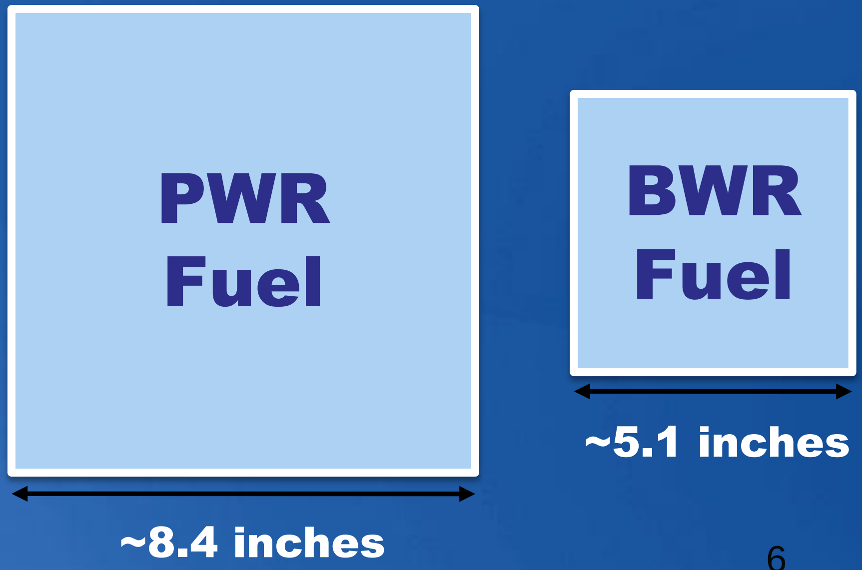
Fuel Assemblies



15x15 PWR Fuel Assembly

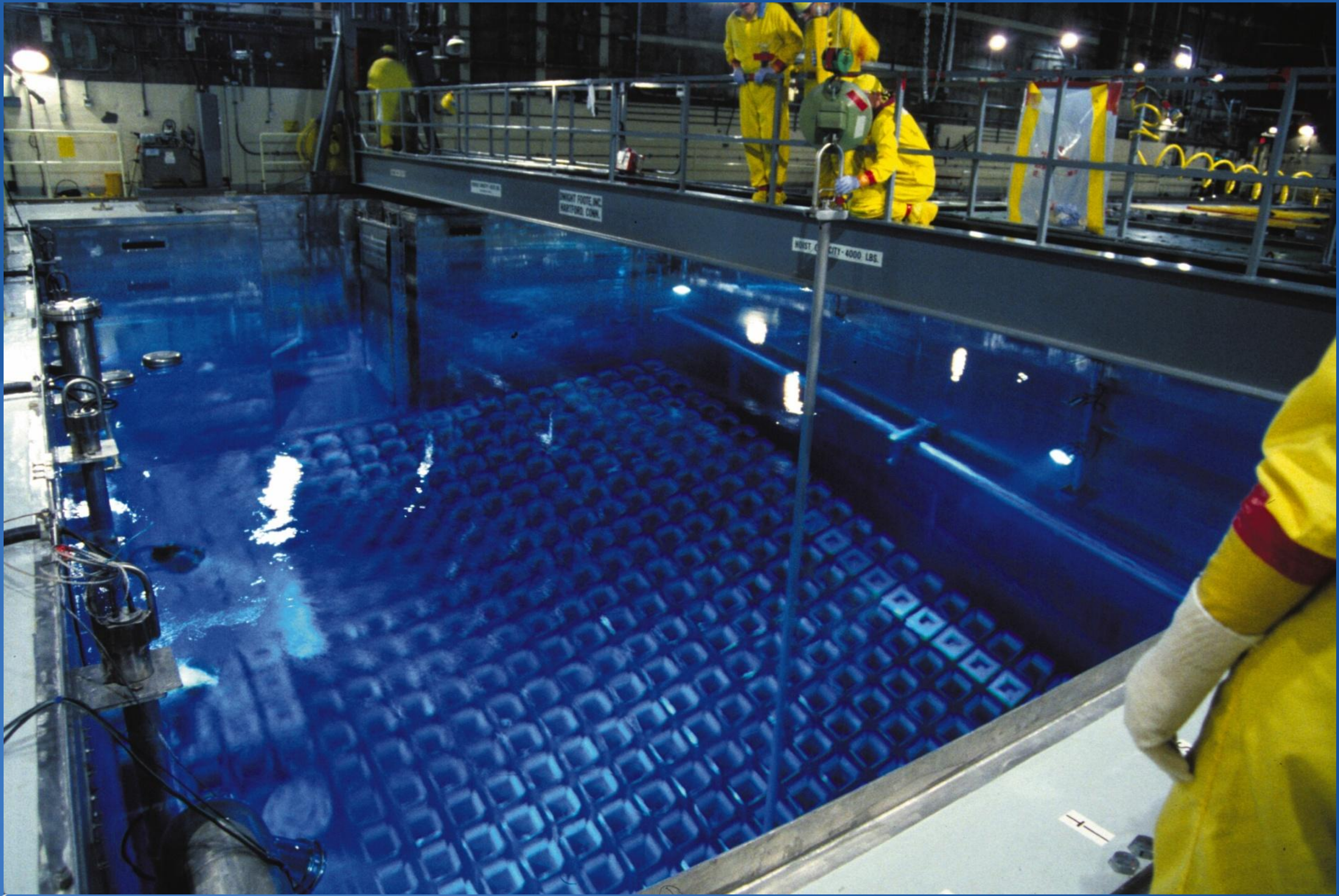
Relative size of PWR and BWR fuel assemblies



Number of Operating Reactors
PWR – 69, BWR – 35

Assemblies in Reactor Core
PWR ~ 190, BWR ~ 750

Used Fuel Stored in Pool



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Dry Cask Storage

Vertical Storage Cask

Horizontal Storage Module

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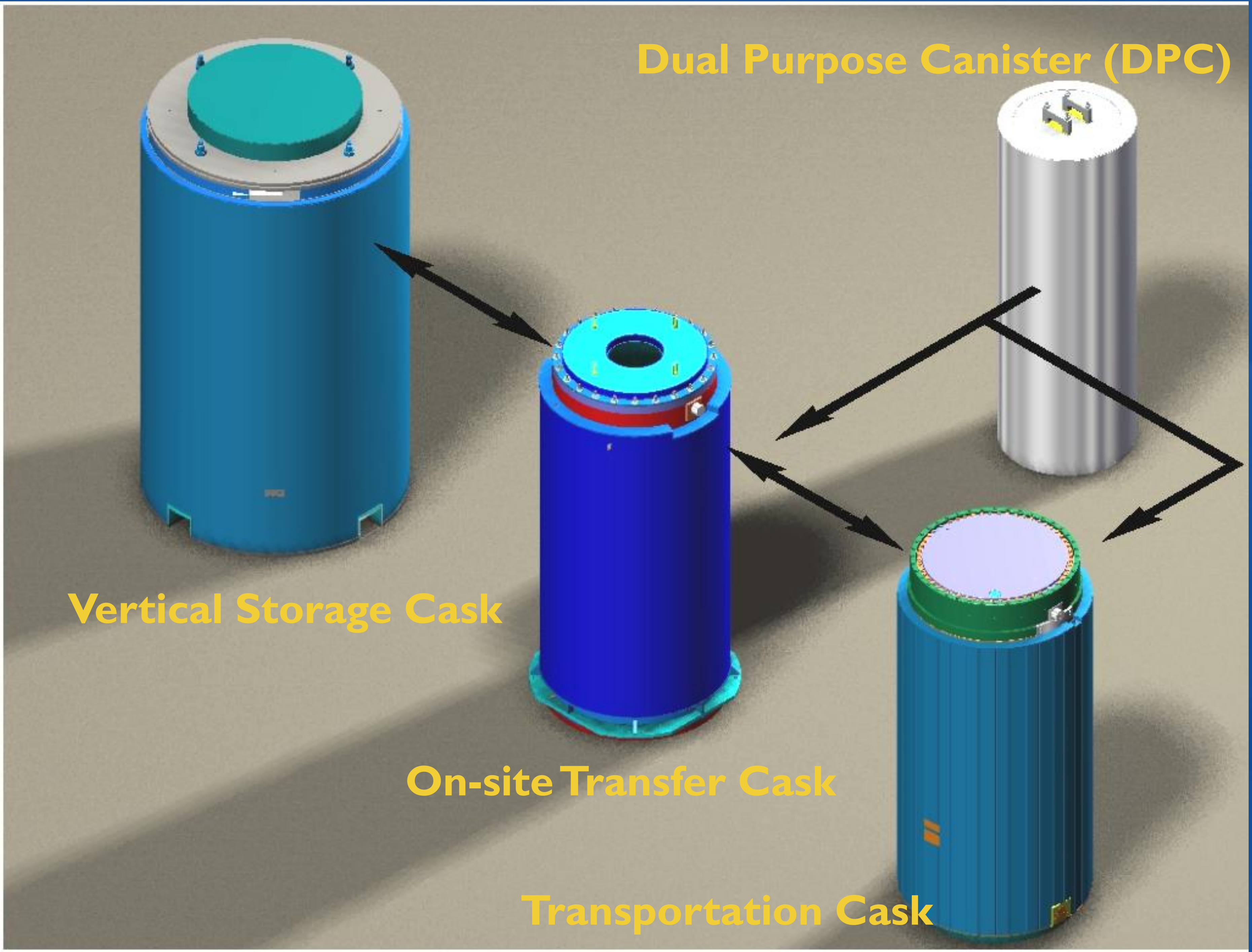
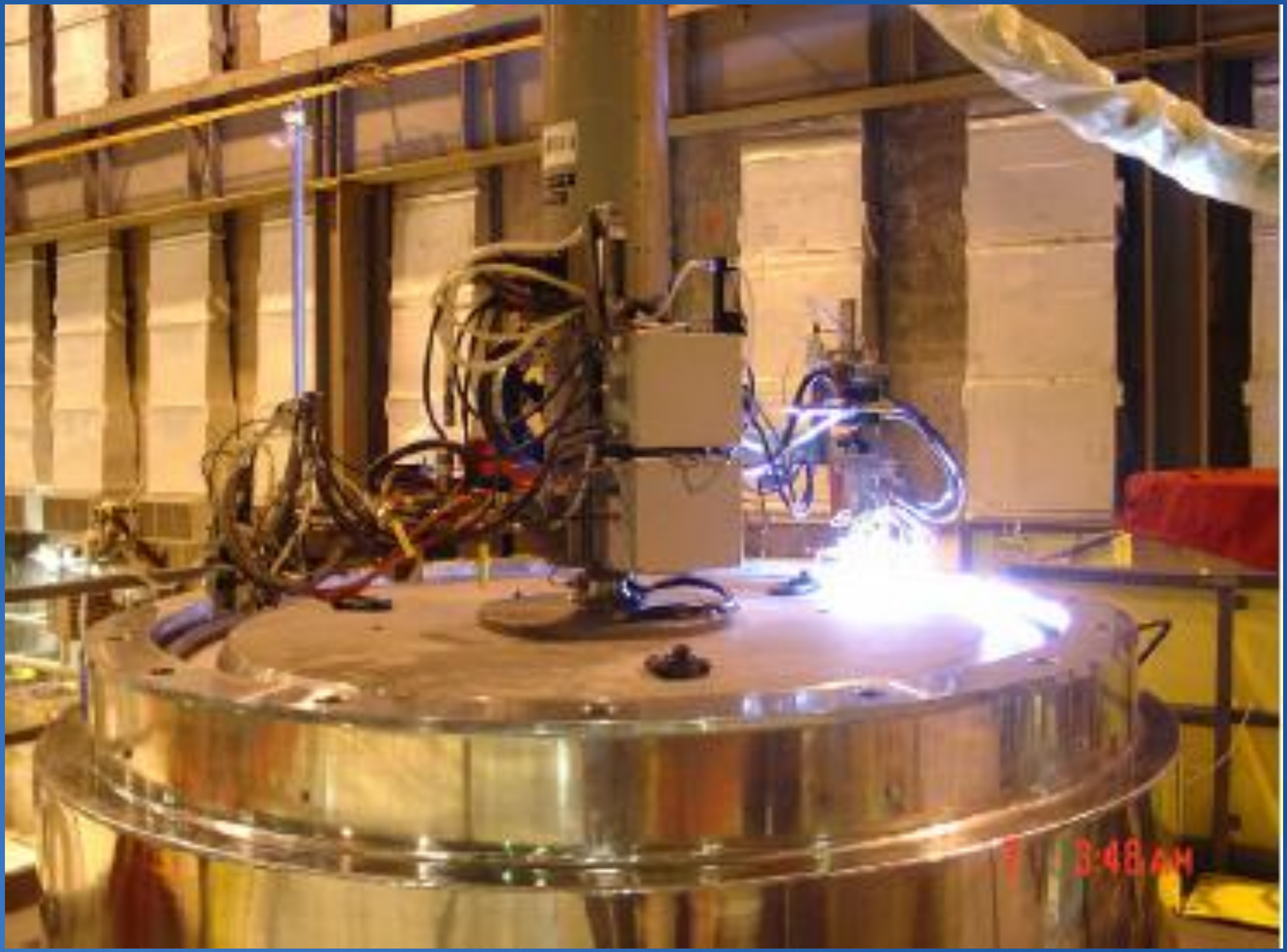

Dual Purpose Canister (DPC)
Vertical Storage Cask
On-site Transfer Cask
Transportation Cask

Preparation of empty canister

Fuel Loading in Transfer Cask

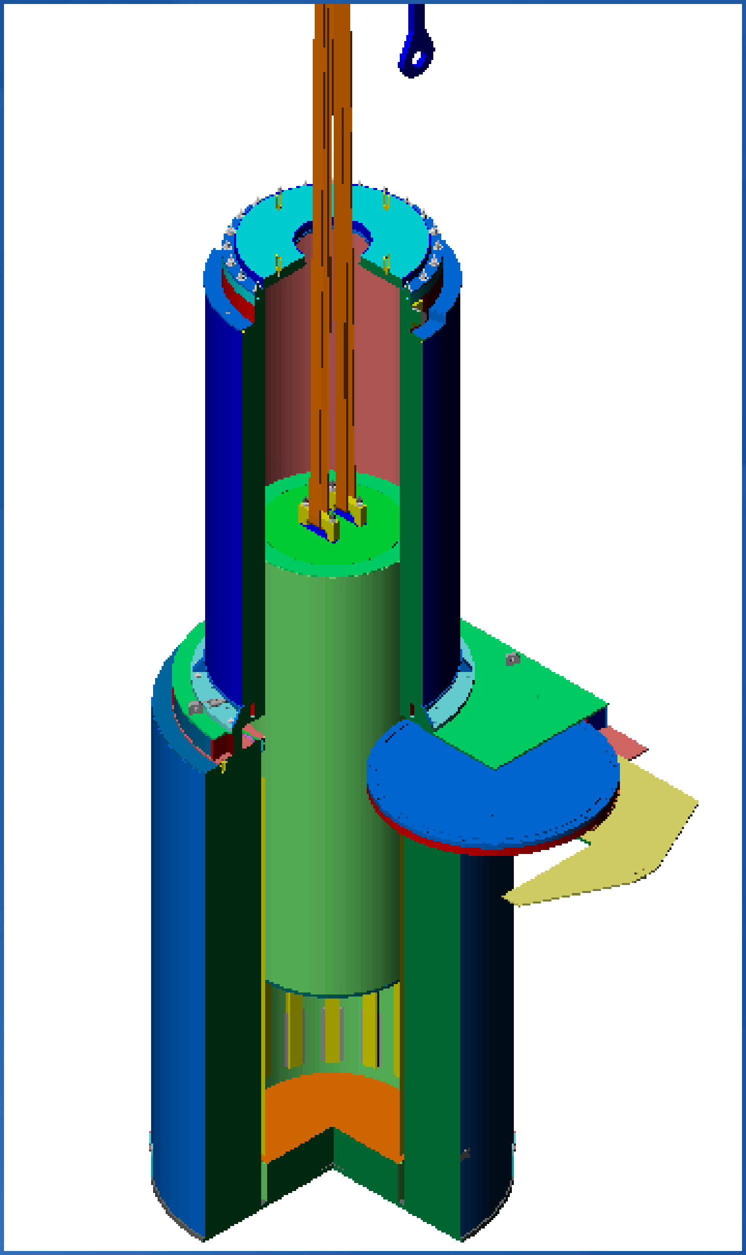
Welding of Canister Lid



DPC Placement into Vertical Storage Cask

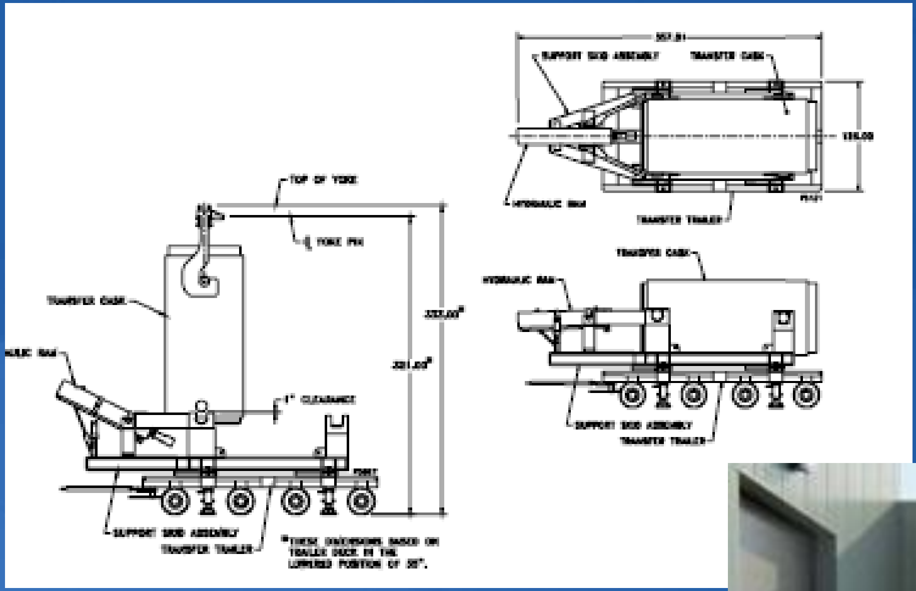
DPC Placement into Vertical Storage Cask

- **Transfer cask is placed atop vertical storage cask**
- **DPC is lowered from transfer cask into vertical storage cask**



Moving Vertical System to Storage Outside Plant

Moving Horizontal System to Storage Outside Plant



Loading Horizontal Storage Modules

Typical Independent Spent Fuel Storage Installation (ISFSI)

Surry Power Station in Virginia

ISFSIs with Vertical Storage Casks

Yankee Rowe

Connecticut Yankee

Typical Vertical DPC Dry Storage Systems

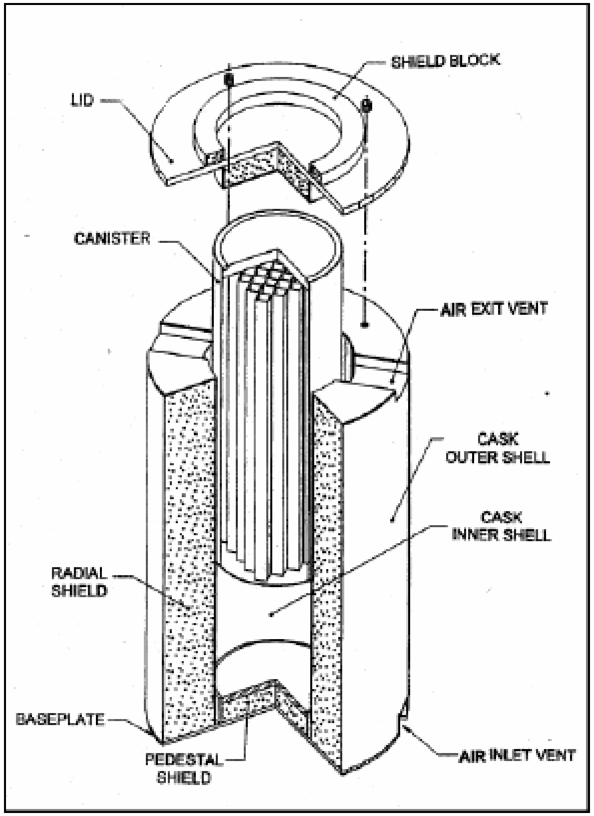


Figure 4-6
Cross Section of the HI-STORM 100 Overpack with MPC [NRC 2001b]

Holtec

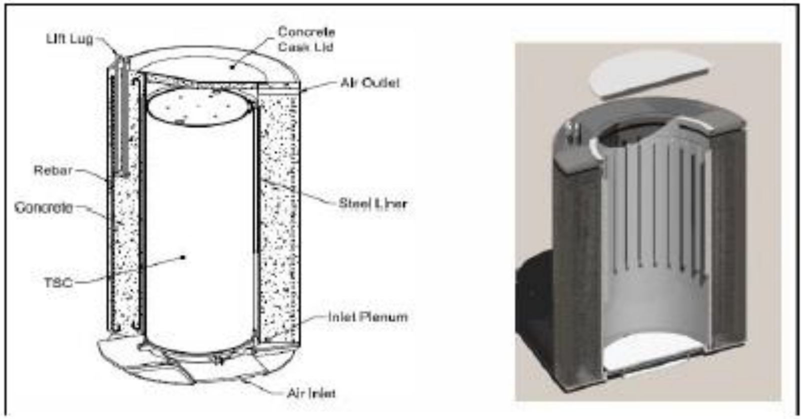


Figure 4-11
NAC MAGNASTOR Dual-Purpose Technology, CoC # 72-1031 [Pennington 2005]

NAC

Bare Fuel Storage Systems

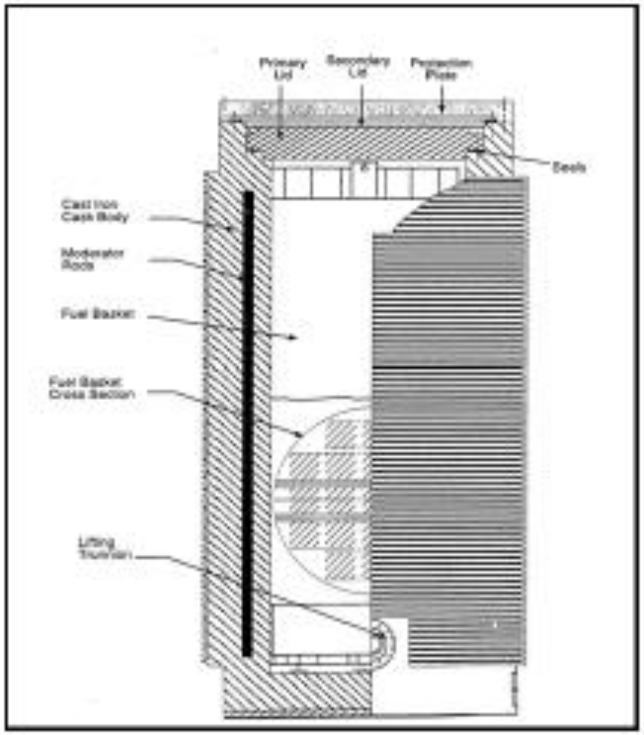


Figure 4-3
CASTOR V/21 Metal Storage Cask, CoC # 72-1000 [NEI 1998]

Castor

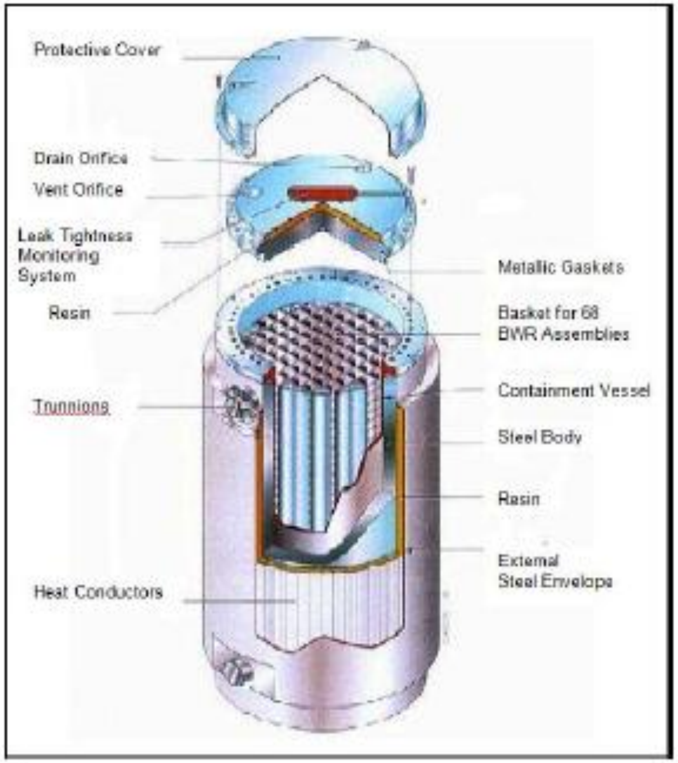


Figure 4-12
TN-68 Transport/Storage Cask, CoC #72-1027 [Bailly 2005]

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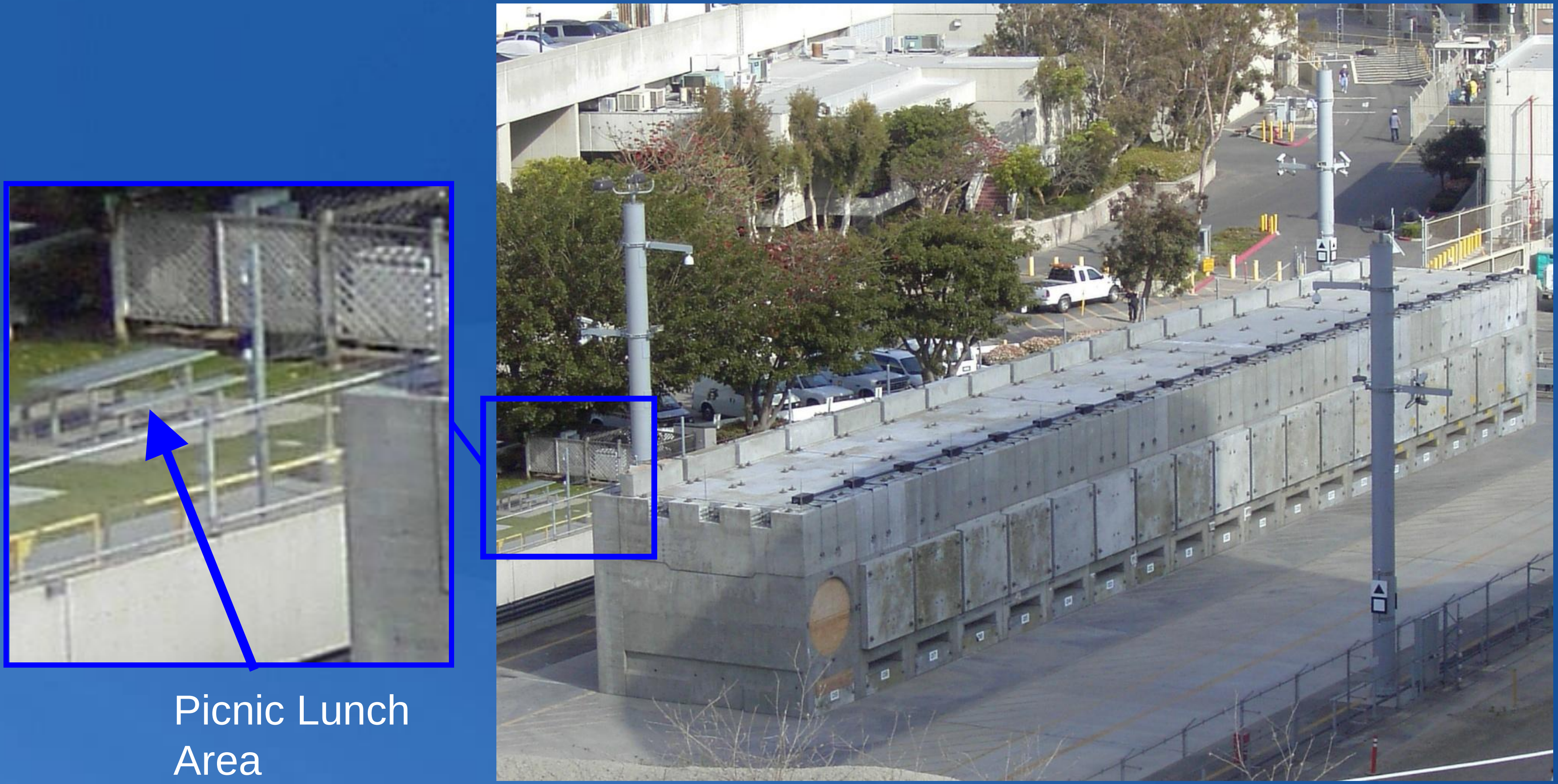
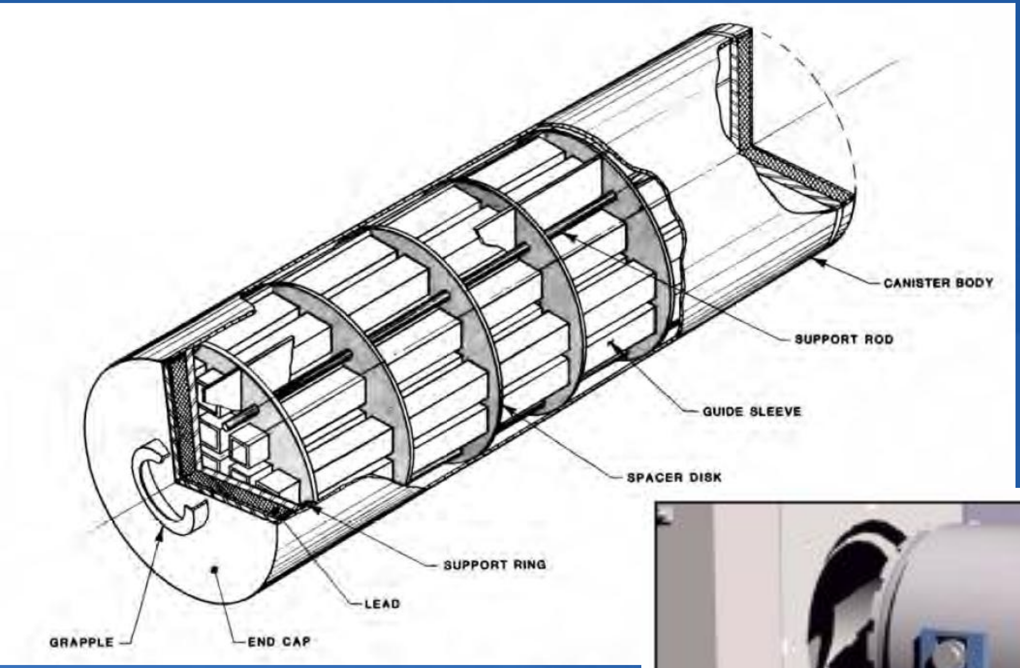
Horizontal Storage Systems at an ISFSI



Picnic Lunch Area

Southern California Edison – SONGS Units 1, 2, and 3

Typical Horizontal DPC Dry Storage Systems



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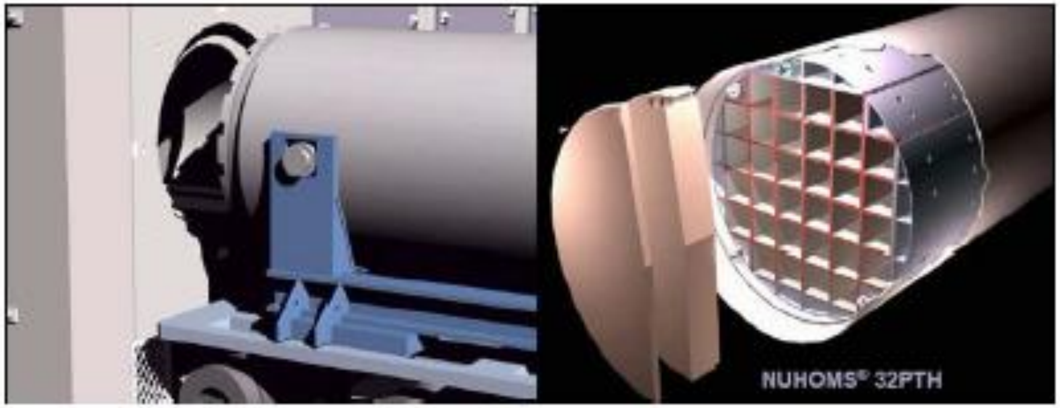

Figure 4-13
NUHOMS® Horizontal Storage Module, Transfer Trailer, and NUHOMS 32PTH DSC [Neider 2005, Neider 2008]

Dry Cask Storage at INL

Figure 2-9. NUHOMS Dry Storage Casks Emplaced in Concrete Horizontal Storage Modules at the Idaho National Laboratory Independent Spent Fuel Storage Installation
(Photo courtesy of Idaho National Laboratory)

Figure 3. The Below-grade Storage Facility CP-749 at the INL Used to Dry Store Peachbottom Reactor SNF

Figure 2. Commercial Dry Storage casks used in SNF tests at the INL
Left to Right: REA 2023; VSC-17; TN 24P; V21; 125B; MC-10

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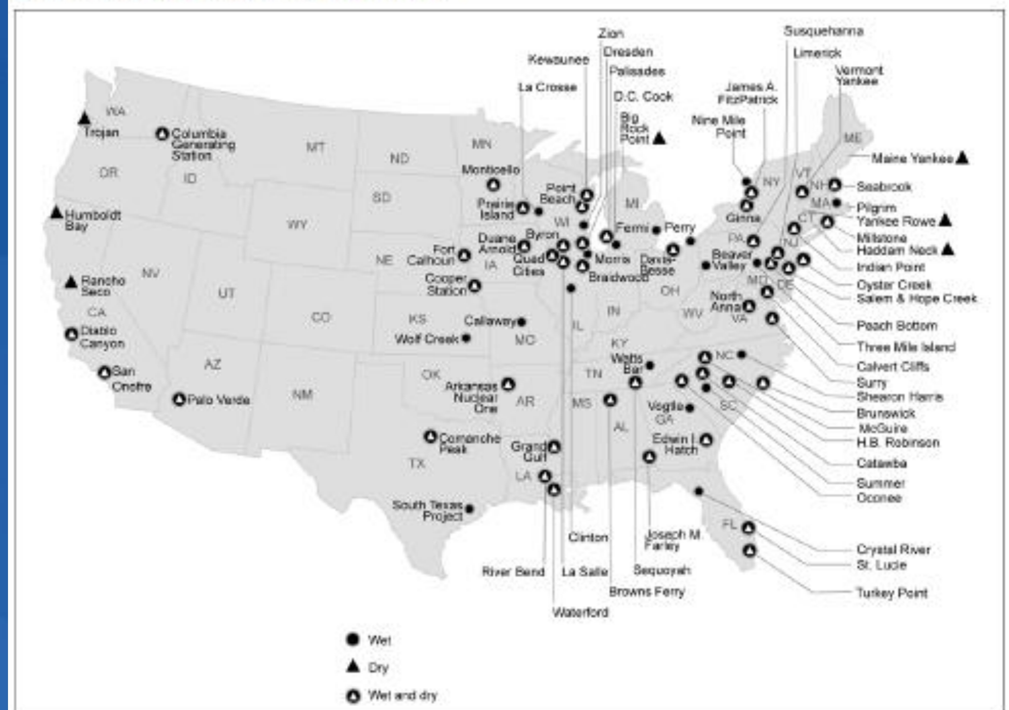
Commercial Used Nuclear Fuel in Storage
June 2012

- **Used fuel inventory**
  - Approximately 69,000 MTU
  - Increases 2 - 2.4k MTU/year
- **Dry cask storage**
  - 67,691 assemblies
  - 19,000 MTU
  - 1,613 casks/modules loaded
  - 58 Operating ISFSIs
    - 1 pool ISFSI, 1 modular vault
- **Projections for 2020**
  - Estimating 88,000 MTU total
  - Estimating 31,000 MTU in dry storage
  - 3,000 casks/modules loaded
  - At 76 ISFSIs
    - All plant sites + Morris & INL
  - Fuel from 119 reactors

Figure 1: Commercial Spent Nuclear Fuel Storage Sites



Source: NRC.

Note: Of the 75 sites, 65 have currently operating reactors, 7 have decommissioned reactors, 2 have reactors being decommissioned, and 1 site was constructed as a storage pool for spent fuel awaiting reprocessing.

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Historical Growth of Dry Cask Storage

DRY CASK STORAGE 1986 – 2011*

YEAR ENDING DECEMBER 31	NUMBER OF ISFSIs ADDED	TOTAL NUMBER OF ISFSIs	CASKS IN SERVICE	FUEL ASSEMBLIES IN DRY STORAGE
1986	-	2		
1987	0	2		
1988	0	2		
1989	0	2		
1990	1	3		
1991	0	3		
1992	1	4		
1993	2	6		
1994	0	6		
1995	2	8		
1996	1	9		
1997	0	9		
1998	1	10		
1999	1	11		
2000	3	14		
2001	3	17		
2002	6	23		
2003	4	27		
2004	1	28	664	22,644
2005	5	33	763	26,531
2006	3	36	848	30,032
2007	1	37	924	33,281
2008	8	45	1,073	40,280
2009	2	47	1,203	45,983
2010	5	52	1,351	52,381
2011	3	55	1,510	59,008

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* Does not include fuel at Morris (wet ISFSI), Fort St. Vrain (modular vault), or INL .

Used Fuel Storage Projections and Cask Transportability

Year	Metric Tons Heavy Metal (MTHM) Total	MTHM Pools	MTHM Dry Storage	Dry Cask Systems						
				Total	Non-transportable		Transportable			
					Bare fuel	Canister	Bare fuel	Bare fuel, *trans license pending*	DPCs	DPCs *Trans. license pending*
2010	64,461	49,666	14,795	1,242	29	209	47	89	651	217
2020	87,721	57,611	30,110	2,231	29	259	176	0	1,767	0
2030	117,071	64,895	52,176	3,593	29	309	216	0	3,036	0
2040	143,741	65,599	78,142	5,196	29	356	252	0	4,759	0

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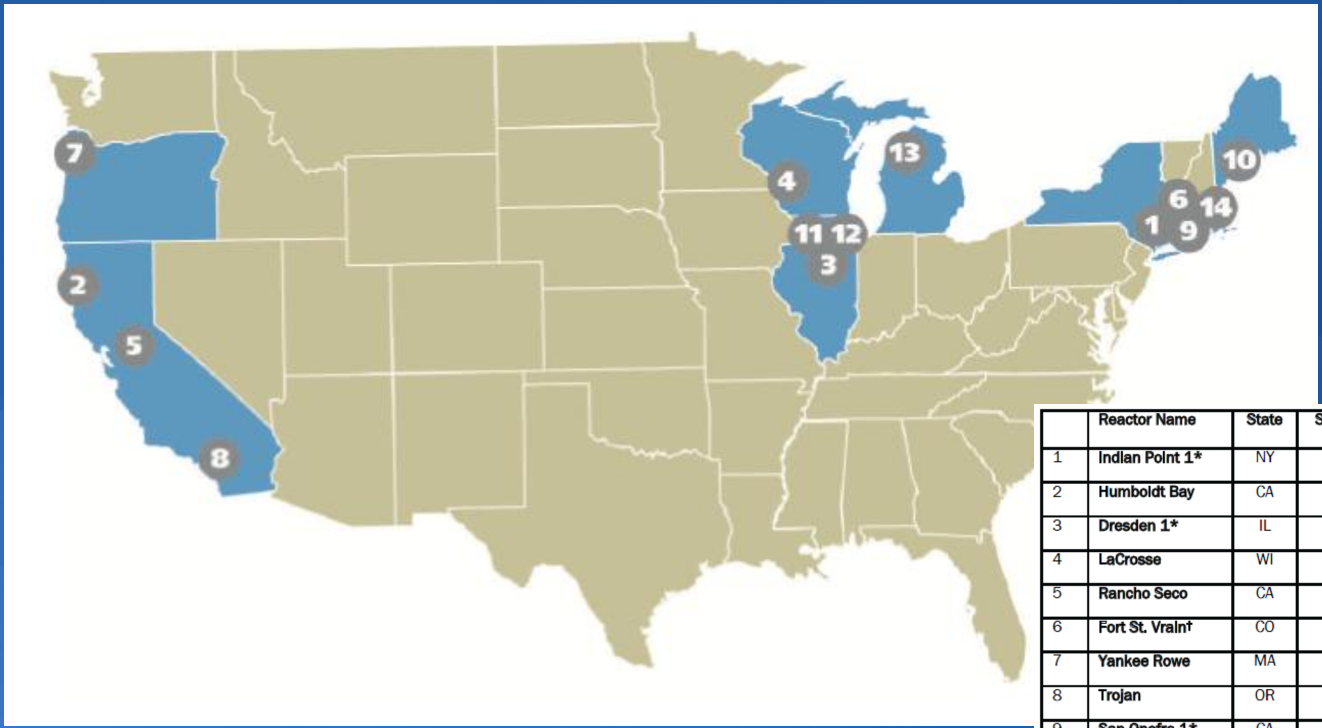
Used Nuclear Fuel Storage at Shutdown Reactors



	Reactor Name	State	Shutdown Date	Storage Type	Decommissioning Status	Used Fuel Stored On Site (MTUs)
1	**Indian Point 1***	NY	1974	Dry Cask	SAFSTOR	33
2	**Humboldt Bay**	CA	1976	Dry Cask	DECON in progress	31
3	**Dresden 1***	IL	1978	Dry Cask	SAFSTOR	69
4	**LaCrosse**	WI	1987	Pool	SAFSTOR	38
5	**Rancho Seco**	CA	1989	Dry Cask	DECON complete	228
6	**Fort St. Vrain†**	CO	1989	Dry Cask	DECON complete	25
7	**Yankee Rowe**	MA	1991	Dry Cask	DECON complete	122
8	**Trojan**	OR	1992	Dry Cask	DECON complete	345
9	**San Onofre 1***	CA	1992	Dry Cask	DECON in progress	146
10	**Haddam Neck**	CT	1996	Dry Cask	DECON complete	422
11	**Maine Yankee**	ME	1996	Dry Cask	DECON complete	542
12	**Zion 2**	IL	1996	Pool	SAFSTOR	1,019 (combined pool)
13	**Zion 1**	IL	1997	Pool	SAFSTOR	
14	**Big Rock Point**	MI	1997	Dry Cask	DECON complete	70
15	**Millstone 1***	CT	1998	Pool	SAFSTOR	522
					Total MTUs	**3,612**

* Collocated with operating reactors

† Transferred to the U.S. Department of Energy on June 4, 1999

Source: Gutherman Technical Services

Dry Storage Safety

- **Dry Casks are robust systems with no moving parts**
- **Defense in depth designs provide long-term protection**
  - **NRC rulemaking increasing license and renewal terms from 20 to 40 years concluded "This increase is consistent with the NRC staff's findings regarding the safety of spent fuel storage as documented in the renewal exemptions issued to the Surry and H.B. Robinson ISFSIs" 76 Fed. Reg. 8874 2/16/2011**
  - **NRC Waste Confidence findings stated "studies performed to date have not identified any major issues with long-term use of dry storage" 75 Fed. Reg. 81072, 12/23/2010**
- **Risk studies affirm high confidence in safety**
  - **2007 EPRI and NRC Probabilistic Risk Assessments determined annual cancer risk due to dry storage between 1.8E-12 and 3.2E-14 ***
- **Characterization project confirmed performance**
  - **In 2000, INL opened a cask after 14 yrs., finding "long-term storage has not caused detectable degradation of the spent fuel cladding or the release of gaseous fission products"**
  - **Opportunities to further verify performance being pursued**

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* Compares to 2E-6 LCF/yr. public & 1E-5 LCF/yr . worker thresholds of negligible risk from NRC's framework for "Risk-Informed Decision-making for Nuclear Material and Waste Applications", Revision 1, February 2008

Regulatory Dose Rate Limits

- **Storage: at the controlled area boundary**
  - **Normal condition: 25 mrem/yr**
  - **Accident condition: 5 rem**
- **Transportation:**
  - **Normal Condition: 10 mrem/hr at 2 meters, 200 mrem/hr on contact**
  - **Accident Condition: 1 Rem/hr at 1 meter**

Annual U.S. Estimated Radiation Dose Per Person, all natural & man made sources = 622 mrem (0.62 Rem)

Transportation of Used Nuclear Fuel

- **Used nuclear fuel is transported in robust containers designed to withstand severe accidents**
  - Truck containers weigh 25 to 40 tons
  - Rail containers weigh 75 to 125 tons
- **Four decades of safety - over 3,000 shipments in US.**
  - 78% by truck and 22% by rail.
  - Transported over 1.7 million miles
- **Over 24,000 shipments internationally.**
  - More than 73,000 MTHM SNF/HLW transported
- **No release of the radioactive contents from the transport cask; no injury due to radioactive contents.**

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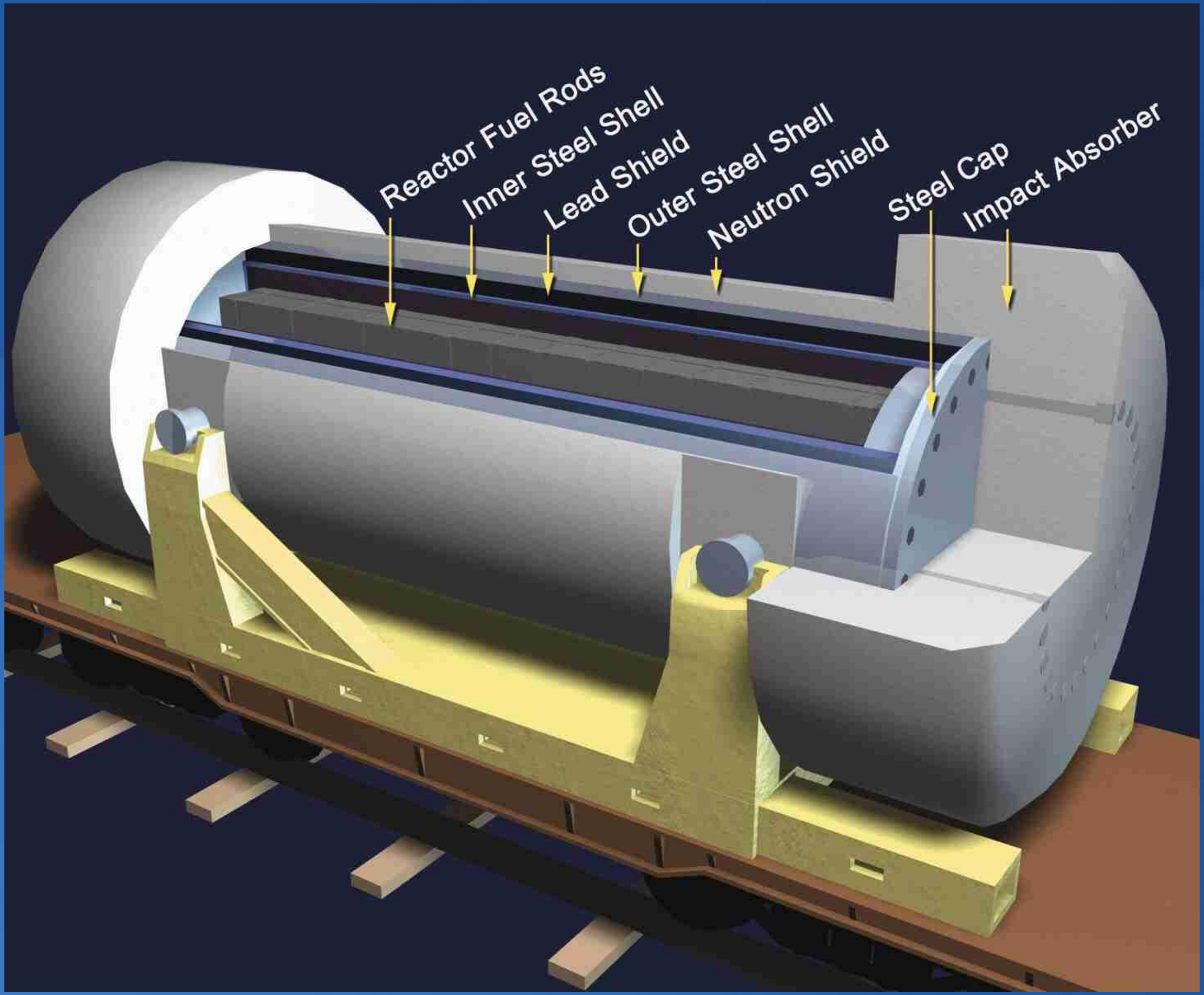
Transportation Cask



Testing of Transportation Cask

Conclusion

- **Dry cask storage is a proven and widely used solution to accumulating inventories of used nuclear fuel at reactor sites**
- **The safety of dry cask storage is well established**
- **Industry is committed to continue to build on this success**