Summary of Nuclear Waste Inventory in the U.S.

Spent Nuclear Fuel Inventory

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ADVANCED REACTORS AND FUEL CYCLES

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1 Introduction

This summary consolidates U.S. spent nuclear fuel (SNF) and high-level waste inventory information from federal databases and national reports to support isotopic composition analysis and fuel-cycle modeling. It provides (1) current commercial SNF inventory, (2) DOE-managed SNF from research and defense programs, (3) research reactor SNF, and (4) reprocessing waste inventories.

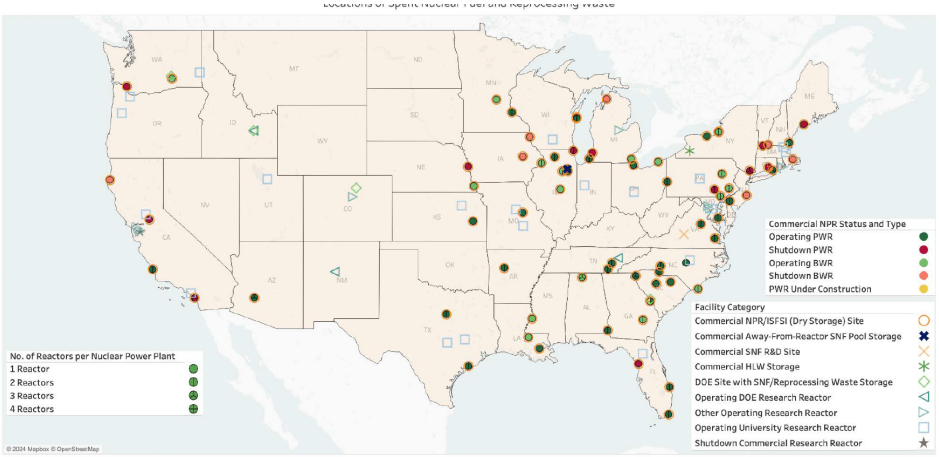

Figure 1: Sites Storing Spent Nuclear Fuel and Reprocessing Waste at the End of 2022

At the end of 2022, the U.S. inventory of spent nuclear fuel (SNF) and primary reprocessing waste was distributed across more than 100 sites in 39 states. These include 73 commercial nuclear power reactor and ISFSI sites, 6 DOE facilities with SNF or research reactors, and 28 research and development (R&D) sites encompassing universities, government laboratories, and commercial research centers. Four major locations manage high-level waste (HLW) and vitrified reprocessing waste, including 3 DOE facilities and one commercial site at West Valley, NY

Commercial Spent Nuclear Fuel at Nuclear Power Reactor and ISFSI Sites (excluding DOE)	90,963 MTHM [a]
Total Amount of Commercial Discharged PWR Spent Nuclear Fuel [b]	135,645 Assemblies 59,013 MTHM [a]
Total Amount of Commercial Discharged BWR Spent Nuclear Fuel [b]	179,466 Assemblies 32,023 MTHM [a]
Total Number of Commercial Spent Nuclear Fuel Canisters/Casks in Dry Storage (See Section 2.1)	3,862
Spent Nuclear Fuel at DOE Sites (includes SNF from DOE Research Reactors)	2,479 MTHM [a,c]
Spent Nuclear Fuel at Other Sites (University and Other Government Research Reactors, Commercial R&D Centers) [d]	1 MTHM [a]
Number of Sites Having One or More Commercial Nuclear Power Reactors and/or ISFSIs with SNF Stored Onsite (excluding DOE Sites) [e]	73
Number of Sites Having All Nuclear Power Reactors Shutdown with SNF Stored Onsite (excluding DOE Sites, See Section 2)	20
Number of Operating Nuclear Power Reactors	92
Number of Shutdown Nuclear Power Reactors with SNF Stored Onsite (excluding DOE sites)	27
Number of DOE Sites with SNF storage and/or DOE research reactors (see Section 3)	6
Number of University Research Reactor Sites (see Section 4.1) [f]	20
Number of Other Government Agency Research Reactors (see Section 4.2)	4
Number of Commercial Research and Development Centers with SNF (see Section 4.3)	4
Number of Primary Reprocessing Waste or HLW Storage Sites (see Section 5.1) [g]	4
Number of Vitrified Reprocessing Waste Canisters at DOE Sites	4,346 [h]
Number of Vitrified Reprocessing Waste Canisters at West Valley Site	278 [i]

Table 1: U.S. SNF and Reprocessing Waste Inventory Summary as of December 31, 2022

Commercial SNF inventories include permanently discharged PWR and BWR assemblies reported through 2022. Quantities exclude reprocessed fuel from the West Valley and Fort St. Vrain reactors. DOE totals include SNF from research, naval, and production programs. Other non-commercial sources include university and government research reactors. Reprocessing waste totals reflect vitrified HLW canisters produced through 2022.

2 U.S. Commercial Spent Nuclear Fuel Inventory

Since 1960, the U.S. has built 131 nuclear power reactors (NPRs) for civilian electricity generation, excluding experimental and non-power units. Nine early demonstration reactors (e.g., Peach Bottom 1, Shippingport, Fermi 1) have been decommissioned, and their SNF is managed by DOE. The Fort St. Vrain gas-cooled reactor's fuel is also under DOE custody at Idaho Na-

tional Laboratory (INL).

Of the remaining reactors, 121 are light-water reactors (LWRs). One (Shoreham) never reached full operation, and Three Mile Island Unit 2 was disabled in 1979—both managed by DOE. As of 2022, 92 reactors operate and 27 are permanently shut down. Each plant includes one or more reactors and typically a co-located Independent Spent Fuel Storage Installation (ISFSI), which becomes the sole facility after decommissioning.

To organize analysis, sites are grouped by reactor status and storage mode:

- Group A: All units permanently shut down.
- Group B: Mixed—operating and shutdown units.
- Group C: All operating units.
- Group F: Away-from-reactor ISFSI (Morris, IL)

A suffix denotes storage configuration (1 = dry only, 2 = mixed, 3 = wet only). For example, Yankee Rowe is Group A1, while Surry is Group C2. Two Diablo Canyon reactors plan early shutdowns before 2030.

Table 2.1 LWR Nuclear Power Reactor Sites by Group/Subgroup (as of December 2022)

Group A: All Units Shutdown Sites (# of Units) – 25 Reactors/20 Sites			
A1 (Dry Storage)		A2 (Dry and Pool Storage)	A3 (Pool Storage)
Reactors Shutdown Prior to 2000			
Big Rock Point (1)	Rancho Seco (1)	Indian Point (3)	
Haddam Neck (1)	Trojan (1)	Palisades (1)	
Humboldt Bay (1)	Yankee Rowe (1)		
La Crosse (1)	Zion (2)		
Maine Yankee (1)			
Reactors Shutdown Post 2000			
Crystal River (1)	Vermont Yankee (1)		
Kewaunee (1)	Fort Calhoun (1)		
San Onofre (3)	Oyster Creek (1)		
Pilgrim (1)	Duane Arnold (1)		
Three Mile Island (1) ††			

Group B: Mixed Status Sites (# of Units) – Total 6 Reactors (4 Operating, 2 Shutdown) /2 Sites		
Currently All Group B Sites have both Dry and Wet Storage Capabilities	B2† (Dry and Pool Storage)	
	Dresden (3)	
	Millstone (3)	

Group C: All Units Operating (# of Units)– 88 Reactors/52 Nuclear Power Plants/50 Sites (Note: All Group C Sites have Wet Storage Capabilities)			
C2 (Dry and Pool Storage)			C3 (Pool Storage)
Arkansas Nuclear (2)	Fitzpatrick (1)‡‡	Prairie Island (2)	Shearon Harris (1)
Beaver Valley (2)	Fermi (1) ††	Quad Cities (2)	
Braidwood (2)	Ginna (1)	River Bend (1)	
Browns Ferry (3)	Grand Gulf (1)	Robinson (1)	
Brunswick (2)	Hatch (2)	Saint Lucie (2)	
Byron (2)	Hope Creek (1) ‡‡‡	Salem (2) ‡‡‡	
Calvert Cliffs (2)	La Salle (2)	Seabrook (1)	
Callaway (1)	Limerick (2)	Sequoyah (2)	
Catawba (2)	McGuire (2)	South Texas (2)	
Clinton (1)	Monticello (1)	Summer (1)	
Columbia Generating Station (1)	Nine Mile Point (2)‡‡	Surry (2)	
Comanche Peak (2)	North Anna (2)	Susquehanna (2)	
Cooper (1)	Oconee (3)	Turkey Point (2)	
Davis-Besse (1)	Palo Verde (3)	Vogtle (2)	
D.C. Cook (2)	Peach Bottom (2) ††	Waterford (1)	
Diablo Canyon (2)	Perry (1)	Watts Bar (2)	
Farley (2)	Point Beach (2)	Wolf Creek (1)	

† Two B2 Sites have a single shutdown reactor and 2 operating reactors.

Table 2: Spent Nuclear Fuel Inventory by Reactor Group/Subgroup (As of 12/31/2022)

Inventory and fuel design data originate from DOE's GC-859 Nuclear

Fuel Data Survey, which catalogs assembly dimensions, enrichment, and burnup characteristics used throughout the report.
At the end of 2022, approximately 91 000 MTU of commercial SNF had been discharged. The discharge totals reported via GC-859 represent only the initial discharge locations and do not account for subsequent transfers.

- Before 2000, limited quantities were reprocessed at West Valley, NY, and five reactors shipped fuel to the Morris, IL away-from-reactor pool storage site.
- bout 73 MTU of SNF was transferred to DOE for research and demonstration programs (e.g., rod consolidation, dry storage testing, vitrification). Roughly 68 MTU remain in DOE storage today.
- SNF from Fort St. Vrain and Three Mile Island Unit 2 is also managed by DOE at Idaho National Laboratory.
- Since 2000, nearly all discharged SNF has remained at the originating reactor sites, stored in pools or dry casks.
- As of 2022, 73 commercial sites, including the Morris facility, hold the national inventory. More SNF is now stored in dry systems than in pools

	Dry Inventory			Pool Inventory		Total Discharged SNF	
Reactor Type	Assy.	Initial Uranium (MT)	SNF Casks	Assy.	Initial Uranium (MT)	Assy.	Initial Uranium (MT)
PWR	94,407	16,675	1,399	78,008	14,131	172,415	30,805
BWR	74,774	32,252	2,463	64,472	27,232	139,246	59,484
Totals	**169,181**	**48,926**	**3,862**	**142,480**	**41,363**	**311,661**	**90,289**

Table 3: Current Inventory at NPR sites by Storage Method as of December 2022

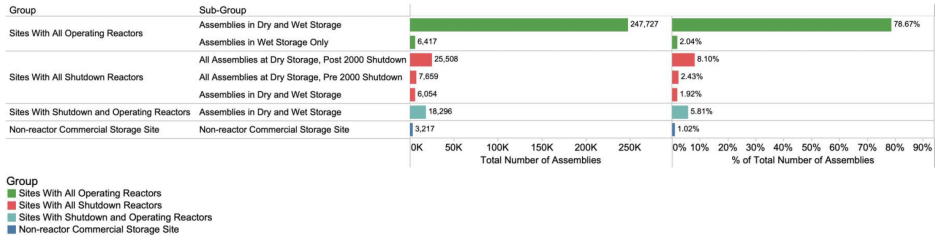

Figure 2: Nuclear Power Reactor and ISFSI Sites (non-DOE) Currently Storing SNF

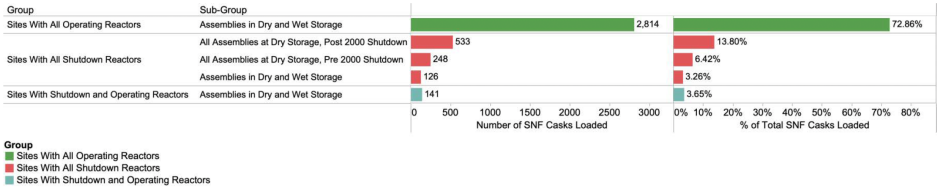

Figure 3: Dry SNF Storage Casks Loaded at Nuclear Power Reactor Sites

Fuel characteristics derived from GC-859 show:

- verage burnup increasing steadily since the 1970s to about 45–50 GWd/MT.
- Corresponding enrichment rising from 2% to 4.5% U-235.

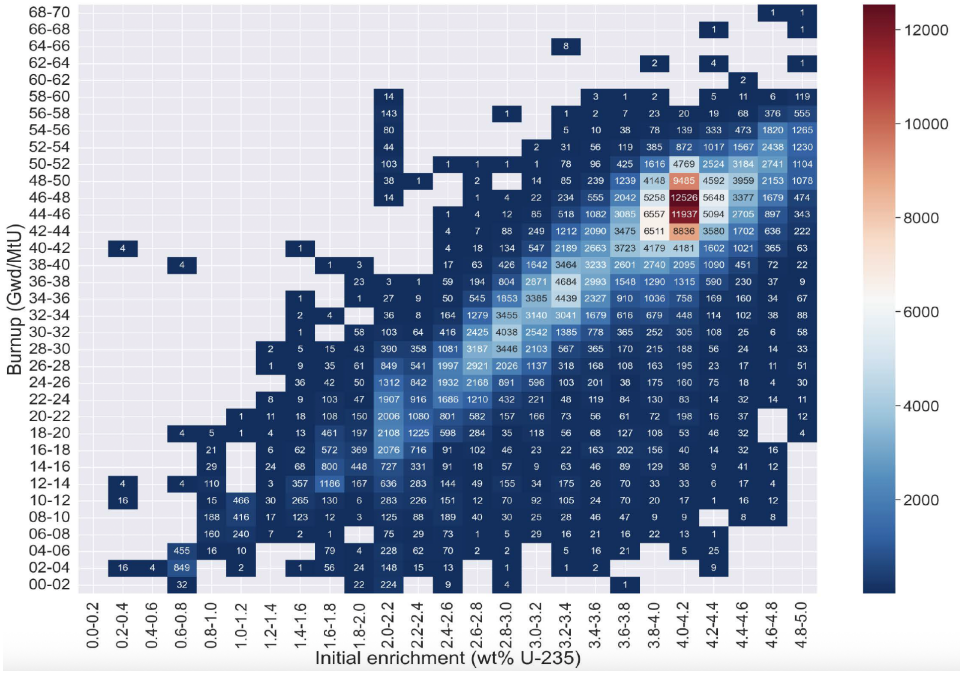

Figure 4: Burn-up (GWd/MTHM) & Initial Enrichment (% U-235) by Number of Assemblies of SNF Through December 2022

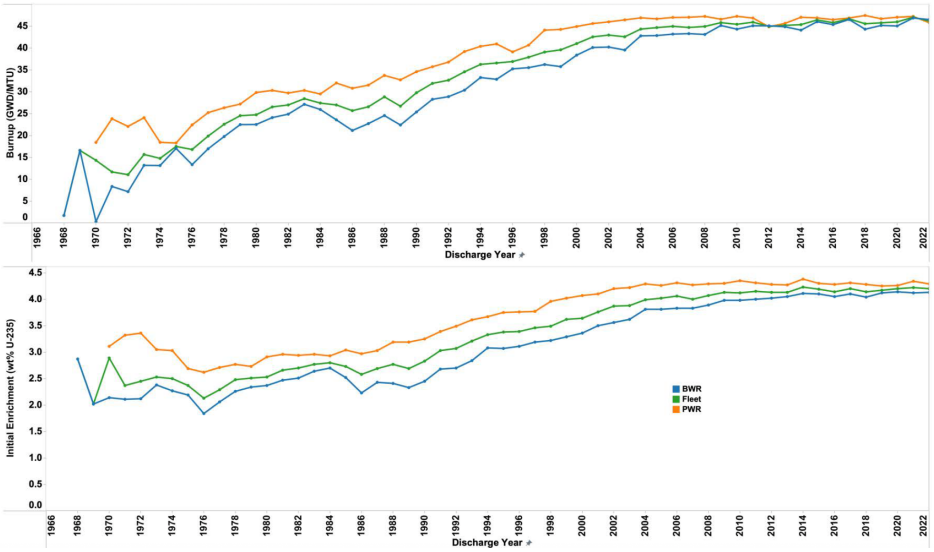

Figure 5: Average Annual Burn-up (GWd/MT) and Enrichment (U-235%)

The figures below show the decay heat behavior of representative spent fuel assemblies at typical U.S. discharge burnups (PWR: 40 and 60G̃Wd/MTU; BWR: 30 and 50G̃Wd/MTU).

Elements	Decay Heat (Watts/MT)							
	Time (years)							
	1	10	30	50	70	100	300	500
Gases H, C, Xe, Kr, I	0	0	0	0	0	0	0	0
Cs/Sr/Ba/Rb/Y	4,608	1,576	824	516	323	160	1	0
Noble Metals Ag, Pd, Ru, Rh	3,447	14	0	0	0	0	0	0
Lanthanides La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Ho, Tm	3,843	109	17	3	1	0	0	0
Actinides Ac, Th, Pa, U	0	0	0	0	0	0	0	0
Transuranic Np, Pu, Am, Cm, Bk, Cf, Es	1,515	785	613	516	449	381	199	139
Others	522	21	3	1	0	0	0	0
Totals	**13,936**	**2,505**	**1,458**	**1,036**	**773**	**541**	**201**	**139**

Table 4: PWR 60 GWd/MT Spent Nuclear Fuel Decay Heat

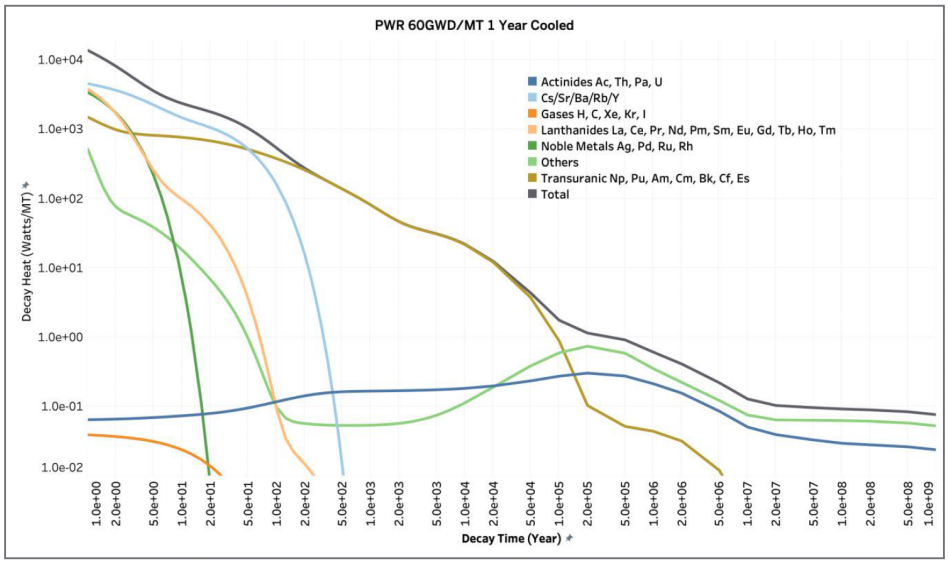

Figure 6: PWR 60 GWd/MT Spent Nuclear Fuel Decay Heat

Elements	Decay Heat (Watts/MT) Time (years)							
	1	10	30	50	70	100	300	500
Gases H, C, Xe, Kr, I	0	0	0	0	0	0	0	0
Cs/Sr/Ba/Rb/Y	3,558	1,257	662	414	259	128	1	0
Noble Metals Ag, Pd, Ru, Rh	2,669	11	0	0	0	0	0	0
Lanthanides La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Ho, Tm	2,734	92	14	3	1	0	0	0
Actinides Ac, Th, Pa, U	0	0	0	0	0	0	0	0
Transuranic Np, Pu, Am, Cm, Bk, Cf, Es	1,627	760	591	496	433	369	199	139
Others	420	17	2	1	0	0	0	0
Totals	**11,008**	**2,137**	**1,271**	**914**	**693**	**498**	**200**	**139**

Table 5: BWR 50 GWd/MT Spent Nuclear Fuel Decay Heat

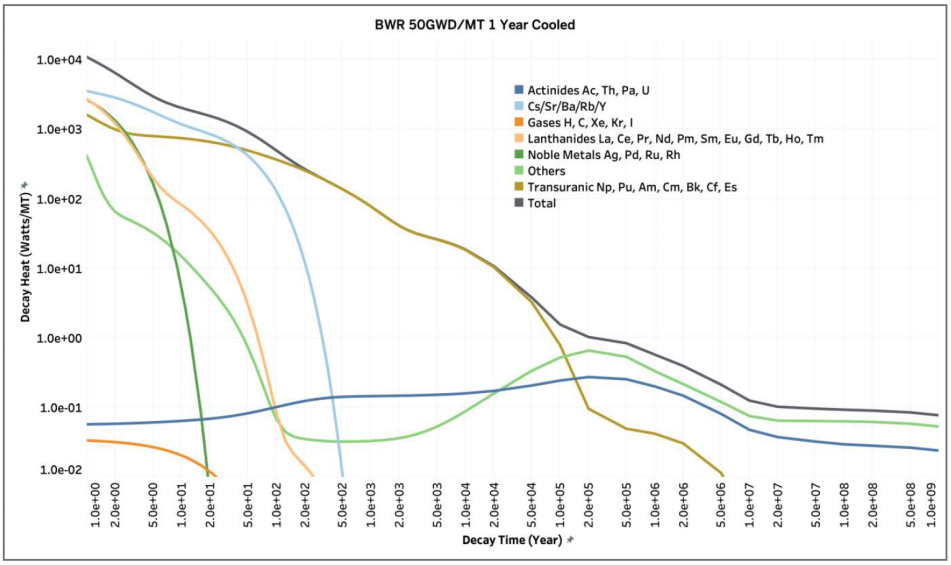

Figure 7: BWR 50 GWd/MT Spent Nuclear Fuel Decay Heat

While commercial power reactors account for nearly all spent fuel generated in the United States by mass, the Department of Energy manages a separate inventory originating from research, defense, and demonstration reactors.

3 SNF at DOE locations

The U.S. Department of Energy (DOE) manages spent nuclear fuel (SNF) that is not part of the commercial nuclear power reactor fleet. This includes fuel from defense production reactors, DOE-sponsored research reactors, early demonstration power reactors, fuel used in research and development programs, and naval reactors.

DOE SNF comes from a diverse set of reactors, including production and isotope-generation reactors, national laboratory research reactors, university and government research reactors, and early power demonstration reactors (e.g., Shippingport, Peach Bottom 1). SNF is highly heterogeneous, ranging from depleted uranium fuel to highly enriched (>93% U-235) test reactor fuel. DOE holds fuel in hundreds of distinct fuel types—over 229,000

individual pieces.

As of the end of 2022, DOE managed approximately 2,446 metric tons of heavy metal (MTHM) of SNF (excluding naval fuel), tracked in the Spent Fuel Database (SFD). For analysis purposes, this inventory has been grouped into 34 standardized categories based on fuel matrix, cladding type, cladding condition, and enrichment—parameters that affect storage, degradation, and repository performance.

DOE estimates radionuclide inventories using template models based on fuel type and decay time. The estimated total activity for DOE SNF in 2030 is:

- 96 million Ci (nominal)
- 195 million Ci (bounding/highest case)

	DOE SNF	
Decay heat per canister (watts)	Number of canisters [11]	Cumulative %
<50	1,411	52.1%
50 - 100	459	69.0%
100 - 220	647	92.9%
220 - 300	100	96.6%
300 - 500	77	99.4%
500 - 1000	6	99.6%
1000 - 1500	3	99.7%
1500 - 2000	-	99.7%
>2000	7	100.0%
Total	**2,710**	

Table 6: Spent Nuclear Fuel Canister Decay Heat in 2030 [NSNFP, 2023]

In 1995, DOE consolidated SNF storage at three sites, where it remains today:

- Hanford (WA): 2,128 MTHM (largest share, stored in Multi-Canister Overpacks)

- Idaho National Laboratory (ID): ~270 MTHM
- Savannah River Site (SC): ~27 MTHM

Most SNF is stored in dry canisters; DOE has standard disposal canister designs but has not yet packaged fuel into those canisters.

DOE currently manages 173.6 MTHM of commercial-origin SNF. DOE also manages some fuel originally discharged from commercial nuclear power reactors for research, testing, and post-irradiation examination. This includes:

- Three Mile Island Unit 2 core debris.
- Fort St. Vrain High-Temperature Gas-Cooled Reactor fuel.
- Fuel transferred for research/vitrification testing.

Decay heat per canister (watts)	2030	
	Number of DOE Standard Canisters [12]	Cumulative %
<50	792	83.4%
50 - 100	54	89.0%
100 - 220	33	92.5%
220 - 300	40	96.7%
300 - 500	3	97.0%
500 - 1000	24	99.6%
1000 - 1500	0	99.6%
1500 - 2000	0	99.6%
>2000	5	100.0%
Totals	**950**	

Table 7: Canister Decay Heat Characteristics of NPR Origin SNF in DOE Possession

The Naval Nuclear Propulsion Program generates SNF from nuclear-powered submarines, aircraft carriers, and land-based training reactors.

- Current naval SNF inventory: ~40 MTHM, projected to be <65 MTHM by 2035.
- Uses highly enriched uranium, resulting in very low transuranic buildup compared to commercial SNF.
- Stored in engineered naval canisters designed to meet repository acceptance limits.

- About 201 naval fuel canisters are currently loaded and stored at INL.

Decay heat per canister (watts)	Number of canisters	Cumulative %
500 - 1000	13	3.3%
1000 - 2500	36	12.3%
2500 - 5000	94	35.8%
>5000	257	100.0%
Total	**400**	

Table 8: Naval SNF Canister Decay Heat

4 SNF at other sites

In addition to commercial power reactors and DOE facilities, a small amount of spent nuclear fuel (SNF) exists at other U.S. sites, including university research reactors, government agency reactors, and commercial research and development centers. These inventories are tracked through the DOE Spent Fuel Database and total only $\tilde{1}$.35 metric tons of heavy metal (MTHM), a very small quantity compared to commercial and the DOE managed SNF.

Approximately 20 university research reactors are actively operating across the United States. They operate at very low power levels (from <1 watt to 10 MW) and use fuel at such low burnup that refueling is infrequent or unnecessary during their operational lifetime. When these reactors eventually discharge spent fuel, it is transferred to DOE storage facilities, primarily at Idaho National Laboratory (INL) or the Savannah River Site (SRS), where it becomes part of the DOE-managed SNF inventory described. A small number of very low-power critical facilities (e.g., AGN-201 reactors and the Rensselaer Critical Facility) are not expected to ever discharge fuel.

State	Installation	Inventory (kg)
California	University of California (Irvine)	20.34
	University of California (Davis)	80.34
Florida	University of Florida (Gainesville)	19.30
Indiana	Purdue University (West Lafayette)	12.03
Kansas	Kansas State University (Manhattan)	21.44
Maryland	University of Maryland (College Park)	19.84
Massachusetts	University of Massachusetts-Lowell	10.64
	Massachusetts Institute of Technology (Cambridge)	20.21
Missouri	University of Missouri (Columbia)	28.95
	University of Missouri (Rolla)	25.52
North Carolina	North Carolina State University (Raleigh)	484.05
Ohio	Ohio State University (Columbus)	26.15
Oregon	Oregon State University (Corvallis)	75.63
	Reed College (Portland)	18.95
Pennsylvania	Pennsylvania State University (University Park)	37.94
Texas	Texas A&M University (College Station)	68.76
	University of Texas (Austin)	42.83
Utah	University of Utah (Salt Lake City)	25.77
Washington	Washington State University (Pullman)	57.53
Wisconsin	University of Wisconsin (Madison)	58.29
Total		1,154.48

Table 9: University Research Reactors

Table 4.2 lists research reactors operated by other government organizations. Permanently discharged SNF from these reactors is generally sent

to either SRS or INL, and the SNF is managed by DOE and included in the inventory discussed earlier.

State	Installation	Inventory (kg)
Colorado	U.S. Geological Survey (Denver)	65.76
Maryland	National Institute of Standards and Technology (Gaithersburg)	13.91
	Armed Forces Radiobiology Research Institute (Bethesda)	18.27
Rhode Island	Rhode Island Atomic Energy Commission, RINSC Reactor (Narragansett)	19.24
Total		**177.17**

Table 10: Other Government Agency Research Reactors SNF

Table 4.3 lists commercial research and development centers. Three sites have reactors while the BWX Technologies site in Virginia is a fuel cycle research center conducting SNF destructive examinations among other activities.

State	Installation	Inventory (kg)
California	Aerotest Research Reactor (San Ramon)	17.50
	General Electric (Pleasanton)	3.98
Michigan	Dow Chemical, Research Reactor (Midland)	14.81
Virginia	BWX Technology, Fuel cycle R&D Center (Lynchburg)	43.89
Total		**80.19**

Table 11: Commercial Research and Development Centers SNF

5 Reprocessing Waste

In addition to spent nuclear fuel (SNF), the United States also manages high-level radioactive waste (HLW) resulting from reprocessing—the chemical separation of plutonium or uranium from irradiated fuel. Reprocessing historically took place at three DOE sites (Hanford, Idaho National Laboratory, and Savannah River Site) and at one former commercial reprocessing plant (West Valley, NY).

Reprocessing waste exists in different physical forms depending on the treatment method:

- Liquid HLW in underground tanks (historical storage)
- Vitrified waste (liquid waste converted into stable glass inside stainless-steel canisters)
- Calcined waste (granular solid waste produced by high-temperature drying)
- Metal/ceramic waste from electrochemical treatment of sodium-bonded fuel at INL

At DOE sites, vitrification is the primary stabilization strategy. Savannah River Site has been vitrifying waste since 1996 and, as of Dec. 31, 2022, has produced 4,346 glass waste canisters. INL holds $\tilde{4}$,400 m^3 of calcined waste from past reprocessing campaigns. Hanford still stores $\tilde{2}$20,000 m^3 of liquid HLW and is constructing a vitrification plant.

Hanford also stores cesium and strontium capsules (1,936 total), originally removed from liquid waste for isotope uses; their total radioactivity has declined from $\tilde{1}$09 million curies to $\tilde{4}$2 million curies through decay.

Electrochemical processing at INL (for sodium-bonded SNF) is treating up to 60 MTHM, producing both ceramic and metallic waste forms.

The combined radionuclide inventory of DOE reprocessing waste corresponds to approximately 1.3 million watts of decay heat, with more than 99% of vitrified canisters generating <1 kW.

At West Valley (NY), the only U.S. commercial reprocessing plant (operated 1966–1972), 640 MTHM of SNF was processed, generating $\tilde{2}$,500 m^3 of liquid HLW. This waste was vitrified into 278 canisters (stored on site).

6 Conclusion

The U.S. spent nuclear fuel inventory is dominated by commercial LWR SNF stored at reactor sites, with a smaller but more diverse DOE inventory and isolated reprocessing waste. Increasing burnup and enrichment trends influence isotopic composition at discharge, which is critical for fuel cycle modeling, decay heat analysis, and storage/disposal system design.

Key Findings:

- Total commercial SNF discharged through 2022: $\approx$ 91,000 MTU
- DOE-managed SNF (non-commercial): $\approx$ 2,446 MTU
- SNF at universities / R&D sites: $\approx$ 1.35 MTU
- High-level reprocessing waste: SRS vitrified canisters: 4,346 + West Valley vitrified canisters: 278

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[1] Andrei Rykhlevskii, Alexander Lindsay, and Kathryn D. Huff. Online reprocessing simulation for thorium-fueled molten salt breeder reactor. In *Transactions of the American Nuclear Society*, Washington, DC, United States, November 2017. American Nuclear Society.