

Overview of Radioactive Waste Management in the U.S.

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November, 2017



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Waste Classification and Disposition Pathways in the U.S.

Defense vs. Commercial

Principally regulated by: U.S. Department of Energy,
Environmental Protection Agency, and/or Nuclear Regulatory
Commission

Commercial SNF and LLW

Defense HLW and SNF

Defense LLW and Low-Activity Waste LAW

Greater-than-Class-C LLW and Defense “GTCC-Like” Waste

TRU Defense Waste

Defense Waste Incidental to Reprocessing (WIR)

Nuclear Waste Classification in the U.S.

High-Level Waste (HLW) and Spent Nuclear Fuel (SNF)

Defense HLW and SNF (extensive reprocessing)

Commercial HLW and SNF (limited reprocessing)

Low-Level Waste (LLW)

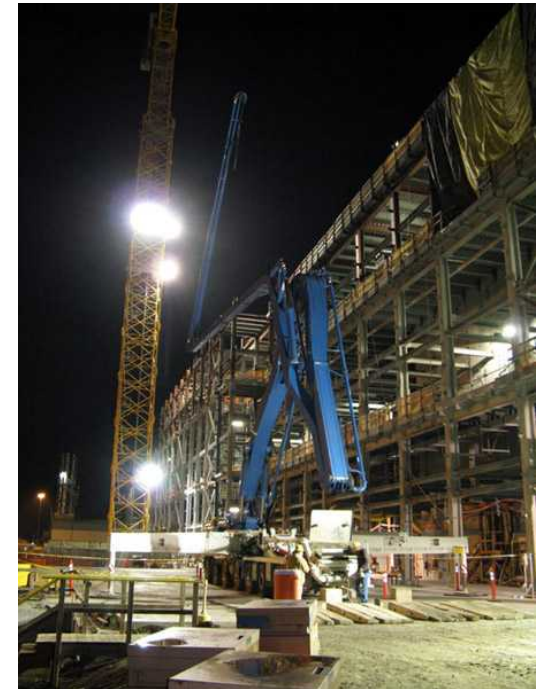
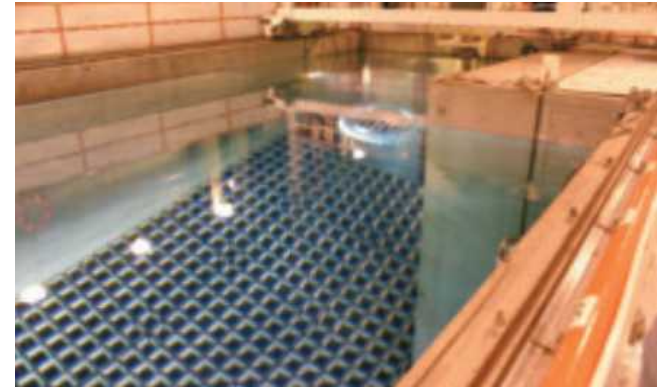
Defense low-activity waste (LAW)

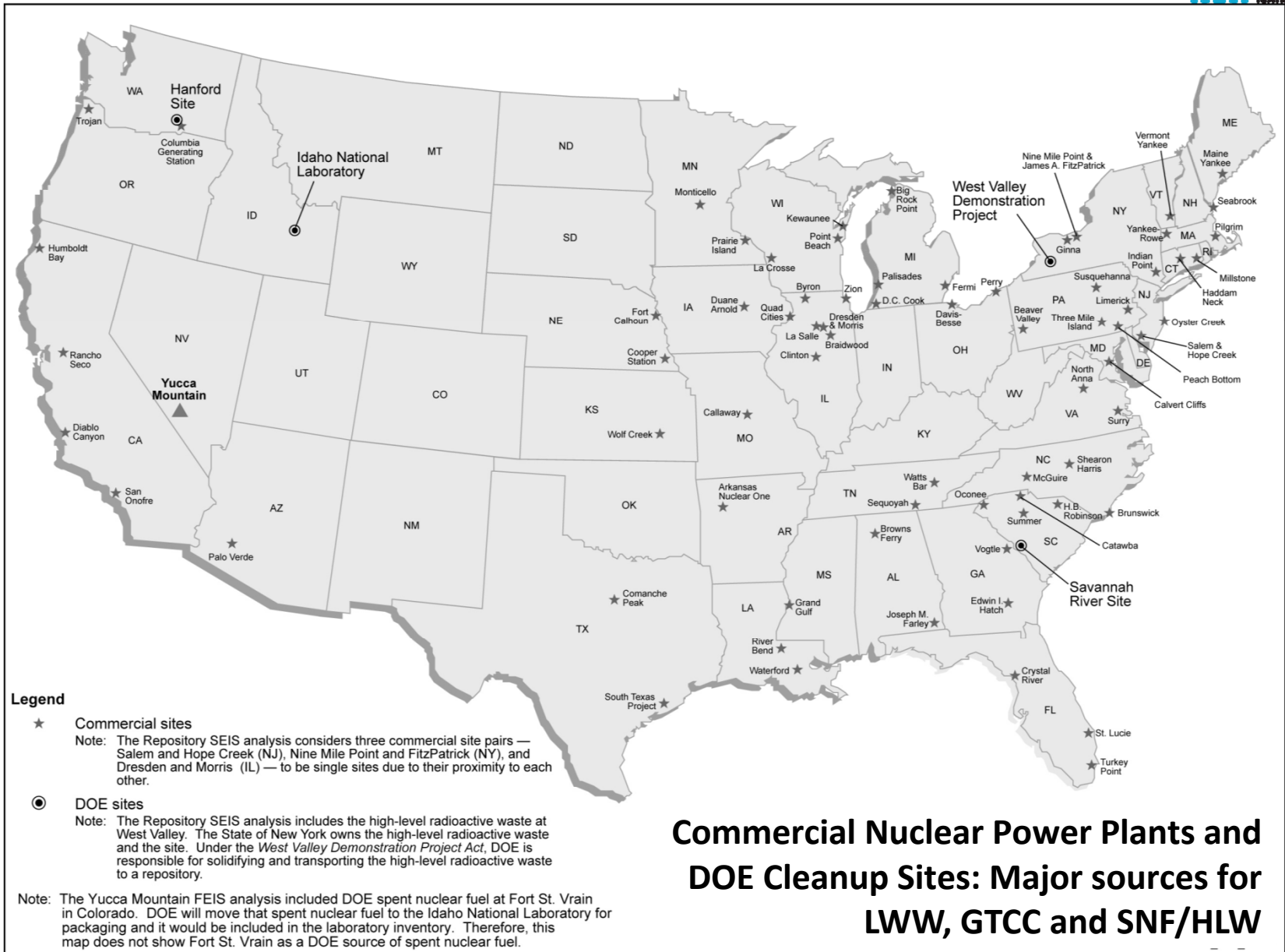
Commercial LLW (Class A, B and C)

Greater-than-Class-C LLW or “GTCC-like” defense waste

Transuranic (TRU) waste (defense; mainly Am & Pu)

Waste Incidental to Reprocessing (WIR; defense)





Nuclear Waste Classification in the U.S. – HLW & SNF

High-Level Waste (HLW) and Spent Nuclear Fuel (SNF)

Defense (extensive) AND Commercial (limited) HLW + SNF

- A. Regulators: U.S. NRC and EPA + Individual States
- B. Disposal pathway: Deep geologic disposal
- C. Examples:
 - * Commercial and defense SNF
 - * HLW glass (Savannah River, West Valley, Idaho, Hanford)
 - * Calcined waste and sodium-bearing waste (Idaho)
 - * Cs-Sr capsules (Hanford)

Low-Level Waste (LLW)

Defense low-activity waste (LAW)

Commercial LLW (Class A, B and C)

Greater-than-Class-C LLW or GTCC-like defense waste

Commercial GTCC

Defense “GTCC like”

Transuranic (TRU) waste (defense; mainly Am & Pu)

Waste Incidental to Reprocessing (WIR; defense)



Nuclear Waste Classification in the U.S. – Defense LAW/LLW

High-Level Waste (HLW) and Spent Nuclear Fuel (SNF)

Defense HLW and SNF (extensive reprocessing)

Commercial HLW and SNF (limited reprocessing)

Low-Level Waste (LLW)

Defense low-activity waste (LAW) and LLW

- A. Regulators: U.S. DOE (implementor and regulator) + Individual States
- B. Disposal pathways:
 - * Convert liquid LAW to solid LLW
 - * Saltstone (Savannah River Site)
 - * Vitrified waste form (Hanford)
- C. Examples:
 - * LAW liquid from tank waste
 - * Facility operations and decommissioning

Commercial LLW (Class A, B and C)

Greater-than-Class-C LLW or GTCC-like defense waste

Commercial GTCC

Defense “GTCC like”

Transuranic (TRU) waste (defense; mainly Am & Pu)

Waste Incidental to Reprocessing (WIR; defense)



Nuclear Waste Classification in the U.S. – LLW

High-Level Waste (HLW) and Spent Nuclear Fuel (SNF)

Defense HLW and SNF (extensive reprocessing)

Commercial HLW and SNF (limited reprocessing)

Low-Level Waste (LLW)

Defense low-activity waste (LAW)

Commercial LLW (Class A, B and C)

A. Regulators: U.S. NRC and EPA + Individual States

B. Disposal pathway: Near-surface burial

C. Examples:

- * Nuclear power plant operation and decommissioning
- * Research, industrial, and medical LLW

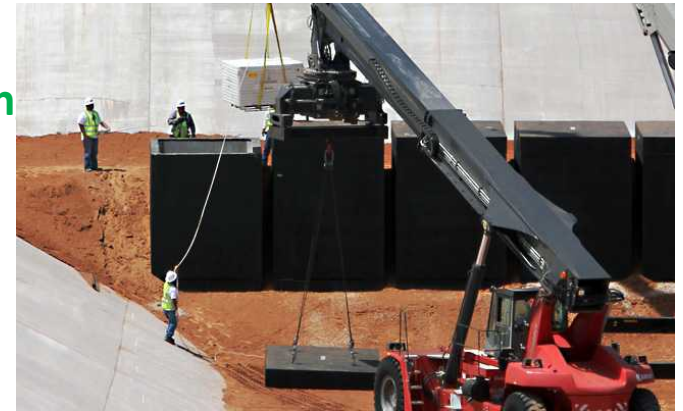
Greater-than-Class-C LLW or GTCC-like defense waste

Commercial GTCC

Defense “GTCC like”

Transuranic (TRU) waste (defense; mainly Am & Pu)

Waste Incidental to Reprocessing (WIR; defense)



Nuclear Waste Classification in the U.S. – GTCC

High-Level Waste (HLW) and Spent Nuclear Fuel (SNF)

Defense HLW and SNF (extensive reprocessing)

Commercial HLW and SNF (limited reprocessing)

Low-Level Waste (LLW)

Defense low-activity waste (LAW)

Commercial LLW (Class A, B and C)

Greater-than-Class-C LLW or “GTCC-like” defense waste^A

A. Regulators: U.S. NRC and EPA + Individual States

B. Disposal pathways: * Deep greater confinement disposal
* Geologic co-disposal

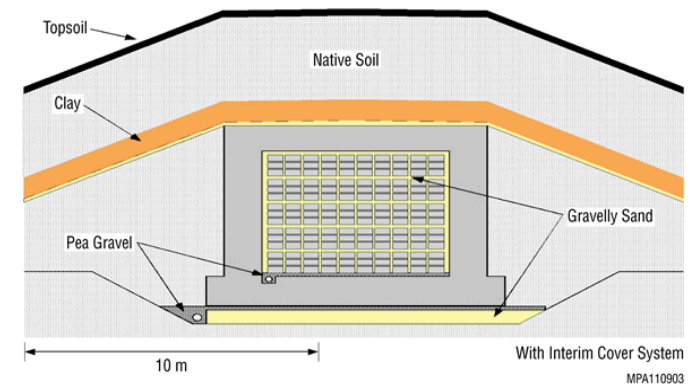
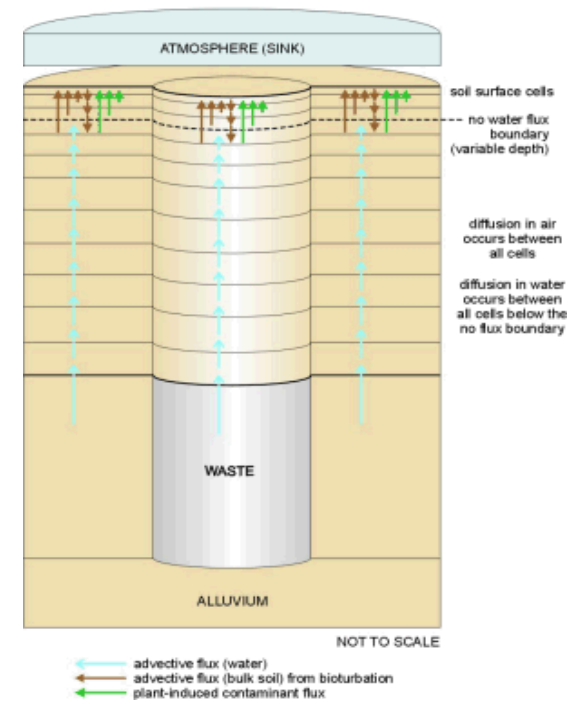
C. Examples: * Activated metals
* Sealed sources

Transuranic (TRU) waste (defense; mainly Am & Pu)

Waste Incidental to Reprocessing (WIR; defense)

^A “GTCC like” is commonly used for defense waste that does not meet LLW criteria or result directly from reprocessing, but it is not a formal waste classification.

Conceptual Model of a Greater Confinement Borehole
Nevada Test Site • Area 5 RWMS



Nuclear Waste Classification in the U.S. – TRU

High-Level Waste (HLW) and Spent Nuclear Fuel (SNF)

Defense HLW and SNF (extensive reprocessing)

Commercial HLW and SNF (limited reprocessing)

Low-Level Waste (LLW)

Defense low-activity waste (LAW)

Commercial LLW (Class A, B and C)

Greater-than-Class-C LLW or “GTCC-like” defense waste

Commercial GTCC

Defense “GTCC like”

Transuranic (TRU) waste (defense; mainly Am & Pu)

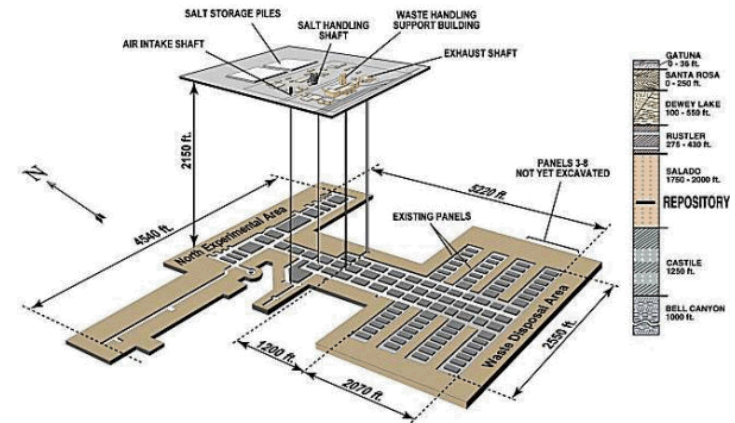
A. Regulators: U.S. EPA only (WIPP) + Individual States

B. Disposal pathways: * Deep geologic disposal (WIPP)
* On-site disposal solutions under study

C. Example: Material processing and facility decommissioning

Waste Incidental to Reprocessing (WIR; defense)

WIPP Facility and Stratigraphic Sequence



Nuclear Waste Classification in the U.S. – WIR

High-Level Waste (HLW) and Spent Nuclear Fuel (SNF)

Defense HLW and SNF (extensive reprocessing)

Commercial HLW and SNF (limited reprocessing)

Low-Level Waste (LLW)

Defense low-activity waste (LAW)

Commercial LLW (Class A, B and C)

Greater-than-Class-C LLW or “GTCC-like” defense waste

Commercial GTCC

Defense “GTCC like”

Transuranic (TRU) waste (defense; mainly Am & Pu)

Waste Incidental to Reprocessing (WIR; defense)

A. Regulators:

U.S. DOE (possible NRC oversight) + Individual States

B. Disposal pathway:

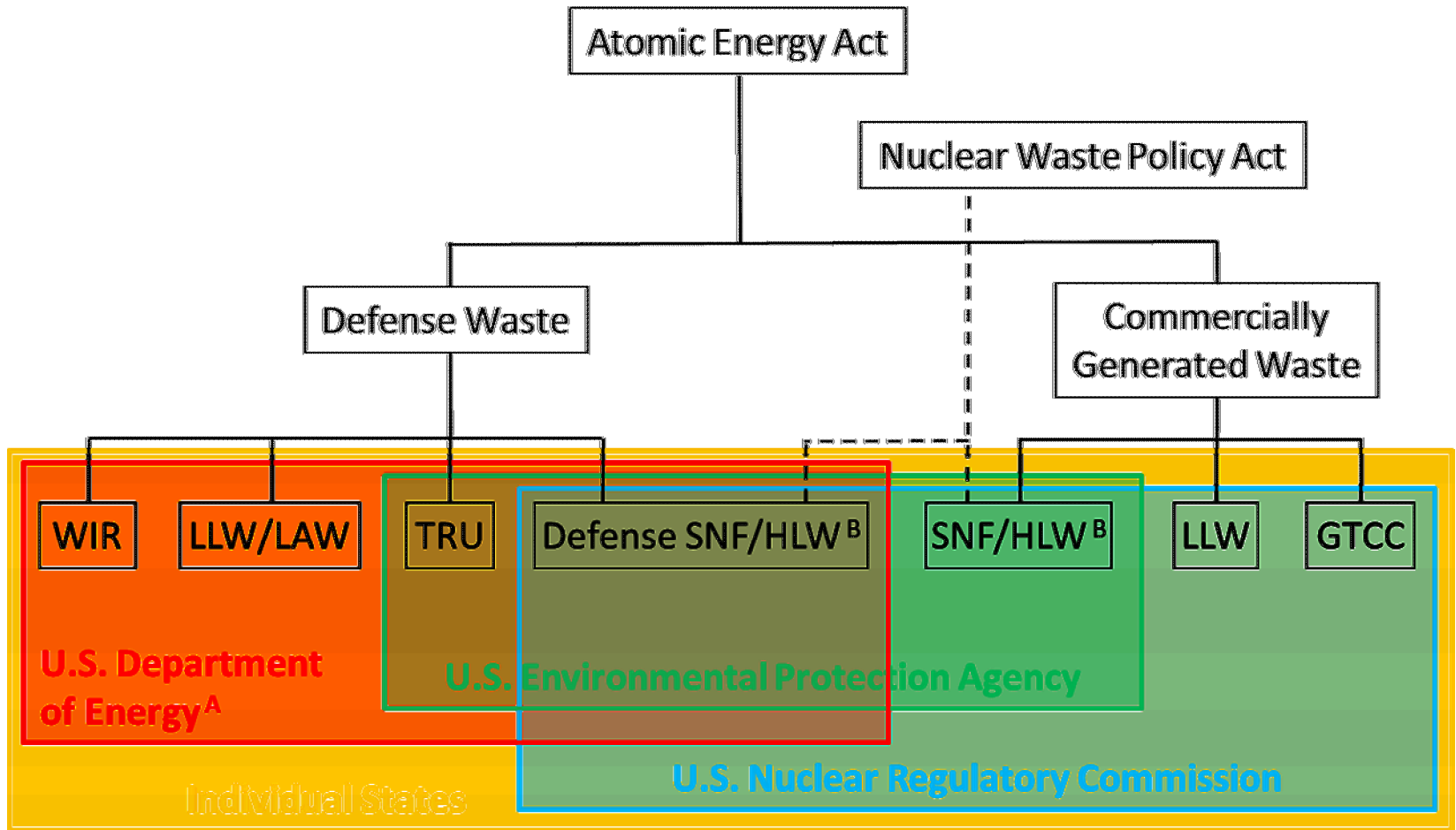
Dispose as LLW or TRU, or by on-site immobilization

C. Examples:

- * Grouted tank residues
- * Tank salt solutions converted to solid form (e.g., saltstone, vitrified, or carbonate)



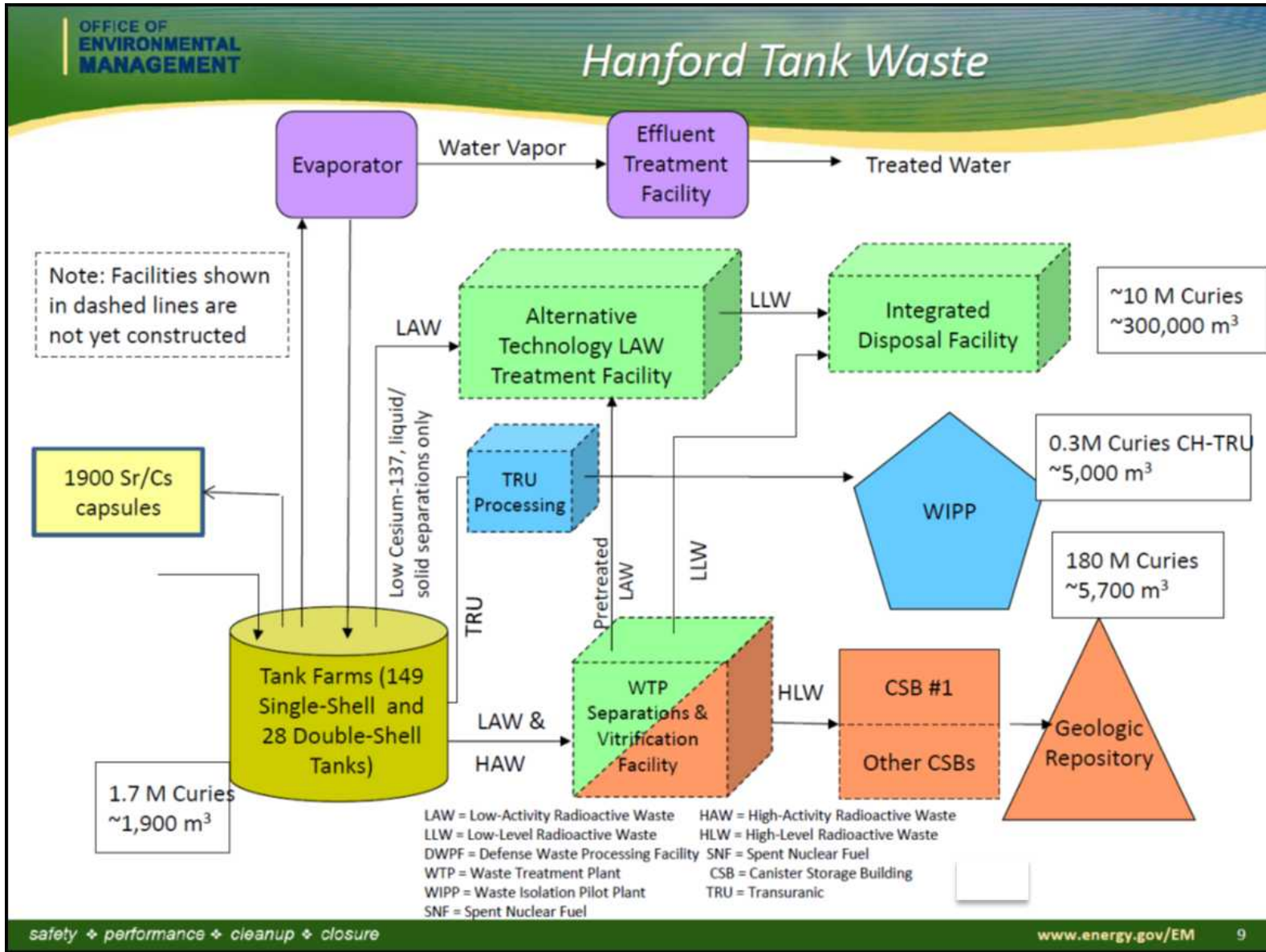
Summary of Radioactive Waste Management Classification and Responsibility in the U.S.



^A The U.S. DOE is both implementor and regulator for WIR, LLW and TRU (except at WIPP), with potential oversight from the U.S. NRC, and direct involvement of the NRC for SNF and HLW.

^B U.S. DOE is implementor for all SNF and HLW (including commercial HLW at West Valley, NY).

LAW/HLW Separates from Tank Waste



Slide from: Picha, K. 2013. *Nuclear Waste Technical Review Board Overview: Office of Environmental Management*. Presentation April 16, 2013. (www.nwtrb.gov)

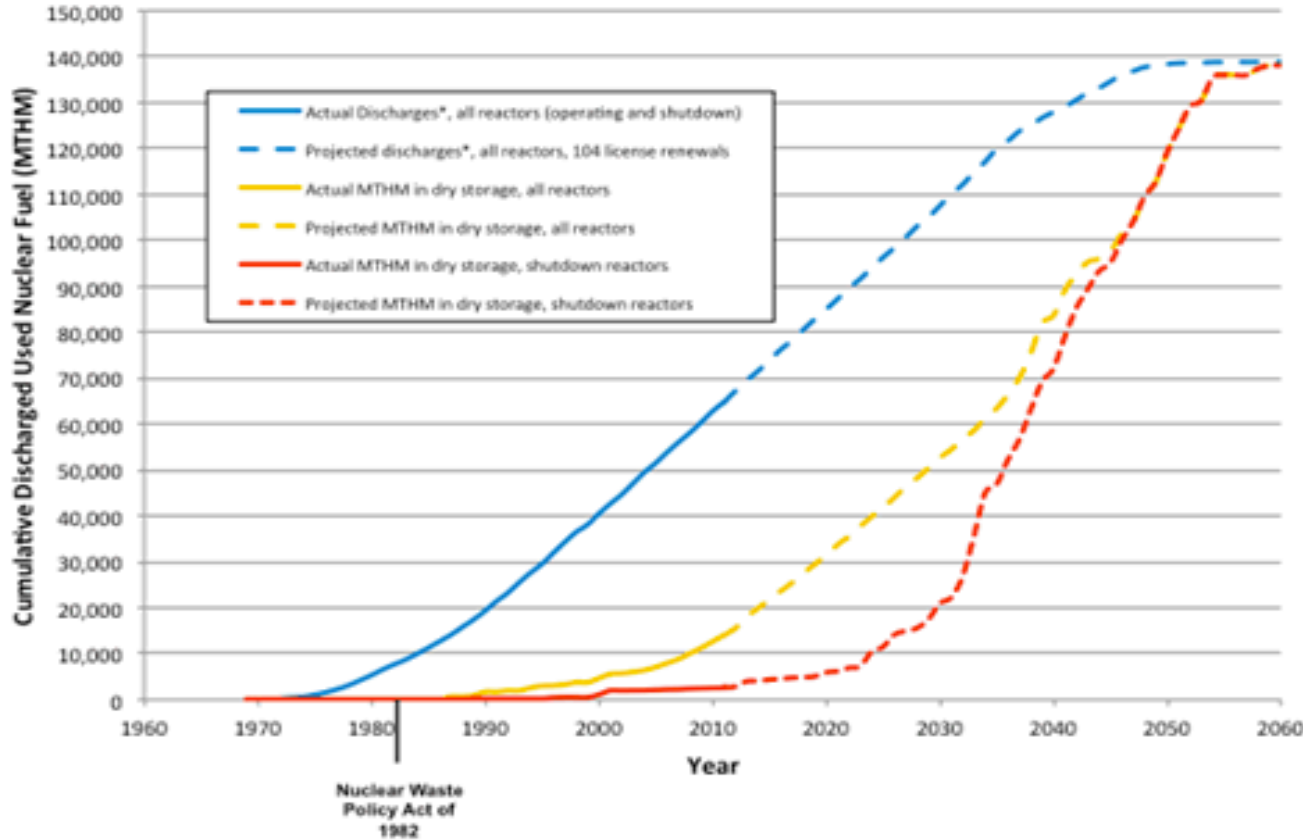
Commercial-Scale Reprocessing in the U.S.?

Projected SNF Quantities from Existing Power Plants

Thermal- vs. Fast-Reactor Strategies for Pu-Recycle

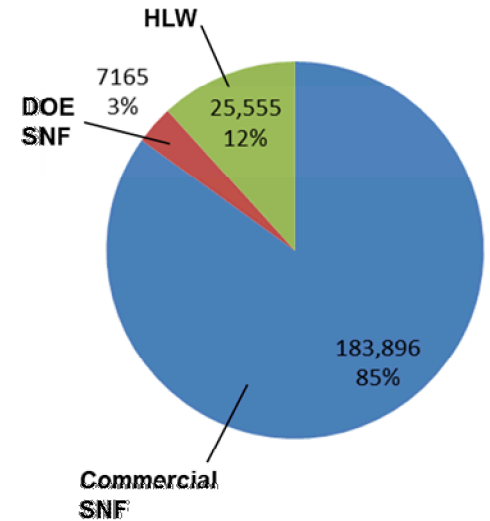
How Much Light-Water Reactor (LWR) SNF is Needed
for a Future Transition?

Projections of Future SNF and HLW for Geologic Disposal



Source: *Based on actual discharge data as reported on RW-859s through 12/31/02, and projected discharges, in this case for 104 license renewals

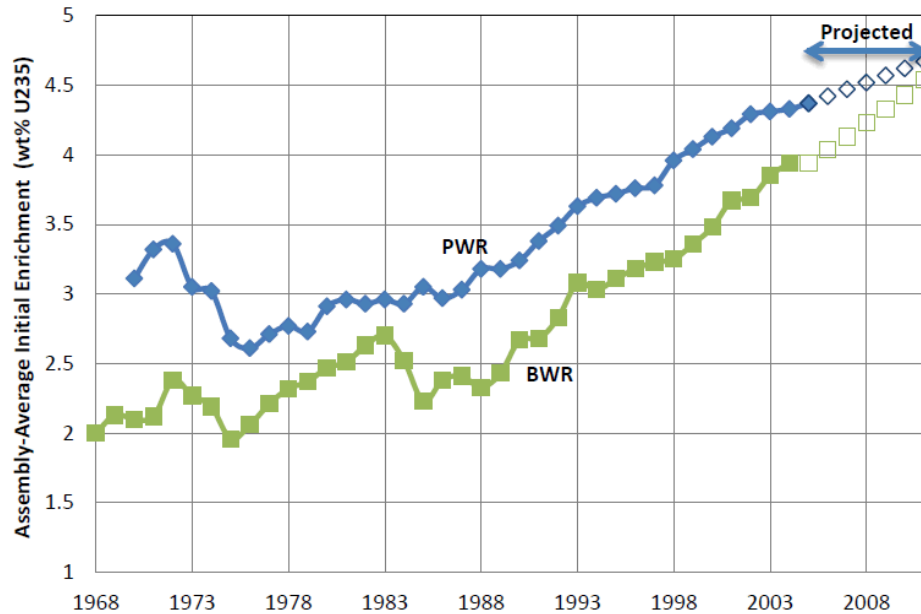
Projected Volumes of SNF and HLW in 2048



Volumes shown in m³, assuming constant rate of nuclear power generation

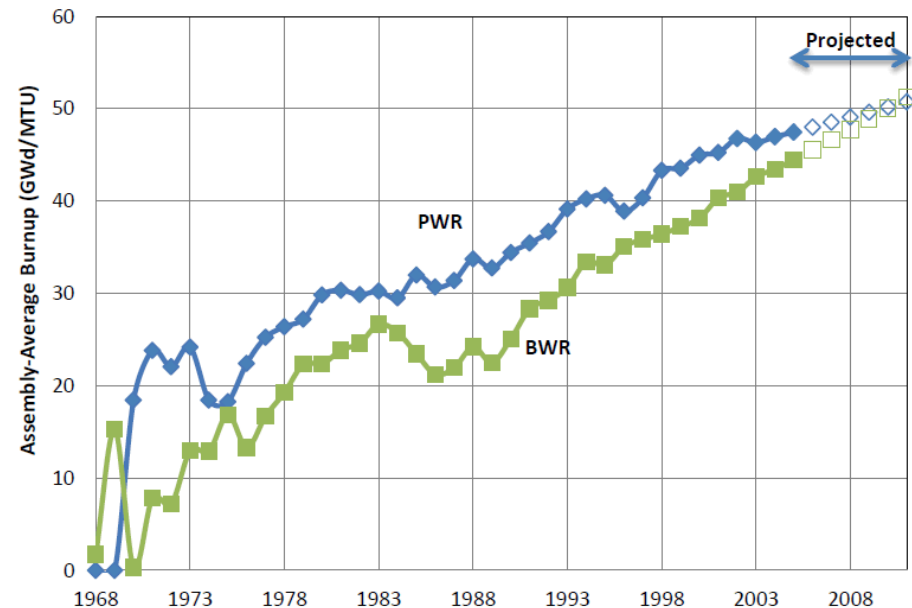
Historical and Projected Commercial SNF Discharges in the United States

Trends in Commercial Spent Fuel Burnup and Enrichment

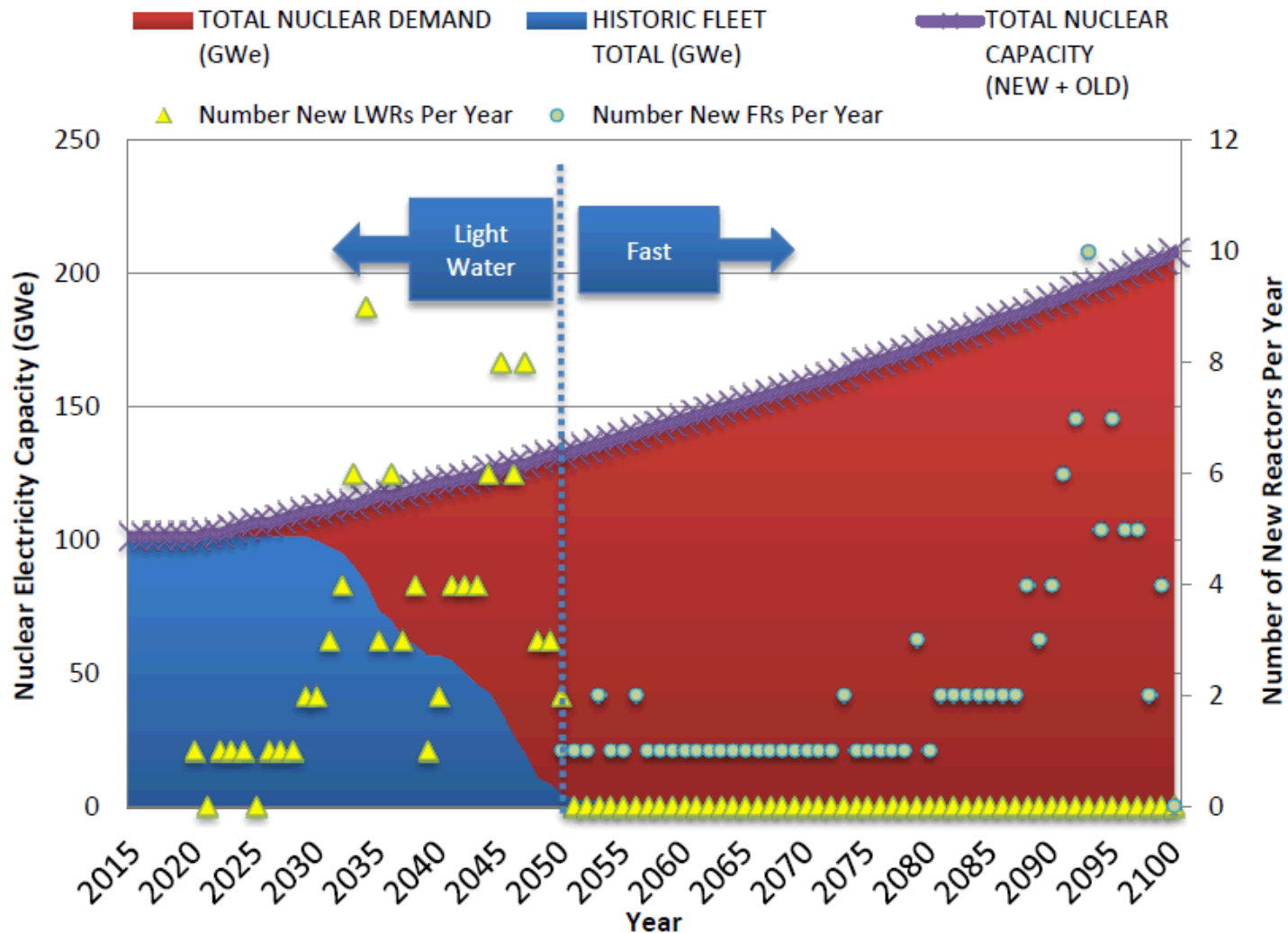


- ← Assembly-average initial fuel enrichment ($^{235}\text{U}/^{238}\text{U}$)
- ↓ Assembly-average burnup (GW-d/MT)

Source: Wagner et al. 2012. Categorization of Used Nuclear Fuel Inventory in Support of a Comprehensive National Nuclear Fuel Cycle Strategy. FCRD-FCT-2012-000232. U.S. Department of Energy, Office of Used Nuclear Fuel Disposition.

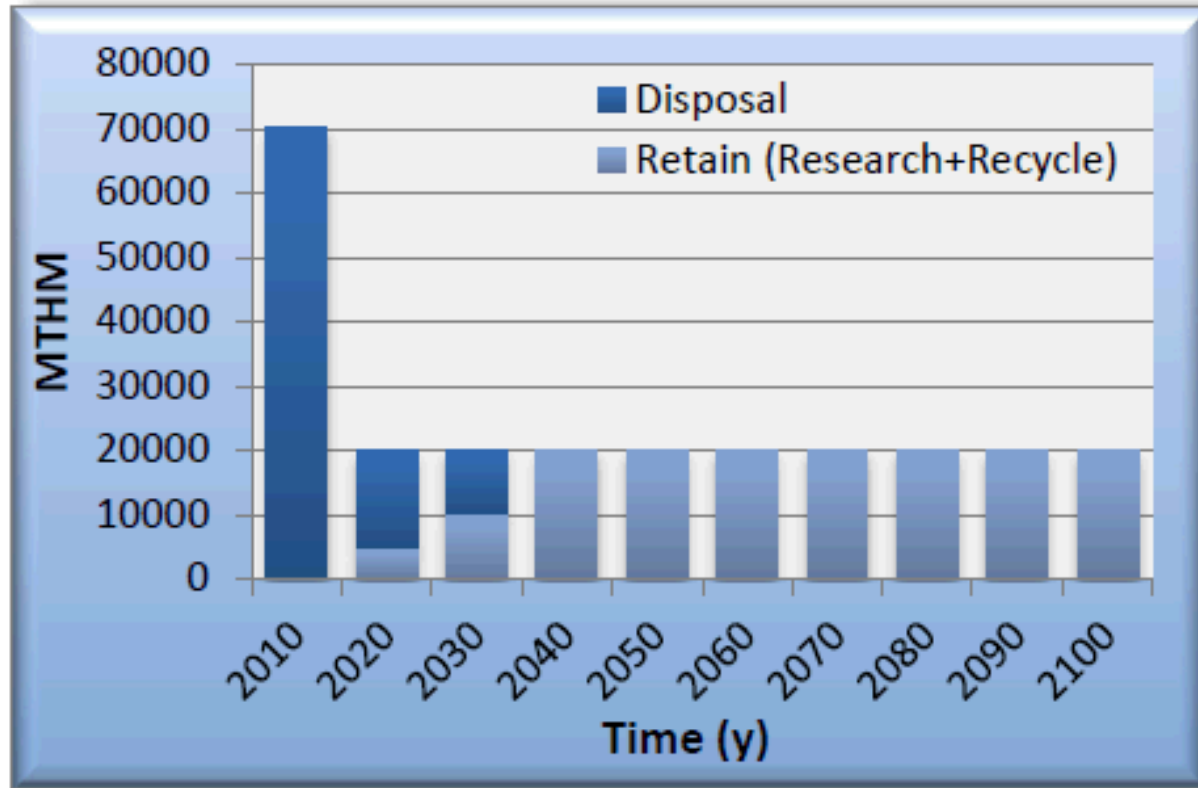


Projected Future Thermal- and Fast-Reactor Builds in the U.S.



Source: Wagner et al. 2012. Categorization of Used Nuclear Fuel Inventory in Support of a Comprehensive National Nuclear Fuel Cycle Strategy. FCRD-FCT-2012-000232. U.S. Department of Energy, Office of Used Nuclear Fuel Disposition.

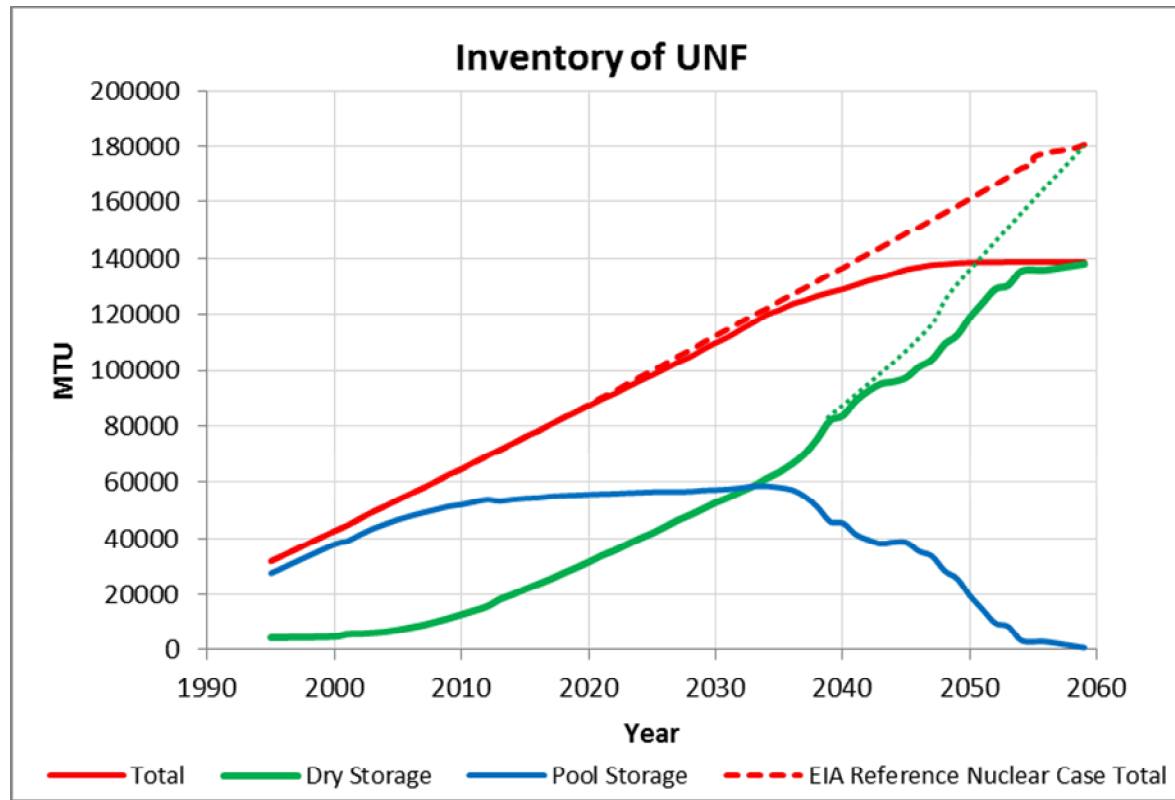
How much LWR fuel is needed to initiate a future, fully closed fuel cycle?



→ Geologic disposal of $\geq \sim 95,000$ MTU LWR SNF

Source: Wagner et al. 2012. Categorization of Used Nuclear Fuel Inventory in Support of a Comprehensive National Nuclear Fuel Cycle Strategy. FCRD-FCT-2012-000232. U.S. Department of Energy, Office of Used Nuclear Fuel Disposition.

Projected Commercial Spent Fuel Accumulation in the U.S. Pool Storage and Dry Storage



- CALVIN-TSL Logistics Simulator (Nutt et al. 2012)
- Existing power plants with 20-year life extensions (60 years total)
- Burnup increase to maximum 5% enrichment
- Transfer from pools to dry storage at reactor shutdown
- Reference Case → Some new builds

Conclusions

- **The U.S. have a HLW/SNF disposal problem.**
- **Commercial SNF continues to accumulate at decommissioned reactor sites (about 12 and counting).**
- **Funding in the form of a mil-levy on retail nuclear-generated power has lapsed.**
- **~\$30B in “Nuclear Waste Trust Fund”**
- **Yucca Mountain program was suspended in 2009.**
- **Long-term dry storage is considered a short-term solution.**