



Used Nuclear Fuel Management

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This is a technical presentation that does not take into account contractual limitations or obligations under the Standard contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (Standard Contract) (10 CFR Part 961). To the extent discussions and or recommendations in this presentation conflict with the provisions of the Standard Contract, the Standard Contract governs the obligations of the parties, and this presentation in no manner supersedes, overrides, or amends the Standard Contract.

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Views presented by the author are not necessarily those of the U.S. Department of Energy. Information is presented from publicly available sources.

Session Overview

- What is used nuclear fuel (UNF)/spent nuclear fuel (SNF)?
- How is UNF currently managed?
- How are UNF facilities regulated? What is the state's role?
- Is storing UNF safe?
- What are the potential environmental impacts of UNF?
- What is the long-term management plan for UNF?
- How would UNF be transported?
- What about advanced reactor UNF?

What is Used Nuclear Fuel? (UNF)

- Removed from reactor after 3-5 years of use
- Solid material: ceramic and metal
- Synonymous with “spent nuclear fuel” (SNF)
- Same “assembly” format goes into and comes out of a nuclear reactor
- Radioactive and thermally hot

Resources: <https://www.nrc.gov/reading-rm/basic-ref/students/science-101/what-is-an-spent-fuel>

<https://www.nwtrb.gov/docs/default-source/facts-sheets/commercial-snf-rev-2.pdf?sfvrsn=18>

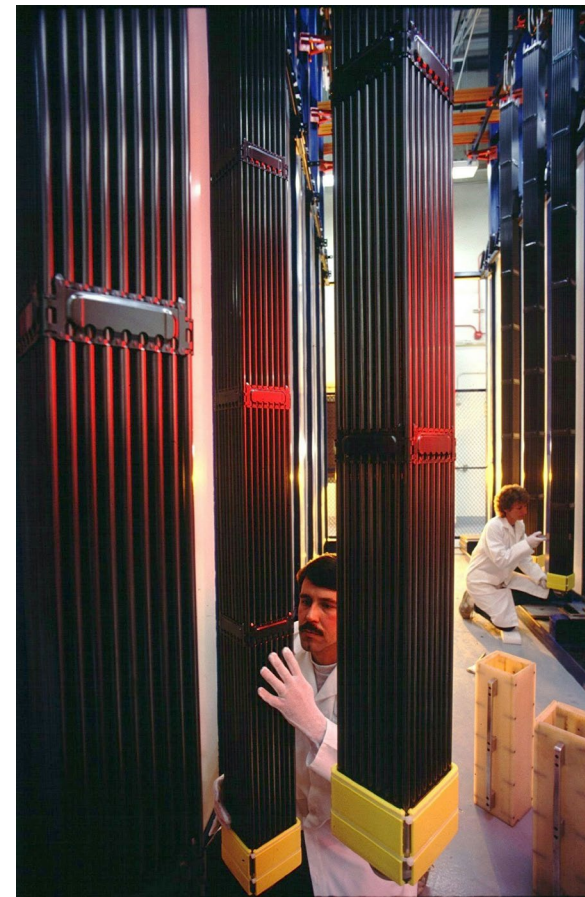
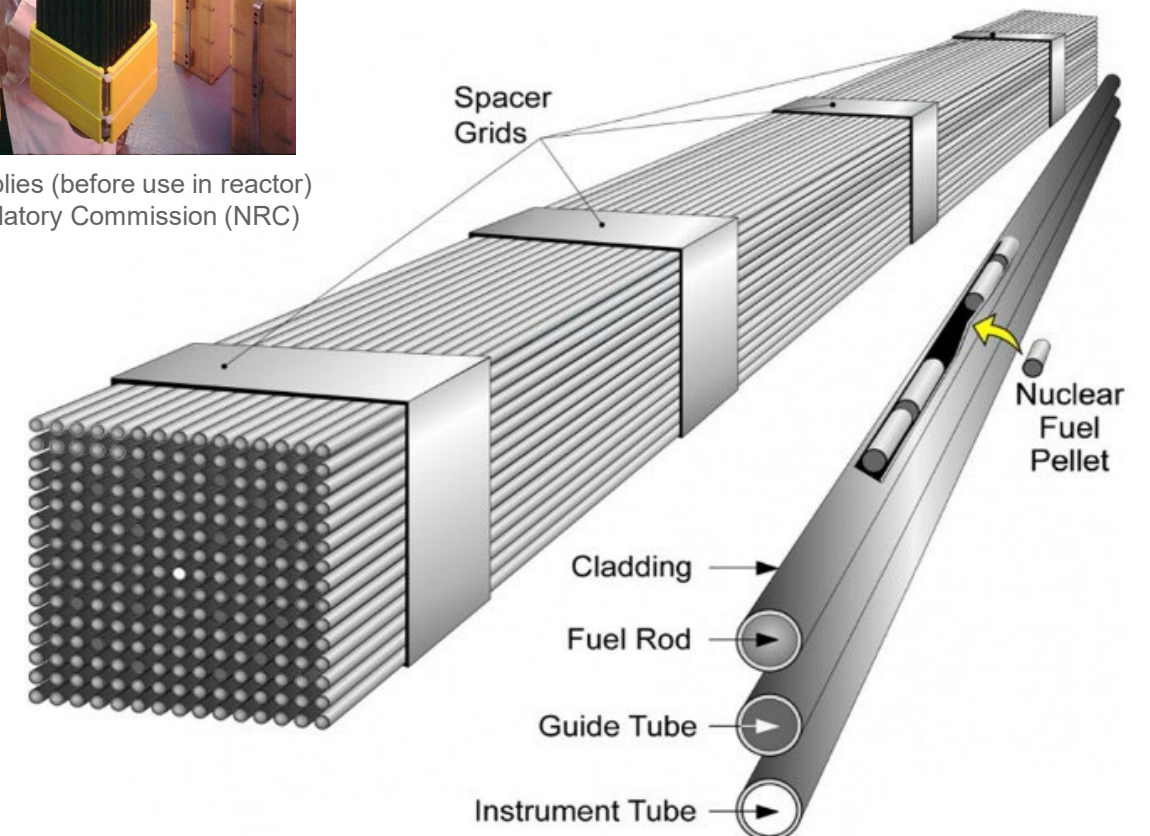


Photo: Nuclear fuel assemblies (before use in reactor)
Source: U.S. Nuclear Regulatory Commission (NRC)



Photo: Nuclear fuel pellets (before use in reactor)
Source: NRC



Schematic of nuclear fuel assembly
Source: open source

How is UNF currently managed?

- Removed from reactor core and moved to spent fuel pool
- Under-water process to maintain shielding
- UNF aged in spent fuel pools (~5-10 years)
- UNF moved to dry cask storage
- Dry cask systems have various formats; all maintain shielding

Resources: <https://www.nrc.gov/waste/spent-fuel-storage/pools>

<https://www.nrc.gov/waste/spent-fuel-storage/faqs>

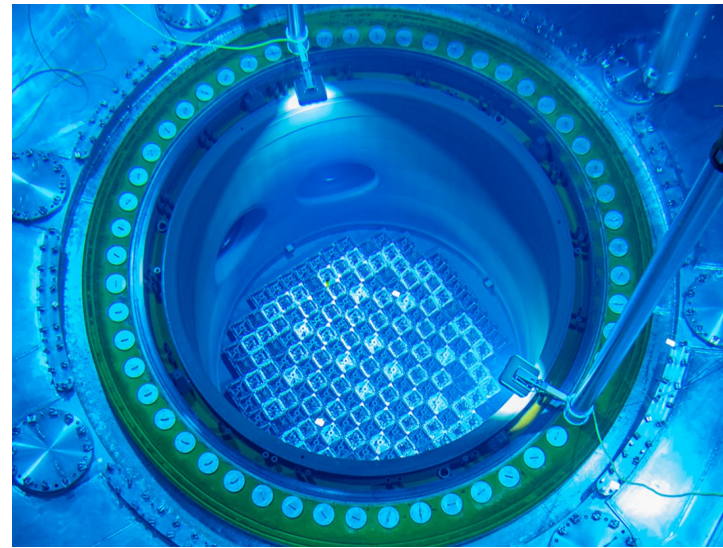


Photo: Nuclear reactor core with fuel assemblies
Source: U.S. Department of Energy

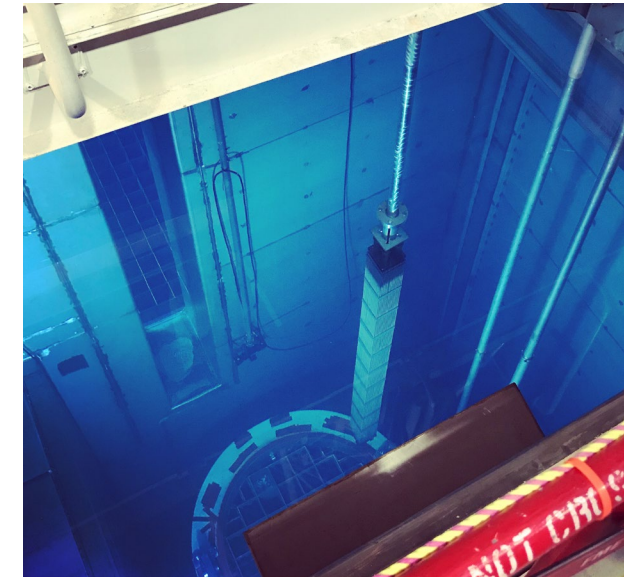


Photo: UNF unloading operations
Source: SONGS Decommissioning

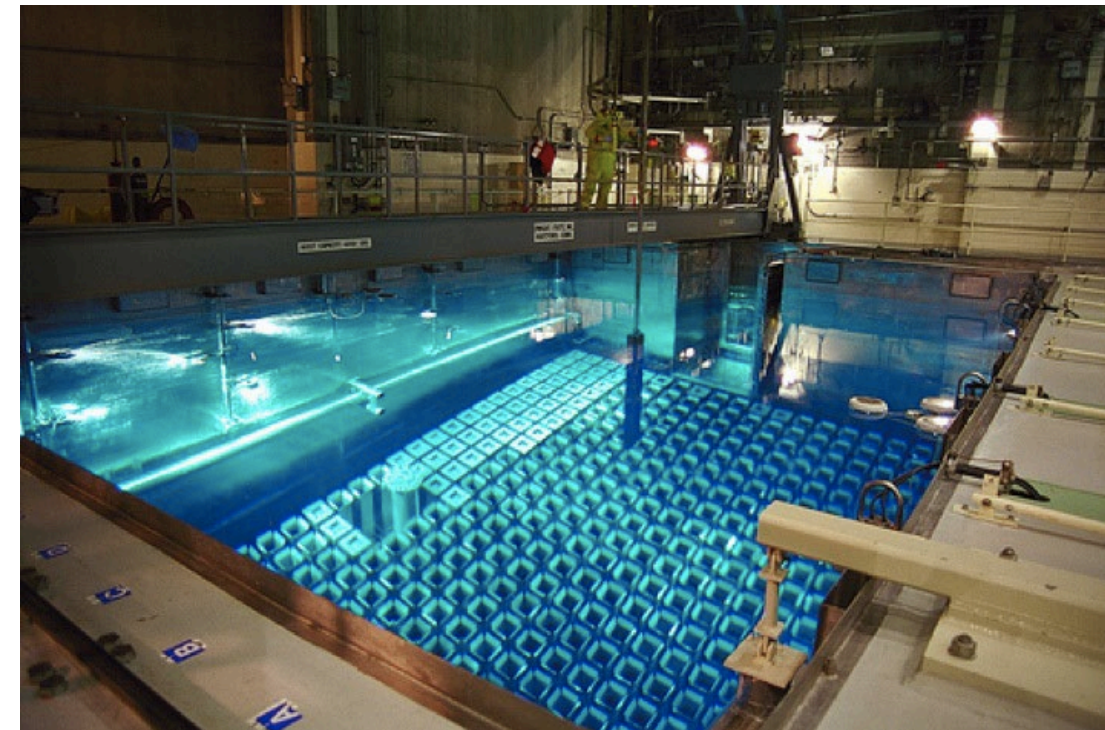
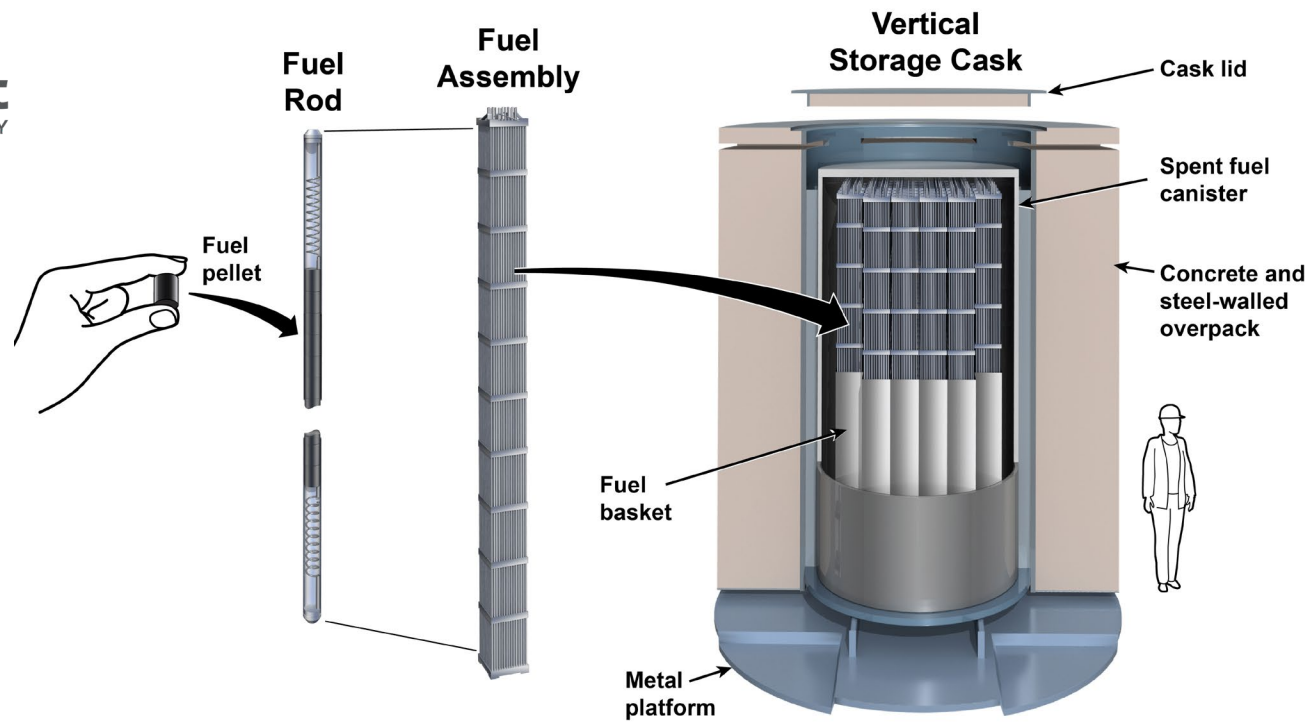


Photo: Spent nuclear fuel pool
Source: American Nuclear Society



created by PNNL for the US DOE-NE,
EED_1397_SpentFuel.1
July 2021 Rev. 6



Photo: Horizontal cask loading operations
Source: Dominion Energy



Photos: 1) Vertical storage system, 2) horizontal storage system and bolted cask systems, and 3) horizontal storage system
Source: Miriam Juckett/PNNL

How are UNF facilities regulated? What is the state's role?



Photo: Vertical casks with cooling towers in background
Source: Miriam Juckett/PNNL

Resources: <https://www.nrc.gov/waste/spent-fuel-storage/designs>
<https://gain.inl.gov/industry-support/regulatory-support/frequently-asked-questions-about-regulatory-support/>

- The United States regulatory authority for commercial nuclear power generation (and UNF management) is the Nuclear Regulatory Commission (NRC).
- UNF facilities undergo rigorous licensing processes.
- Dry casks must be certified by the NRC.
- Facilities subject to inspection and monitoring
- State role can include permits and planning such as:
 - Utility regulation
 - Land and water use
 - Waste management
 - Environmental oversight
 - Emergency planning
- Some negotiated state-specific agreements
- Agreement state programs

Is storing UNF safe?



Photo: U.S. DOE and national laboratory team at UNF storage site
Source: Miriam Juckett/PNNL

Resources: <https://www.nrc.gov/waste/spent-fuel-storage/licensing>
<https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1567/index>

- Safety and security are paramount in nuclear facility licensing. Requirements relate to:
 - Engineering design (structural, thermal, etc.)
 - Criticality safety
 - Radiation protection
 - Natural hazards
 - Accident resilience
 - Operating procedures and controls
 - Site-specific characteristics
 - Physical protection
 - Cyber security
 - Emergency management plans
- No accidents have resulted in radiological release at dry cask storage facilities.
- Occupational safety limits apply to protect workers and the public.
- UNF is stored safely around the world.

What are the potential environmental impacts of storing UNF?



Photo: Independent spent fuel storage installation at decommissioned nuclear reactor site
Source: Maine Yankee (Three Yankees)

Resource: <https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1748/index>

- “Static” facilities with no effluents
- Most impacts at construction phase
- Impacts typically assessed in National Environmental Policy Act evaluations for:
 - Land use
 - Groundwater and surface water
 - Air quality
 - Ecology
 - Geology and soils
 - Waste management
 - Noise
 - Visual and scenic impacts
 - Social and economic effects
 - Cumulative impacts
- Nexus with other laws, such as:
 - National Historical Preservation Act
 - Endangered Species Act
 - Clean Water Act

What is the long-term management plan for UNF?



- UNF storage is subject to aging management and re-licensing programs of the NRC.
- Globally, geologic repositories are recognized as a viable – but politically challenging – solution.
- Under the Nuclear Waste Policy Act (as amended), the U.S. Department of Energy has responsibility for long-term disposition of UNF from commercial nuclear reactors.
 - Standard Contract
 - Prior repository program (Yucca Mountain)
 - Recent/current efforts (Collaboration-based siting, Nuclear Lifecycle Innovation Campuses)
- Long term impacts have been assessed by NRC.

How will UNF be transported?

- Transportation casks are certified by the NRC.
- DOE has a certified railcar and rail consist design.
- A stringent regulatory framework ensures safety and security.
- UNF transportation has an outstanding safety record.

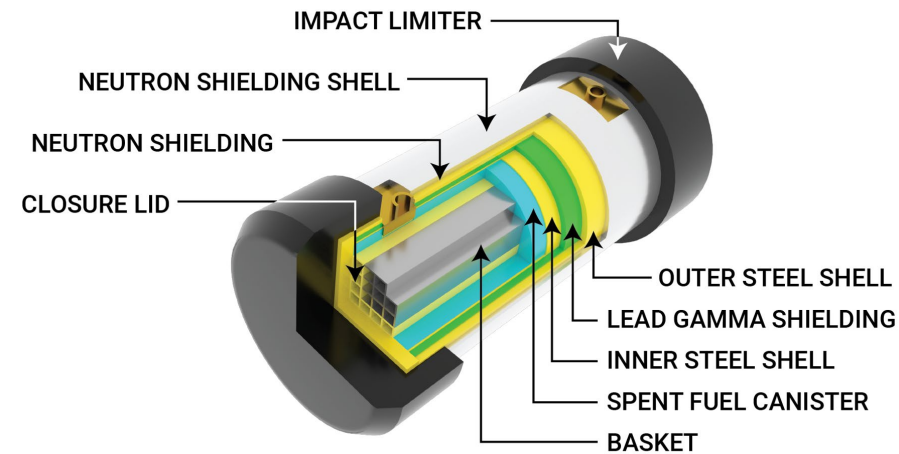
Resources: <https://www.nrc.gov/waste/spent-fuel-transp>
https://www.energy.gov/sites/prod/files/2017/03/f34/Enhanced%20safety%20record%20report%20-%20final%20public%20release_0.pdf



Photo: West Valley cask on railcar
Source: DOE



Photo: Test weight on Atlas railcar
Source: Miriam Juckett/PNNL



Graphic: Transportation cask schematic
Source: Open source



Photo: DOE Rail Escort Vehicle
Source: Miriam Juckett/PNNL

What about advanced reactor UNF?



Photo: Demonstration of Microreactor Experiments test bed area
Source: National Reactor Innovation Center

- New types of reactors use different fuel than the current U.S. nuclear reactor fleet.
- New types of fuel may require different management practices and modifications to UNF management regulations.
- Conditioning and treatment of UNF will likely be required or desired for several designs.
- Ongoing collaboration with reactor vendors to understand fuel cycle back-end impacts is recommended.



Thank you!

Questions?

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