THIRD WAY

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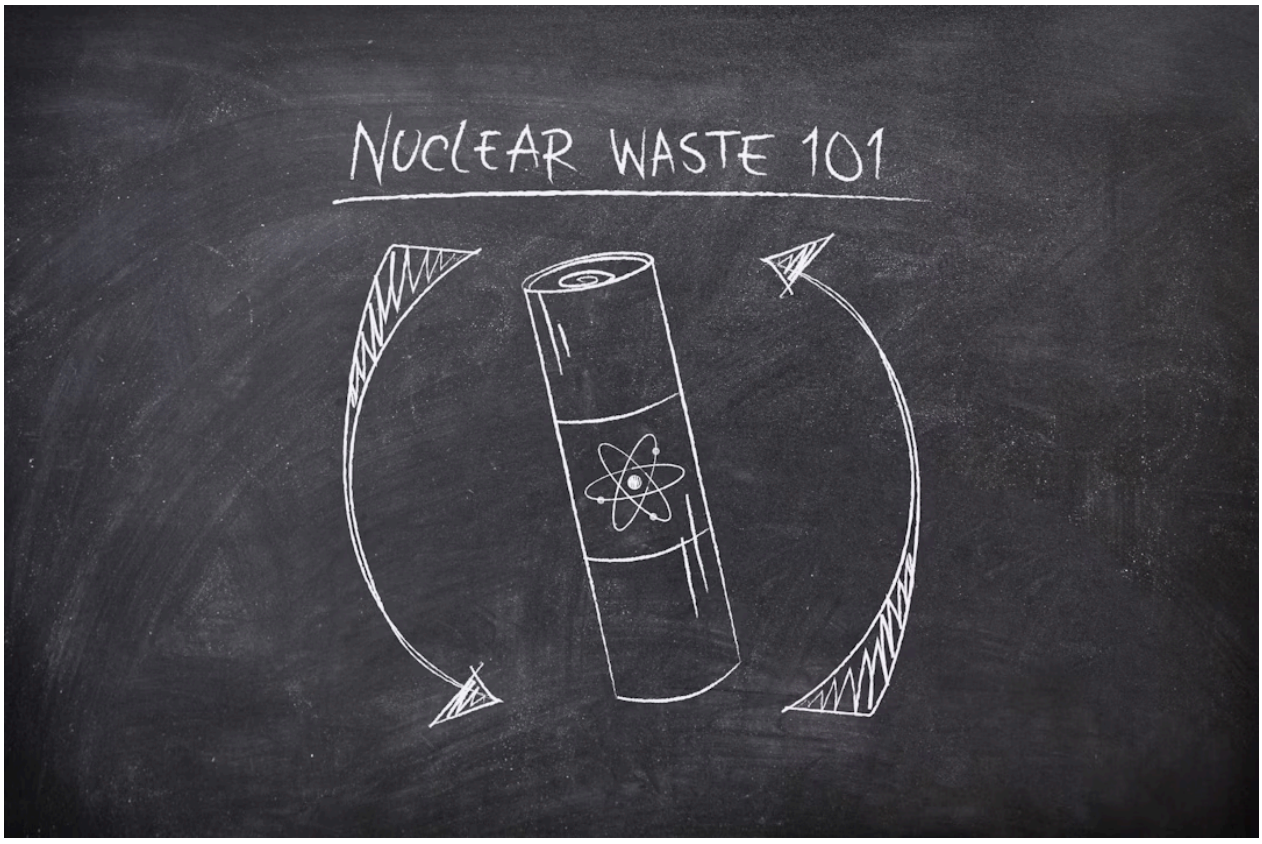
Nuclear Waste 101: What Do We Do With Used Nuclear Fuel?



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The Biden Administration and a bipartisan Congress have taken significant steps to strengthen the domestic supply chain for nuclear fuel—known as the *front-end* of the nuclear fuel cycle—but we still lack a comprehensive strategy to answer the question "*what about the waste*?"

The US's effort to regain global leadership in nuclear energy will require a decisive strategy to manage nuclear waste, the core of the *back-end* of the nuclear fuel cycle.

Because nuclear leadership is not just about the reactors. American leadership needs to demonstrate that we have a handle on the different pieces of infrastructure needed to actually produce nuclear energy from start to finish.

Spent nuclear fuel, the most radioactive nuclear waste, has long been a thorny issue in the US. It has been stored safely at nuclear facilities around the country since nuclear energy's early days, but political and community skepticism have limited our ability to develop a comprehensive long-term strategy. As innovations take off in reactor technology, licensing and regulation, and supply chain development, there is a window of opportunity to think innovatively about how to manage used nuclear fuel for the long term.

What's Nuclear Waste? And What Do We Do With It?

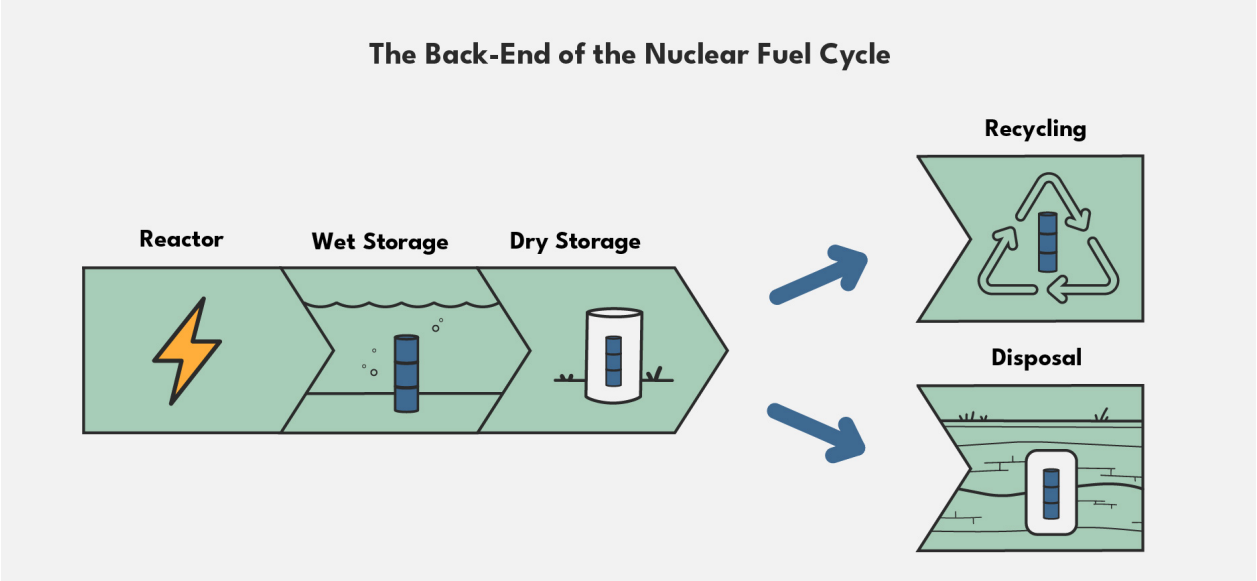
Nuclear waste is a colloquial term encompassing all of the radioactive material that comes from operating a nuclear reactor. This can refer to lower radioactivity-level wastes such as the shoe covers worn by plant operators and non-fuel reactor components exposed to radiation (collectively called radioactive waste), or it can mean the more radioactive material, in particular the used or spent nuclear fuel (SNF) that comes out of the reactor. Generally, when people discuss nuclear waste and the challenges of managing it, they're referring to spent nuclear fuel.

So What is SNF, Really?

In contrast to the toxic sludge depicted in pop culture, SNF actually just looks like long rods of uranium ore held together by metal brackets into "assemblies". In other words, it looks just like it did when it went into the reactor. What's changed is the elemental makeup of the fuel. In the reactor, atoms of specific uranium isotopes are split to release energy. The fission chain reaction in the reactor core replaces the original uranium isotopes with new elemental isotopes. These isotopes emit radiation as they decay over thousands of years to more stable isotopes.

What Do We Do With Spent Fuel?

The back-end of the fuel cycle includes multiple steps to keep this radioactive SNF safely isolated away from people and the environment as it decays. The US commercial approach is currently limited to onsite storage, but eventually we will need a more long-term plan.



Wet Storage

In typical reactors, nuclear fuel remains in the core for 3 to 6 years. After that, it's immediately moved to an onsite *cooling pool* and covered with at least 20 feet of water which keeps it isolated from facility operations as its temperature decreases. The fuel rods are placed in specific positions within the grid of the pool, ensuring they can't continue the chain reactions they underwent in the reactor. Every US nuclear facility has a cooling pool and, without them, rods would be literally too hot to handle.

Dry Storage

After five to ten years in the cooling pool, fuel may be moved into cylindrical steel canisters and surrounded by concrete and other shielding materials in *dry storage.* These tall casks usually stand outside at nuclear facilities, and can hold nuclear fuel for decades. In the US, the casks themselves can be inspected and licensed for up to 80 years, but the fuel could safely be stored there much longer.

Storage for one hundred years seems like a reasonably long-term strategy, but when the radioactive material takes tens of thousands of years to fully decay, this is not a permanent resolution to the waste challenge.

What *Could We* Do With It?

Right now, the US does not have any long-term facilities for managing SNF from power plants beyond wet then dry storage. However, several other countries have such facilities, and are charting a course forward that can help inform future US strategy.

Interim Storage Facilities

A more centralized interim storage facility can help consolidate the amount of SNF to be stored by transferring it to a separate facility that takes fuel from multiple nuclear plants. Sweden is the best example of a country that operates this kind of centralized storage facility for its fuel. The US Department of Energy is exploring options for this type of storage through its consent-based siting consortium program.

Disposal

Decades of international research have determined that "disposing" of SNF deep underground is the best way to keep SNF away from people and the environment. Multiple barriers between the SNF and the environment ensure fuel containers can sit undisturbed for thousands of years. Finland, Sweden, Canada, Switzerland, and France have led in this space, with Finland to begin disposing of fuel underground in 2025.

The Nuclear Waste Policy Act of 1982 authorized DOE to begin resolving long-term SNF storage issues. Despite selecting Yucca Mountain in Nevada as the preferred site for SNF disposal, the US has since fallen behind its peers. Multiple factors, including lack of political will and insufficient public acceptance, led to the Yucca Mountain project stalling. It remains in limbo today.

The US does have its own example to turn to: the Waste Isolation Pilot Plant in New Mexico. This underground disposal facility contains defense-generated waste, not SNF from power plants, but it provides helpful lessons–and well-paying jobs for the community.

Fuel Recycling

Even though fuel coming out of a reactor is "spent," over 90 percent of the uranium material that can be split to produce energy still exists. Multiple countries, including the US, have at different times extracted the usable uranium and plutonium to make more fuel. The traditional refining process—called reprocessing—chops up the fuel and separates plutonium from all other elements in the waste to remake it into a plutonium-uranium fuel. US policy has generally not encouraged it due to nonproliferation concerns about production of purified plutonium, which can be used for nuclear weapons.

However, new processes to recycle usable fuel are under development, like the Advanced Research Projects Agency - Energy's (ARPA-E) CURIE program which poses new possibilities for recycling fuel, particularly for advanced reactors, in ways that address proliferation concerns.

Technology development and feasibility assessments are ongoing. Upcoming advanced reactor deployment has spurred interest in recycling as an innovative alternative to traditional long-term

storage. Despite this progress, waste streams from recycling fuel would still require disposal, and the question of what happens to nuclear waste would remain unanswered if the US were to solely pursue fuel recycling.

Breaking the Policy Gridlock

There's a lot of work to do to resolve the stagnant, reactive approach to US spent fuel management. While long-term solutions may take a decade or more to select and implement, the groundswell of enthusiasm for a new generation of nuclear energy can help push the waste issue forward. There's progress being made in SNF R&D, and there are statutory and non-statutory fixes that can be made to make the US a leader in the back-end. These include:

- Updating the EPA's generic repository standards
- Considering an independent waste management organization
- Funding additional R&D into fuel recycling that reduces nuclear proliferation risk
- Eventually amending statute so the US can revisit disposal beyond Yucca Mountain
- Improving community engagement and implementing consent-based siting

Conclusion

The way the US has managed nuclear waste for decades works for now—but eventually, a longer-term approach is needed. The US has the potential to bolster its global leadership by improving its back-end policy to complement its leadership in the fuel supply arena. To do so, Congress and the Administration need to use today's momentum in nuclear policy to begin laying the groundwork for future progress.

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