As seen in the June 2025 issue of **Nuclear**News

SMARTER WASTE STRATEGIES:

Helping deliver on the promise of advanced nuclear

Technical advisory committee members in front of a full-scale universal nuclear waste canister prototype developed through ARPA-E's UPWARDS program. (Photos: Deep Isolation)

by Chris Parker

At COP28, held in Dubai in 2023, a clear consensus emerged: Nuclear energy must be a cornerstone of the global clean energy transition. With electricity demand projected to soar as we decarbonize not just power but also industry, transport, and heat, the case for new nuclear is compelling. More than 20 countries committed to tripling global nuclear capacity by 2050. In the United States alone, the Department of Energy forecasts that the country's current nuclear capacity could more than triple, adding 200 GW of new nuclear to the existing 95 GW by mid-century.

What's equally compelling but far less discussed is what happens after the electricity is generated: how we manage the spent nuclear fuel and high-level radioactive waste that every reactor inevitably produces.

The advanced reactors now coming to market—whether small modular reactors; high-temperature, gas-cooled reactors; sodium-cooled reactors; or molten salt designs—promise inherent passive safety, lower costs, and new applications. However, they also introduce new fuel forms and new materials, creating new waste management challenges—and potentially new waste management opportunities as well.

Thus far no country has succeeded in permanently disposing of its legacy SNF: Finland and Sweden are getting close, while others such as France, Switzerland, and Canada are making considerable progress. But many others, including the United States, are not. Meanwhile, all SNF remains safely stored above ground in facilities that will last for many decades, but which have not been designed for the many centuries of isolation that are required for safe and permanent disposal.

With advanced nuclear technologies, we face a dual challenge: managing the technical complexities of new fuel types while overcoming the same policy and commercial barriers that have long stalled progress toward integrated waste management and geologic disposal.

NEW FUELS, NEW RULES:
The back-end challenge

Next-generation fuels are exciting. They are efficient and in many cases are inherently and passively safe. But they don't fit neatly into the legacy infrastructure and policy frameworks designed for large light water reactors. New approaches will be needed for packaging, transport, and disposal.

Yet in many countries, including the United States, policy, regulation, and investment continue to focus primarily on the front end of the fuel cycle—finding the materials and manufacturing the new fuel types—or on the building and licensing of the reactors. The back end of the fuel cycle—management and ultimate disposal of SNF—remains largely unexplored territory. This creates uncertainty and business risk for project developers while offering opportunities for suppliers of integrated management systems.

ENTER WISARD:
A global effort to get ahead of the curve

To address these challenges, the OECD Nuclear Energy Agency launched a new three-year joint project in May 2025 called WISARD: Waste Integration for Small and Advanced Reactor Designs. Its goal is to explore how innovative reactors may require equally innovative approaches to radioactive waste management, from storage and transport to treatment, reprocessing, and disposal.

Deep Isolation was one of several industry stakeholders that worked with the NEA over the past year to shape this vital initiative. To ensure a strong evidence base, we collaborated with the Nuclear Energy Institute and the Electric Power Research Institute on a stakeholder research program, gathering direct insights from industry and government stakeholders on the biggest perceived barriers to cost-effective, integrated waste management—and what would help unlock progress.

STAKEHOLDER VOICES

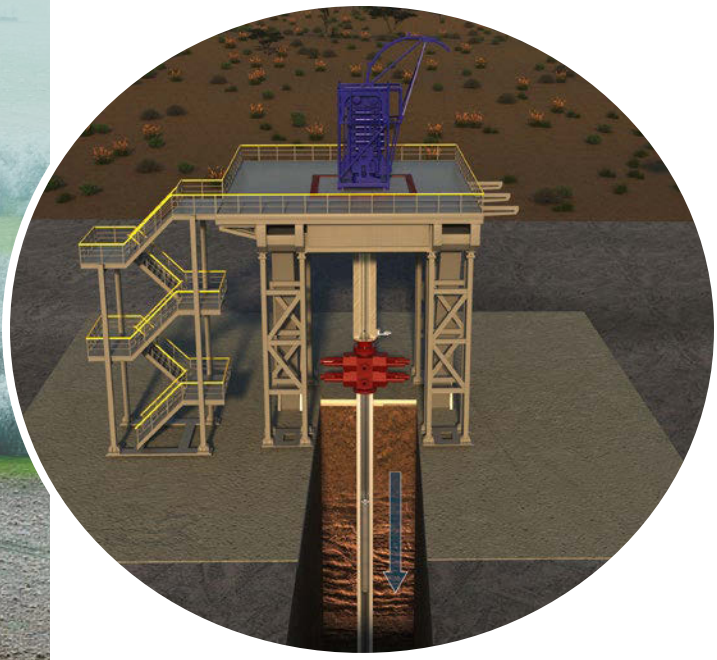
Our research included interviews, surveys, and follow-up discussions with senior stakeholders in five countries with a focus on the U.S. market. We heard from utilities, regulators, waste managers, policymakers, and reactor developers. The results were highly informative:

- 96 percent agreed that public support for new reactors is outpacing support for waste disposal facilities.
- 92 percent said that policy, funding, and attention are disproportionately focused on the reactors themselves, instead of on the back end.
- 76 percent viewed uncertainty about future disposal paths as a major source of risk and additional cost for the advanced nuclear industry.
- 68 percent pointed to the lack of commercial incentives to optimize costs across the entire back-end system.
- 56 percent flagged as a major barrier the absence of multifunctional canisters that are approved for storage, transport, and disposal without repackaging.

Continued

Above: A prototype waste canister is lifted from a test drillhole during an initial emplacement and retrieval demonstration.

Right: The prototype canister in the drillhole receptacle.



Above: An illustration of a deep borehole drilling rig.

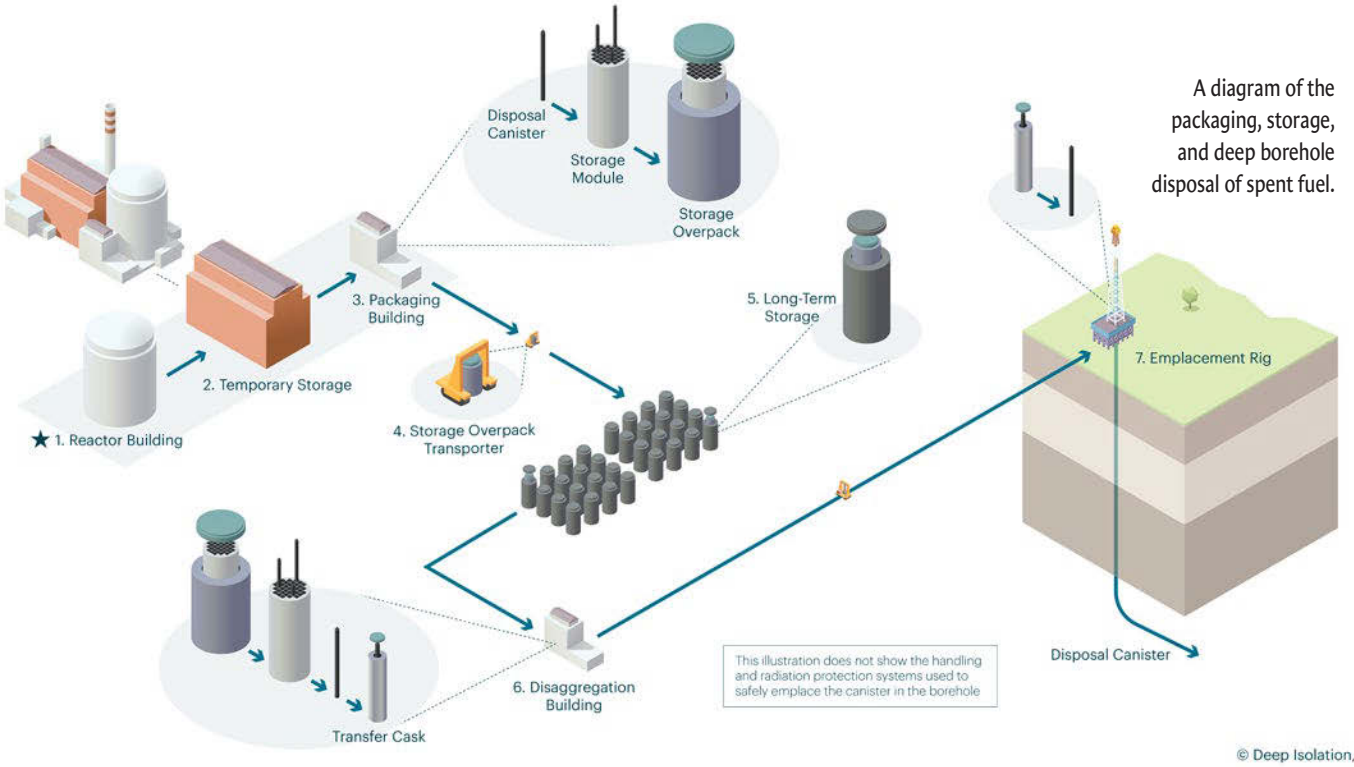
Left: Deep Isolation's former test drilling facility.

One industry participant put it bluntly: "Advanced reactors currently have no approved options for the management of their spent nuclear fuel. There is no guidance and no path forward that would minimize risk to our company."

Another added: "There is certainly a significant step change in acceptance of nuclear and SMR technology. These dialogues are currently widespread and almost continuous. It is interesting, however, that these discussions rarely, if ever, deal with the back end of the fuel cycle. It is almost as if, as an industry, we are about to repeat the same mistakes we made 50 years ago."

Many participants highlighted the particularly acute challenges within the U.S.:

- "It will be hard to license any new reactors of any size or type without a compliant national program that can sign a standard contract. Either move forward with existing law or amend it to allow alternative solutions, including those in the private sector."
- "In the United States, there is a strong incentive for advanced reactor companies not to think about the back end of the system. There is only downside for having a plan—no upside."
- "The U.S. lacks a policy to keep life-cycle waste management costs as low as reasonably achievable. Each waste producer is incentivized to use the cheapest near-term solutions without regard for the impacts on life-cycle costs."



A diagram of the packaging, storage, and deep borehole disposal of spent fuel.

THE OPPORTUNITY:

Aligning policy and market incentives

So, what would help? Stakeholders ranked their top three priorities:

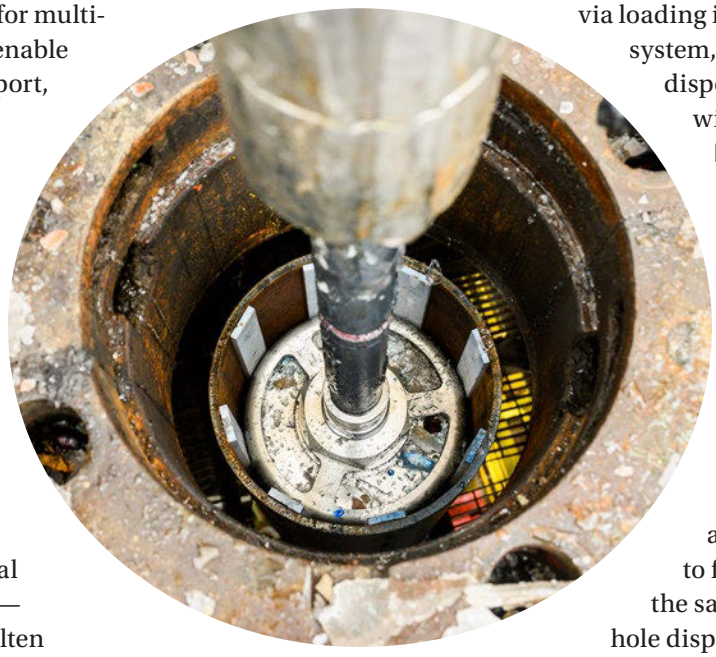
1. Clear policy, regulatory, and commercial frameworks that incentivize organizations to optimize safety and cost across the entire back-end system.
2. Greater certainty around waste acceptance criteria (WAC) for geologic repositories.
3. Establishing standards for multifunctional canisters to enable seamless storage, transport, and disposal.

Deep Isolation, in partnership with NAC International and with funding support from the DOE's ARPA-E program, has addressed the third point with its multifunctional canister: the Universal Canister System. The UCS is a triple-purpose solution designed for storage, transport, and disposal of advanced reactor waste—including TRISO fuels, molten salts, and vitrified waste—in both mined and deep borehole repositories. By avoiding costly and complex repackaging, the UCS offers a smoother, safer, and more affordable path from reactor to repository.

The UCS is not just a theoretical concept. Deep Isolation has marked significant milestones over the past several years to make it commercially available:

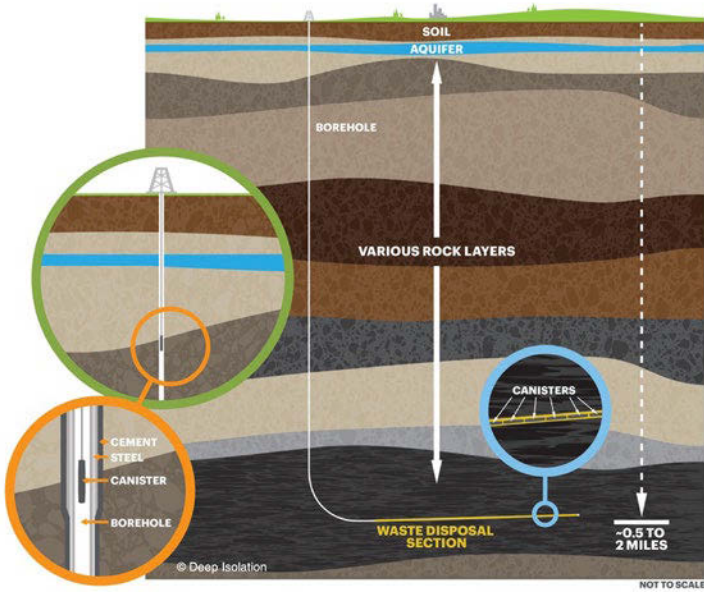
- The UCS is designed to ensure compatibility with existing licensed systems for storage and transport, to facilitate disposal in a mined repository via loading into a standard overpack system, and to allow for direct disposal in a deep borehole without any modifications.
- Multiple prototype canisters have been manufactured in both the U.S. and the U.K. to ensure adequate domestic and international supply chains and the manufacturability of the UCS.

These prototypes are being used in current and future test programs to further demonstrate the safety case of deep borehole disposal.



The prototype waste canister in the deep borehole well.

Continued



An illustration of deep borehole nuclear waste disposal.

■ The UCS's unique lift adapter has been designed and tested to seamlessly integrate with standard oil and gas equipment to ensure the safe emplacement into and retrieval from a borehole.

■ Testing of canisters and associated equipment materials in prototypic deep borehole conditions (i.e., high-temperature and high-pressure environments) has been conducted, which has enhanced corrosion analyses, demonstrated acceptability, and identified opportunities to optimize future design iterations.

■ Performance assessment screening models have been developed to evaluate the repository performance of the UCS when disposing of a range of advanced reactor waste streams in a mined repository, a vertical borehole, and a horizontal borehole sited in both shale and crystalline basement rock. Generic waste acceptance criteria have been generated across all these scenarios.

All completed analysis and empirical testing to date confirm that the UCS is a robust enabler of integrated spent fuel management for advanced reactors.

WASTE ISN'T AN AFTERTHOUGHT—
It's the path forward

There is a pressing need for more integrated solutions that address both policy and technology to support the deployment of advanced nuclear technologies, and for greater engagement by policymakers regarding the uncertainties of the back end of the fuel cycle. The lack of clear requirements for waste disposal makes planning difficult, not only adding to the risk and cost of new projects but also furthering negative public perception of nuclear energy.

If we're serious about a new nuclear future, we must be equally serious about the back end of the fuel cycle. That means not just new technologies but also new thinking. Our research shows that while the barriers are real, so are the opportunities. We have the tools. We have the knowledge. Now, we need the will—and the policy frameworks—to ensure that advanced nuclear technology can truly deliver on its promise.

Because in the end, waste isn't just a technical problem. It's a litmus test for how well we're planning this energy transition. And the world is watching.

Chris Parker is chief commercialization officer at Deep Isolation. He is the lead author of the Waste Management Symposium 2025 paper "Opportunities and Barriers for Optimizing Costs Across the Back End of the Advanced Nuclear Industry."

The Deep Isolation team at the company's Deep Borehole Demonstration Center in Cameron, Tex.