facility is estimated to have a production capacity of approximately 20 MT/year of MOX fuel, though analysts said it remains unclear whether operations have formally begun.

The MOX facility is widely believed to support China's expanding fast reactor program, particularly the second CFR-600 unit currently under construction. China's first CFR-600 reactor began operation in 2023 using Russian-supplied fuel; however, analysts expect future units to transition toward domestically produced MOX fuel fabricated from plutonium recovered through China's reprocessing program.

According to Dr. Zhang's analysis, a single 200 MT/year reprocessing plant operating at full capacity could separate approximately two metric tons of plutonium annually. IPFM analysts noted that this output would significantly exceed the annual plutonium requirements of a single CFR-600 reactor, potentially allowing China to accumulate substantial quantities of separated reactor-grade plutonium if multiple facilities became operational.

The report further noted that China has already been operating a smaller pilot reprocessing plant at the Jiuquan Nuclear Complex at Gansu since approximately 2010. That pilot facility has a capacity of about 50 MT/year.

China's last official civilian plutonium inventory declaration to the International Atomic Energy Agency (IAEA) was submitted in 2017 and reported 40.9 kilograms of separated civilian plutonium as of December 31, 2016. However, the IPFM report cited conference materials and independent estimates suggesting the pilot facility may have operated at nominal capacity since 2017, potentially producing roughly 500 kilograms of reactor-grade plutonium annually.

Based on those estimates, analysts suggested China may have accumulated between four and five metric tons of civilian reactor-grade plutonium by 2026, independent of any future production from the larger demonstration facilities now appearing to enter operation.

The blog post emphasized that substantial uncertainty remains regarding the scale and future direction of China's plutonium recycling activities. While Beijing has consistently framed its reprocessing and fast reactor initiatives as components of a civilian nuclear energy strategy, some international observers continue to raise safeguards and transparency concerns due to dual-use nature of separated plutonium.

IPFM analysts argued that greater transparency surrounding China's civilian plutonium stockpiles and fuel cycle activities would help reduce international uncertainty. The report specifically called attention to China's decision to discontinue voluntary civilian plutonium reporting to the IAEA after 2017 and suggested that resuming such disclosures could improve confidence regarding the country's expanding reprocessing program.

As China continues rapidly expanding both its commercial reactor fleet and advanced reactor development efforts, the apparent acceleration of its reprocessing and MOX fuel infrastructure signals an increasingly significant role for plutonium recycling within the country's long-term nuclear strategy.

Industry Calendar

- May 31-June 3, 2026
  ANS Annual Conference
  https://www.ans.org/meetings/ac2026
  Sheraton Denver, Denver, CO
- June 9, 2026
  US NWTRB Board meeting
  https://www.nwtrb.gov/meetings/upcoming-public-meetings/spring-2026-board-meeting---june-9--2026
  AUSA Conference & Event Center, Arlington, VA
- August 2-6, 2026
  INMM 67th Annual Meeting
  https://inmm.org/news/events/inmm-67th-annual-meeting
  JW Marriott Austin, Austin, TX
- August 2-5, 2026
  U.S. Women in Nuclear
  https://www.nei.org/conferences
  Hyatt Regency Seattle, Seattle, WA

Details are available at:
/https://www.uxc.com/c/data-industry/Calendar.aspx

Top Story

Designing for advanced reactor spent fuel storage and disposal

As advanced reactors start to transition from conceptual designs to commercial deployment, front-end innovation is commanding the spotlight. UxC's flagship publication, the *Ux Weekly,* covered the recent SMR (small modular reactor) & Advanced Reactor conference *Reuters* hosted May 11-12 in Austin, Texas. In covering that conference, we noted, "The event provided a clear indication that SAMR (small and advanced reactors) interest has moved well beyond the early discussion phase and into the early development stage."

The recent Used Fuel Management Conference, held annually by the Nuclear Energy Institute, included sessions that focused on back-end solutions for advanced reactors, specifically how the fuel used to power them will be managed after core discharge. The first session was chaired by Steve Edwards of Duke Energy, and included Philip Bartholomew of Holtec International, Kyle Stanton of TerraPower, Mike Valenzano of NAC International, and Jesse Sloan of Deep Isolation.

Bartholomew highlighted a important reality for advanced nuclear deployment – back-end readiness must be treated as a core component of deployment readiness. He noted that today, domestic spent nuclear fuel management follows a highly consistent, predictable structure – pool storage followed by dry cask storage at every nuclear reactor in the United States (except one at Duke Energy's Harris plant because it has four spent fuel pools and thus dry storage is not needed for the foreseeable future). The back-end lifecycle is governed by mature regulatory pathways, i.e. 10 CFR Part 72 for storage and 10 CFR Part 71 for transportaion. Yet, the fuel designed for some advanced reactor models can present risks for deployment as the fuel selected at the front-end drives the storage, transport, and disposal solutions at the back-end.

Bartholomew presented four distinct "back-end lanes" organized by fuel form:

Oxide fueled advanced light water reactors (LWRs) and water-cooled SMRs have the shortest, most predictable path to domestic backend readiness. Because existing dry storage and transportation systems were largely built around oxide fuel, these concepts introduce no fundamental conceptual differences for the spent fuel lifecycle. Cohesive, commercially-licensed product lines are already available.

A prime example is Holtec's SMR-300, which uses standard 17 x 17 pressurized water reactor (PWR) fuel with an enrichment level at or below 5%. Consequently, the fuel is already licensed for storage in Holtec's existing systems. By aligning with existing infrastructure and regulatory precendents, this approach prioritizes schedule certainty and bypasses the deployment risks associated with novel waste form qualification.

TRISO fuel is known for its safety features in the front-end of the fuel cycle, but the back-end for TRISO fuel is still maturing. Tri-structural isotropic (TRISO) particle fuel – utilized by concepts such as Kairos Power, Westinghouse's eVinci microreactor, and X-energy's Xe-100 – is widely praised for its robust front-end safety characteristics; however, its back-end infrastructure is not yet industrialized.

TRISO fuel presents a variety of discharge forms, including pebbles, compacts, and prismatic blocks. Currently, package standardization and canning strategies remain unsettled. Furthermore, the graphite-heavy nature of this waste volume expands the physical footprint and alters long-term disposal assumptions. The industry has yet to establish a standardized TRISO-specific packaging, transport, and disposal basis, and the underlying thermal, criticality, and source-term data models for these packages are still maturing.

Metallic fueled designs, including TerraPower's Natrium, the ARC-100, and Oklo's fast-reactor concepts, introduce significant back-end novelty that requires early qualification work. Because metallic fuel behaves differently than traditional oxides under long-term storage conditions, it presents unique challenges that elevate back-end risk.

Liquid-fueled molten salt reactors (MSRs), such as those from Natura Resources and Terrestrial Energy's MSR, face the most distinct divergence from legacy systems. For these designs, the spent fuel strategy cannot be treated as a late-stage appendix to the project, but must be integrated into the initial construction and licensing plan.

Key back-end gaps constraining deployment

To ensure that back-end readiness does not become a bottleneck for advanced reactor commercialization, Bartholomew detailed four gaps that the industry and regulators must address:

- Lack of standardized packages for non-oxide fuels – while oxide fuels use already licensed dry cask systems, no standardized commercial transport or storage packages exist for TRISO, metallic, or salt-bearing waste streams.
- Unclear disposal pathways for novel waste – current deep geological repository assumptions are optimized for standard LWR assemblies, but the definitive regulatory and technical criteria for disposing of large volumes of graphite or highly corrosive salt wastes remain undefined.
- Lagging regulatory frameworks – while 10 CFR Parts 71 and 72 are mature, they are heavily prescriptive and tailored to oxide fuel forms. Adapting these licensing frameworks to accommodate non-oxide physics, novel criticality controls, and unique degradation mechanisms is an ongoing challenge.
- Backend-to-reactor timing mismatch – back-end solutions can take decades to research, test, license, and manufacture. If reactor deployment moves at an accelerated commercial pace while back-end qualification lags behind, first-movers risk facing a regulatory bottleneck where reactor operators are ready to generate power, but lack a licensed path to store or dispose of the spent fuel.

Parallel strategies for future deployment

The advanced reactor industry cannot afford to treat spent fuel management as a "tomorrow problem," Bartholomew stressed. For oxide-fueled advanced LWRs and water-cooled SMRs, the path forward is an expansion of the existing domestic infrastructure. For non-LWR concepts using advanced fuel forms, deployment risk must be mitigated by maturing storage, transport, and final disposition pathways in parallel with reactor design and construction. Technical performance at the front-end is only half the battle – commercial success belongs to the designs that secure a clear, licensed path to the back-end.

Microreactors

Mike Valenzano, Director of Transortation Projects at NAC International, in his presentation on microreactors, explained that these reactors are manufactured entirely in a factory and designed for rapid deployment. These downscaled units offer power outputs ranging from a few kilowatts to several megawatts. Their primary value proposition lies in their mobility – delivering scalable energy and/or process heat to remote settings such as mines, military installations, isolated research stations, and disaster response zones.

Because these reactors operate in areas lacking traditional spent fuel pools or heavy handling infrastructure, their back-end strategy must be built into the initial engineering design.

Valenzano presented three engineering and regulatory pathways to manage and remove the spent fuel from the field once a microreactor reaches the end of its life.

- The reactor vessel as the shipping package – in this scenario, the microreactor itself is a self-contained, fully integrated transport package. The spent fuel remains locked inside the reactor vessel, and the entire unit is shipped intact back to a centralized facility. This approach significantly simplifies on-site field operations, but it increases engineering complexity. The reactor vessel itself, along with its internal structures, must be fully certified to satisfy the stringent structural, thermal, and containment regulations of 10 CFR Part 71 and the International Atomic Energy Agency (IAEA) transport standards.
- Traditional in-field defueling – in this scenario the operator can choose to extract the spent fuel from the microreactor at the deployment site prior to transport. This pathway exempts the reactor vessel from 10 CFR Part 71 spent fuel containment requirements and allows the use of existing, licensed commercial transport packages. However, removing highly radioactive fuel in a remote area requires specialized portable equipment, strict shielding protocols, and complex field operations. Furthermore, after the fuel is gone, the highly activated structural components of the reactor must still be packaged and transported as radioactive waste.
- Overpack cask loading – this path involves shutting down the reactor, leaving the core intact, and loading the entire microreactor structure into a large, external transportation overpack or shipping cask. This method avoids the risks of remote, in-field fuel extraction while removing the reactor internals from the requirements of Part 71 certification. It is considerably simpler than defueling in the field, but the larger microreactors will require heavy-lift cranes and specialized transport equipment to complete the operations, and the internal reactor components must still be robust enough to support structural safety analyses for the final transport configuration.

Valenzano outlined three challenges that stand between current microreactor concepts and scaled commercial deployment:

- Technical design complexity – engineering a vessel to withstand both the high temperatures of operational power generation with the severe impact, fire, and drop-tests rquired for a Part 71 transport license is a large hurdle to overcome.
- Severe remote logistics – microreactors are specifically designed for regions characterized by limited transport infrastructure. Moving the heavy, large components via unpaved roads, seasonal ice routes, or small airfields presents a significant logistical challenge, which is further complicated by strict international import/export controls and the broader, unresolved domestic question – once the fuel is loaded and transport-ready, what is its final destination?
- Physical protection and security – spent fuel is subject to rigid, non-negotiable security requirements. Maintaining a robust physical protection posture for highly enriched advanced fuels requires significant coordination and overhead.

While a microreactor is inherenty independent from fixed infrastructure, that independence ends at the back-end. Developers must design these reactors for ease of extraction – not just for ease of power generation. Whether a designer chooses to transform the reactor into a licensed shipping package, defuel the reactor in the field, or use an overpack transportation cask, the ultimate commercial viability of microreactors relies on establishing a clear, standardized lane from remote deployment back to final disposition.

Separately, the NRC announced May 19 it has accepted for review a construction permit application to build an advanced microreactor at the University of Illinois Urbana-Champaign, launching a detailed safety and environmental review of a project that would mark a significant milestone in university nuclear research. The application proposes a reactor based on NANO Nuclear Energy's KRONOS Micro Modular Reactor (MMR) design, a next-generation system using helium cooling and a molten-salt heat transfer process engineered for enhanced safety and efficiency. The KRONOS MMR uses TRISO particle fuel.

Notaby, the NRC is planning to issue a new 10 CFR Part 71 regulation for microreactors this spring that is risk-informed and performance-based. On May 19, the Advisory Committee on Reactor Safeguards (ACRS) issued a letter to Chairman Ho Nieh with its generally favorable assessment of the proposed rulemaking.

Natrium Spent Fuel

Kyle Stanon presented TerraPower's Natrium project – the Kemmerer Power Station Unit 1 in Wyoming. On March 4, 2026, the United States Nuclear Regulatory Commission issued a historic construction permit for the Kemmerer plant, marking the first approval for a commercial non-LWR in more than 40 years. The first Natrium plant is being developed through the US Department of Energy's Advanced Reactor Demonstration Program (ARDP), and is expected to be completed in 2030.

Unlike today's LWRs, the Natrium reactor is a 345-megawatt sodium-cooled fast reactor coupled with TerraPower's breakthrough innovation – a molten salt energy storage system, providing built-in gigawatt-scale energy storage. This makes the plant a perfect support for high-renewable penetration grids where variable power output is a concern. While fast reactors are often associated with a closed fuel cycle, TerraPower has optimized the Natrium plant specifically for once-through fuel cycle economics.

Under this once-through fuel cycle strategy, the spent metallic fuel is intended for direct disposal in a deep geological repository (DGR) or in deep boreholes. This baseline relies on a strong regulatory and historical foundation – metallic fuel has clear precedence in repository acceptance criteria, dating back to characterizations established during the Yucca Mountain Safety Analysis Report (SAR).

Metallic fuel's physical and radiological properties have logistical advantages over legacy systems, as reflected in the table below.

Metric	Natrum SNF vs LWR SNF	Impact on back-end infrastructure
SNF mass	72% less mass	Reduces heavy metal tonnage requiring transportation
SMF physical volume	42% less volume	Shrinks the footprint required for a repository
Decay power	Lower total decay power	Lowers long-term thermal loads per unit of generated electricity

These specific characteristics mean that Natrium's spent fuel load is highly accommodable within existing DGR designs. By shrinking both the physical footprint and the long-term thermal stress placed on repository host rocks, the back-end profile of the reactor becomes an advantage rather than a liability.

Back-end processes will require a structured, multi-tier cooling process at the site before the fuel is prepared for final dry storage or transport:

- In-vessel storage – upon discharge from the core, the spent fuel remains within the reactor vessel in a spent fuel pool for one to two cycles to allow the hottest short-lived isotopes to decay.
- Ex-vessel storage tank – the fuel assemblies are then transferred out of the vessel into an adjacent sodium-cooled storage tank for further thermal cooling, typically completing the initial sodium-cooled phase within five years.
- Water storage pool – following the sodium-cooled phase the fuel is transitioned to a spent fuel pool structurally identical to current LWR pools. The pool can accommodate up to 20 years of plant discharges.
- Dry cask storage – Once the fuel elements transition to the spent fuel pool, TerraPower intends for their physical handling and thermal profile to mirror traditional LWR fuel assemblies. From the pool, the fuel moves directly out of the fuel handling building onto an adjacent concrete pad for dry storage.

Separately, on May 20, TerraPower announced it has signed agreements with HD Hyundai and Hyundai Engineering & Construction (HDEC) to support the rapid commercialization and deployment of a fleet of Natrium reactor and integrated energy storage plants in the coming years.

Deep Borehole Disposal

While mined deep geological repositories remain the standard for large-scale commercial spent nuclear fuel disposal, deep borehole disposal has emerged as a viable, modular disposal alternative, particularly for the diverse, non-traditional waste forms generated by advanced microreactors and SMRs. Jesse Sloan, Executive Vice President of Engineering at Deep Isolation, explained this disposal method, and the objectives of the Deep Borehole Demonstration Project.

The Universal Canister System (UCS) is key to deep borehole disposal. Developed in collaboration with partners NAC International, University of California Berkeley, and Lawrence Berkeley National Laboratory, the UCS is designed to accommodate spent fuel, high-level radioactive waste from advanced reactors, and vitrified waste from reprocessing. Once spent fuel is loaded into the UCS at the plant site, it never needs to be repackaged, even if the final disposal pathway or repository location is not yet defined. This feature eliminates the radiological risks and capital costs associated with future fuel-handling operations.

The UCS is moving from the design phase to commercial readiness. Deep Isolation was recently selected for an ARPA-E SCALEUP Ready award, which secured federal support to advance the universal canister system and deep borehole disposal (*SF* No. 1607 April 10, 2026). The SCALEUP consortium consists of a team of the following nuclear technology, drilling, and waste management organizations:

- Westinghouse serves as the launch customer to integrate next-generation reactor technology with permanent disposal
- NAC International leads the UCS fabrication, surface operations, and regulatory licensing
- Halliburton will direct subsurface borehole construction

and engineering

- Occlusion Nuclear Solutions will manage complex subsurface operations
- Amentum will oversee comprehensive operational safety and quality assurance.

The primary objective of this full-scale SCALEUP initiative is the Formal Issuance of Licensing (FILE) for an eVinci microreactor. This regulatory framework will establish a fully licensed, repository-ready lifecycle, detailing how eVinci spent fuel will be transported within the UCS using NAC's licensed MAGNATRAN transportation cask and stored in NAC's MAGNASTOR storage system.

To validate these operations in real-world conditions, the consortium has launched a multi-phase, non-radioactive, end-to-end full-scale demonstration program. Following a team kick-off workshop in November 2025, active borehole design and emplacement procedures are underway.

The demonstration program aims to achieve two primary objectives:

- Validate standard drilling practices – demonstrate the feasibility of drilling a repository-grade borehole using standard oil and gas industry practices, properly sized to support the long-term storage and disposal of nuclear waste canisters at representative depths within a suitable shale formation.
- Simulate end-to-end repository operations – execute full-scale handling, emplacement, and retrieval sequences using prototypic equipment.

Disposal of a canister in a borehole is fully reversible. The exact steps taken to emplace the UCS into a borehole can be performed in reverse to safely retrieve a canister from the borehole if needed.

By demonstrating that advanced reactor waste (and commercial spent fuel in some cases) can be safely packaged once at the reactor site, transported to the borehole repository, and permanently disposed using standard procedures from the oil and gas industry, Deep Isolation is creating a scalable back-end solution that can mature alongside advanced reactor development.

News – International

Andra and BGE agree to exchange information on radioactive waste management

On May 6, the French National Agency for Radioactive Waste Management, Andra, and its German counterpart, the Bundesgesellschaft für Endlagerung (BGE), signed a cooperation agreement that builds on the relationship established between the two organizations over several years. The agreement reflects their shared commitment to continuing collaborative work and structures for the next five years.

An initial cooperation agreement was signed in 2018, following the creation of the BGE in 2017, for a period of five years, until 2023. The new Andra-BGE agreement is thus based in mutual benefit and reciprocity. It covers the main areas of expertise of both agencies – the two parties can exchange information on their respective deep geological disposal projects for radioactive waste by sharing technical information and lessons learned, while also facilitating site visits.

In conjunction with signing the agreement, the Andra staff were invited to visit the Asse mine, a former salt mine used from 1967 to 1978 as a storage site for low- and intermediate-level radioactive waste (see last week's Top Story for more information about the Asse mine). This visit allowed Andra to learn about the operations carried out on-site by BGE, and to observe the monitoring systems in place. The photo below is of the Asse mine.


Photo source: Andra

For the final management of the low-level waste (LLW) and intermediate-level waste (ILW), the German government selected the site of the former Konrad iron mine in Lower Saxony in 2018. The facility, located at a depth of 850 meters and with a capacity of 303,000 cubic meters, is expected to be operational in 2030.

Germany is working to establish a deep geological repository (DGR) for its most radioactive waste. Germany expects to benefit from Andra's experience with the Cigéo project, particularly in the phased development and organization of the project since 1991, and with the knowledge on disposal in clay formations acquired through the underground laboratory. The BGE is also interested in Andra's communication and dialogue strategy with stakeholders regarding the project.

For its part, Andra is interested in the BGE's information and stakeholder dialogue strategy, and is observing the process of selecting a DGR as conducted by the BGE. As part of that process, the entire German territory was initially considered, then gradually reduced to half, and now to a quarter of the country's territory. Saline, granite, and clay geological formations are being considered.