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NUCLEAR FUEL RECYCLING

IF UTAH PLANS TO BE A NUCLEAR HUB, IT'LL NEED A LOT OF FUEL. WHY MINE IT WHEN THE U.S. HAS 90,000 TONS OF SPENT FUEL WITH 90% OF ITS ENERGY REMAINING?







Nuclear power plants in the United States have generated over 90 million metric tons of "spent" nuclear fuel that is far from spent. It contains an estimated 90% of the energy it had before going into a reactor. Nevertheless, it sits in concrete storage vaults at 94 nuclear reactors scattered across 28 states, where it could remain radioactive for millions of years.

Governor Spencer Cox's plan to transform Utah into a hub of nuclear energy means that our state will host spent fuel as well—unless we could recycle it.

That is what University of Utah's Michael Simpson, PhD, Professor of Metallurgical Engineering, has been working on for nearly 30 years. Simpson began his career at Idaho National Laboratory (formerly Argonne National Laboratory) in Idaho Falls. He worked on pyrochemical processing, a way to separate uranium and other actinides—radioactive elements on that bottom row of the periodic table—from spent fuel. It's a way to recover and reuse the leftover energy.

After 17 years at Idaho National Laboratory, Simpson joined the U of U in 2013 and continued to research fuel recycling (also known as "reprocessing"). His research has implications not just for addressing that 90,000 tons of spent fuel, but for building a nuclear hub in Utah.

Nuclear fuel recycling is nothing new. France, which derives about 70% of its electricity from nuclear energy, reprocesses nuclear fuel over and over until there's no energy left to extract. The French use a technique called PUREX—plutonium-uranium redox extraction—which involves dissolving spent fuel in acids to separate uranium and plutonium.

In 1977, President Jimmy Carter banned nuclear fuel reprocessing techniques like PUREX over concerns about proliferation. If someone managed to steal the separated plutonium—or, if a country adopted PUREX under the guise of a recycling program—they'd be well on their way to making a nuclear weapon.

Here's where nuclear fuel recycling gets interesting—and difficult. Pyroprocessing is proven. Idaho National Laboratory pyroprocesses spent fuel used in its Experimental Breeder Reactor-II (EBR-II), which was shut down in 1994. This creates a fuel called high-assay low-enriched uranium (HALEU, usually pronounced "hey-loo").

Conventional nuclear plants throughout the U.S. use uranium enriched 4% to 5%. HALEU is enriched up to 19.9%. For perspective, weapons-grade uranium is enriched to about 90%.

HALEU is in high demand among the startups developing small modular reactors (SMRs). These are the new breed of allegedly safer, smaller, mass-produced nuclear reactors that have raised billions of dollars from venture capital firms and big tech companies, like Amazon and Microsoft, that want them to power AI datacenters.

Unfortunately for these SMR startups, pyroprocessing at Idaho National Laboratory is one of the only domestic sources of HALEU, most of which used to be imported from Russia. That facility has produced about 5 metric tons of HALEU total. Hypothetically, it could produce 5 tons per year, but it has never achieved that rate.

That's why in 2002, Simpson secured a $1.5 million Department of Energy grant to develop pyroprocessing for spent conventional fuel—the 90,000 metric tons sitting in concrete vaults, growing by 2,000 tons per year. Pyroprocessing conventional fuel does not make HALEU. Rather, it produces uranium and transuranic actinides (U/TRU)—a mishmash of elements right of uranium on the bottom row of the periodic table. The only type of reactors that can use these actinides are called fast reactors, which Simpson compares to garbage incinerators. The U.S. doesn't have any fast reactors left—EBR-II at Idaho National Laboratory was the last one.

Thus, the issue, says Simpon, is "How do you create an industry that's not there yet?" A handful of startups are developing fast reactor SMRs that could use recycled fuel, but none have built prototype reactors let alone commercial-scale plants as of this writing.

"There's not a customer quite yet," Simpson explains. In all likelihood, SMR companies would have to pre-purchase recycled fuel before a recycling facility could get financing to build. But if no startup has a secure source of fuel, they're unlikely to get financing for a commercial plant.

The Department of the Interior is keen to open new uranium mines (including one recently approved in San Juan County, Utah). But why not use the fuel we have already mined? Rather than burn and store spent fuel here in Utah, where it will become a future generation's problem, we could maximize the value of uranium and minimize the waste.

Perhaps that option is coming soon. Simpson is in talks with potential industrial partners to move pyroprocessing towards commercialization.

Utah and federal tax dollars have funded years of pyroprocessing research at the U of U. If Utah lawmakers are serious about building a nuclear hub, a few test reactors won't cut it. Forming a closed loop of uranium mines, commercial fast reactors, and fuel recycling facilities sounds more promising.