WHITEPAPER

Enabling Clean Nuclear Power

Endeavoring to solve the worldwide issue of nuclear waste through fusion technology



Imagine how much we might help solve the problem of mounting nuclear waste if instead of creating more waste, nuclear power reactors could burn it over and over again

Defining the Challenge

National support for nuclear energy in the United States is the highest it has been in decades. A 2022 survey by ecoAmerica* showed more than 61 percent of Americans believed "a lot more" or "more" money should be spent on next-generation nuclear technology. Climate change issues, geopolitical uncertainties and rising energy costs are among the factors in the changing sentiment.

And yet the same barriers to nuclear power that have existed for decades continue to persist today. In the same survey, the two largest public concerns to upgrading nuclear technology were waste disposal and health and safety.

The buildup of spent nuclear fuel continues to be a significant issue socially. environmentally and economically. The International Atomic Energy Agency reports nearly 400,000 tons of spent fuel were generated between 1954 and 2016. The United States currently has an estimated 86,000 metric tons of spent nuclear fuel, a number that is growing by about 2,000 tons per year. And there are currently just two acceptable storage methods for that spent fuel – either in specially designed pools or in dry cask storage – onsite at reactors across the country.

We estimate the annual global nuclear waste management market opportunity was approximately $20 billion in 2021. We believe that the expansion of the market to include spent nuclear fuel disposition and remediation could potentially grow the nuclear waste management market to be a $50 billion annual market opportunity by 2030.

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Canvassing Solutions

Spent nuclear fuel isn't actually "spent" at all; it still has more than 90 percent of its energy capacity available. If it could be recycled, it can potentially be reused – again and again – in the same reactors where it originated.

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With economic, security and climate matters in mind, 35 members of Congress in November penned a letter to Jennifer Granholm, the United States Secretary of Energy. They asked the Department of Energy ("DOE") to accelerate development of technologies that may increase sustainability of the U.S. nuclear fuel cycle through reprocessing and recycling. And they asked the DOE to report on its work to advance technologies that might be used to reduce fuel security risks, be economically viable, and may help manage nuclear waste produced by the U.S. reactor fleet.

At SHINE, we believe we can play a major role in the future in both recycling spent nuclear fuel so that it can be reused, as well as in transforming long-lived radioactive waste into shorter-lived materials.

Leveraging Technology

SHINE is already well into research and development activities and hopes to execute in the next five years the first part of that plan: separating spent fuel and recycling it back to reactors. Through the medical isotope production phase of our business, we have already developed technology that navigates highly radioactive uranium solutions and separates out valuable materials. In fact, our Chrysalis medical isotope production facility is in many ways a pilot plant for recycling nuclear waste.

The processes we use to separate medical isotopes, like molybdenum-99, will give us practice isolating valuable isotopes from a radioactive uranium stream. In recycling spent nuclear fuel, we plan to expand on those processes. Once the spent nuclear fuel has been dissolved and clarified, it enters the co-decontamination (CoDCon) process, which begins by removing purified uranium and a plutonium/uranium mix to be returned and reused in reactors. Other steps in the separation process will potentially extract valuable isotopes and precious metals (ruthenium, rhodium or palladium, for example) from the waste stream.

Longer-term, over the next decade, we intend to scale our fusion technology to take waste mitigation a step further. While waste streams consist of roughly 5 percent or less of long-lived radioactive waste, we aim to use transmutation to drastically shorten their half lives. For instance, some of these radioisotopes can take millions of years to decay, but we believe – through additional experience and advancements in technology – those radioisotopes can be transformed into other radioisotopes that decay in decades, or less.



Combatting Nuclear Waste With Fusion

- Recycling the majority of spent nuclear fuel to be reused in reactors
- Recovery of precious metals and high-value isotopes
- Potentially drastic reduction in the half life of long-lived radioactive waste

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Delivering New Outcomes

Until fusion energy becomes possible, nuclear fission offers a carbon-free source of clean energy to reduce dependence on fossil fuel and help combat climate change. The lack of a permanent disposal path for spent nuclear fuel leaves the planet vulnerable to accidents that could release large amounts of radioactive substances into the environment.

We aim to solve one of fission's biggest drawbacks with our promising technology. We have proven and continue to develop that technology. And, we have proven our abilities to design a first-of-its-kind nuclear facility – as well as navigate the nuclear regulatory process.

Through our current work to produce medical isotopes, we are de-risking and proving our abilities to: design and build seismically qualified concrete hot cells; design and build criticality-safe tanks and piping; design and construct aqueous uranium transport systems; and develop fission product separation systems from aqueous uranium solutions.

By continuing to scale these abilities, we have the potential to augment the current momentum in the nuclear space by expanding fission's scope, reach and impact. And we plan to do it by drastically reducing – or possibly even eliminating – one of the largest economic and social barriers by laying to waste the issue of spent nuclear fuel.

Reference:

Speiser, M., Hill, A. N. (September, 2022). American Climate Perspectives Survey 2022.
ecoamerica.org/wp-content/uploads/2022/09/acps-2022-vol.-iii-energy-attitudes.pdf

About SHINE

SHINE deploys its safe, cost-effective and environmentally friendly fusion technology in a stepwise approach. Its systems are used to inspect industrial components in aerospace, defense, energy and other sectors. SHINE's proprietary medical isotope production processes create molybdenum-99 and non-carrier-added lutetium-177. These important medicines are used in tens of thousands of daily procedures to diagnose and treat heart disease, late-stage cancer, and other serious illnesses. In the future, SHINE plans to scale its fusion technology to help solve one of energy's toughest hurdles by recycling nuclear waste. Through a purpose-driven and phased approach, SHINE aims to generate fusion power to deliver clean, abundant energy that could transform life on Earth.

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