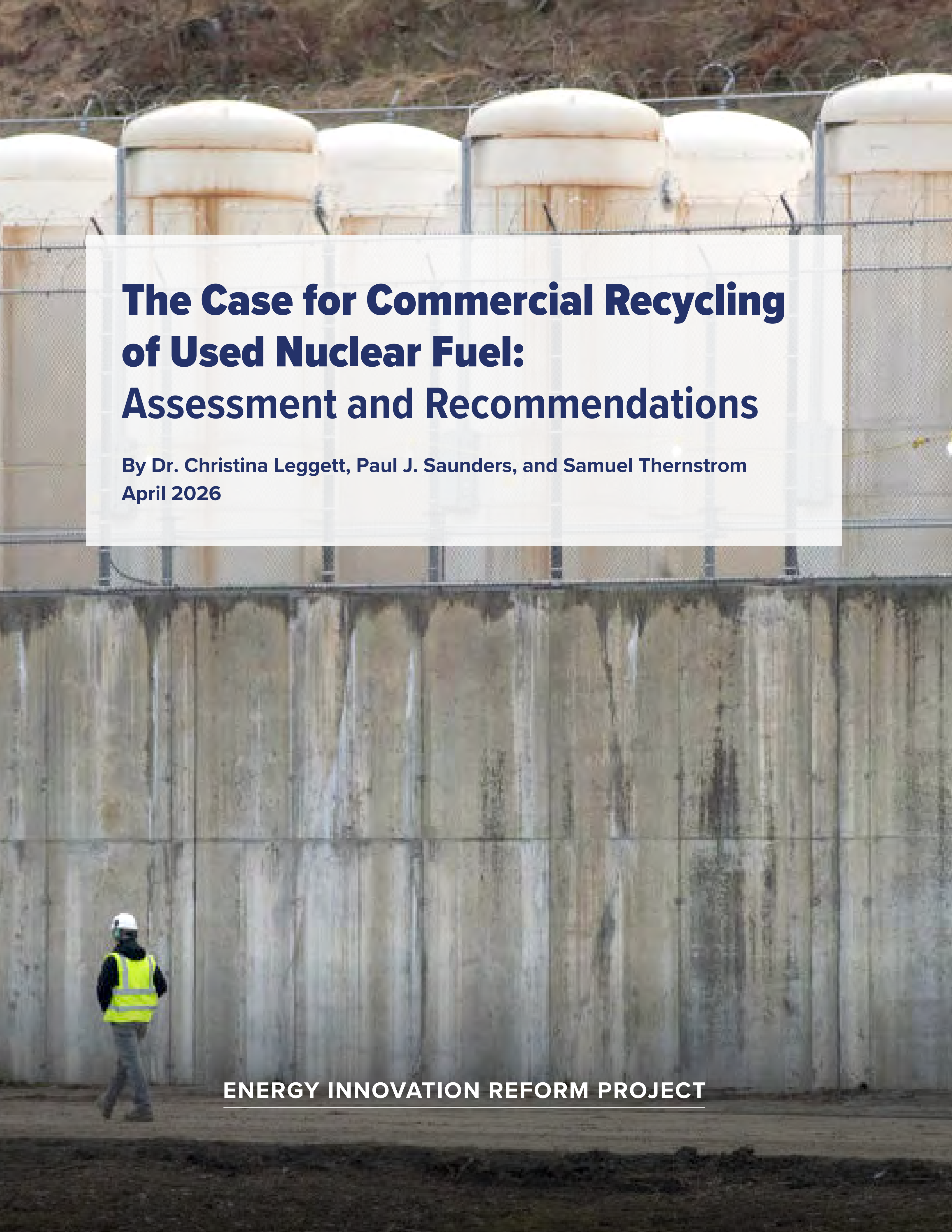

The Case for Commercial Recycling of Used Nuclear Fuel: Assessment and Recommendations

By Dr. Christina Leggett, Paul J. Saunders, and Samuel Thernstrom

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ENERGY INNOVATION REFORM PROJECT

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Energy Innovation Reform Project is a non-partisan non-profit organization dedicated to promoting policies that advance innovation in energy technologies and practices to improve the affordability, reliability, safety, and security of American energy supplies and our energy economy. EIRP was founded in Washington, DC in 2013. Its work combines policy reports, scholarly research, and economic modeling with creative efforts to bridge partisan differences over energy policy.

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Abbreviations

DGR	deep geologic repository
DOE	Department of Energy
GNEP	Global Nuclear Energy Partnership
GWe	gigawatt-electric
HALEU	high-assay low-enriched uranium
HEU	high-enriched uranium
HLW	high-level waste
IAEA	International Atomic Energy Agency
LEU	low-enriched uranium
LEU+	enriched to between 5% and 10% U-235
LWR	light water reactor
MC&A	material control and accounting
MT	metric ton
NRC	Nuclear Regulatory Commission
PRIDE	Pyroprocess Integrated Inactive Demonstration
PUREX	plutonium uranium reduction extraction
TRU	transuranic
U/TRU	uranium/transuranic
UNF	used nuclear fuel

Executive summary

The US nuclear industry is undergoing rapid growth, driven by increased electricity demand, advanced reactor development, and heightened energy security concerns following Russia's 2022 invasion of Ukraine. These developments have sparked renewed interest in recycling used nuclear fuel (UNF) as part of a sustainable, closed fuel cycle. Today, commercial UNF recycling is not only feasible but also strategically necessary for the United States.

America's past recycling programs have been costly and short-lived. Since US officials last seriously considered pursuing recycling, technology, policy, and markets have evolved rapidly. Today, the US government and private sector firms can address the three long-standing challenges to UNF recycling—**economics, waste management, and proliferation**.

The economics of recycling have improved:

- Rising global uranium demand and a growing need for high-assay low-enriched uranium (HALEU) fuel for advanced reactors increase the strategic and commercial incentives for recycling as a supplementary domestic fuel source, including in space-based applications.
- Advanced recycling technologies (e.g., pyroprocessing) are simpler, more modular, and projected to be cheaper than legacy PUREX systems.
- Recycling can support US economic and national security goals by supplying critical minerals (e.g., lanthanides, platinum-group metals) and valuable isotopes, including valuable radioactive isotopes used in nuclear medicine (imaging) and radiotherapy (treatment).

Advanced techniques for waste management are available:

- The US has accumulated approximately 94,000 metric tons of UNF with no operational deep geologic repository. Recycling this UNF is possible with advanced recycling technologies and should substantially reduce the amount of high-level waste requiring permanent disposal, thereby reducing repository footprint and costs while also recovering valuable isotopes for energy, space, medical, and industrial uses.

Emerging UNF recycling methods need not increase the risk of proliferation:

- Modern safeguards and advanced recycling technologies can significantly mitigate concerns about the potential diversion of plutonium by using faster, near-real-time monitoring (or accounting) and co-recovery of plutonium with other fissile materials. In addition, recycling transuranic elements in a commercial reactor reduces the volume of material requiring safeguards by effectively destroying the material, rather than maintaining it in long-term storage (the current practice).
- US recycling will not increase the risk that other nations develop nuclear weapons. Past proliferators have overwhelmingly used means other than recycling to obtain needed fissile material. America's geopolitical rivals are already pursuing reprocessing notwithstanding past US self-restraint.

The federal government should consider the following actions:

- Adopt a national policy statement in support of UNF recycling, modeled after the statement in the George W. Bush administration’s 2001 National Energy Policy.
- Develop and release a comprehensive, integrated waste strategy that incorporates UNF recycling alongside disposal.
- Expand US Department of Energy funding and public-private initiatives to accelerate deployment of commercial UNF recycling capabilities.
- Update legislation such as the Atomic Energy Act of 1954 and the Nuclear Waste Policy Act to bolster the commercial deployment of modern recycling technologies.

Technological advances, new market dynamics, and HALEU supply constraints have created a strategically significant opportunity for the US to implement commercial nuclear fuel recycling. By enacting supportive policies and taking associated federal actions, the US can responsibly reduce the burden of nuclear waste, enhance energy security, secure critical minerals, and reestablish global leadership in nuclear innovation—all steps that could have far-reaching economic and security benefits.

Introduction

The US nuclear industry has experienced rapid growth and seen an increase in public and bipartisan political support over the past decade. Companies such as Kairos Power, Oklo, and X-energy are leading the development of advanced reactors,[1] which range in size from a few megawatts up to several hundred megawatts and feature enhanced, passive safety features. These reactors can provide reliable electricity for data centers and remote communities; can consume used nuclear fuel (UNF); and can provide high-quality nuclear heat for nonnuclear applications. This is a promising situation for civilian nuclear energy, but it also entails important requirements for fuel supply and has significant implications for America's approach to the fuel cycle.

Many advanced reactors under development require high-assay low-enriched uranium (HALEU) fuel,[2] and can even use plutonium and other transuranic (TRU) elements as fuel.[3] These fuels are higher in energy density than the low-enriched uranium (LEU) generally used in commercial nuclear reactors today, meaning that at equivalent quantities, HALEU fuels produce more energy than LEU fuels. This higher energy density is one factor that allows advanced reactors using HALEU fuel (many of which are small modular reactors—SMRs—or even smaller micro-reactors) to generate useful amounts of energy while remaining small relative to LEU reactors. US nuclear aircraft carriers and submarines—which require very small power plants that can operate for decades without refueling—use even more energy-dense highly enriched uranium (HEU). HEU and plutonium can, of course, be used to manufacture nuclear weapons.

Companies are building new advanced reactor fuel cycle infrastructure, including fuel fabrication and enrichment facilities in the US that accommodate the new fuel and uranium needed for America's next generation of nuclear reactors. At the same time, uranium ore prices have increased sufficiently to encourage new investment in US mining and conversion, thanks to growing global demand for enriched uranium stemming from new reactor construction, the US legislative ban on Russian uranium imports, and other factors.[4]

US avoidance of uranium supplies and conversion and enrichment services from adversarial nations seems likely to persist for some time. Slow development of new mining, conversion, and enrichment in democratic countries will also tend to support durable high prices. Because these two trends appear to be enduring, they provide stronger justification for the substantial and long-term investments necessary to conduct commercial UNF recycling.

To address the growing need for HALEU, General Matter and Orano USA recently announced plans to enter the domestic enrichment market alongside Urenco USA, which currently operates a commercial enrichment facility in the United States, and Centrus Energy, which is developing one. The US government has invested billions of dollars to support these elements of the burgeoning advanced reactor industry, both via legislation and programs such as the HALEU Availability Program and the Advanced Reactor Demonstration Project.[5]

The promise of advanced nuclear reactors has also led to commercial interest in recycling the nation's UNF to unlock more energy from the fuel rather than continuing to store it for future disposal.[6] US-based companies such as Curio, Oklo, and SHINE are actively pursuing the commercialization of advanced recycling technologies. Proponents of recycling emphasize its potential to reduce the volume and overall burden of highly radioactive waste requiring permanent disposal, ease some of the demand for uranium ore, enable substantial improvements in uranium fuel utilization, and supply valuable critical minerals and radionuclides that can be used for diverse applications such as medical treatment and space exploration.

Although the United States briefly engaged in commercial recycling of UNF more than five decades ago, several factors—evolving government policy, concerns about proliferation, and market conditions—combined to chill interest in commercial recycling until recently. During America's absence from the field, France and Russia secured global leadership. Russia further uses its expertise to offer other countries fuel and recycling services (along with reactor construction and financing) in a comprehensive package; the aim is to help the state nuclear monopoly Rosatom win attractive, multi-decade contracts for nuclear construction and fuel services with other countries, including nuclear newcomers. China may be developing a similar approach.

Current market conditions, advances in recycling technologies, and the robust market interest in advanced reactors have created conditions that are ripe for restarting domestic commercial recycling and enabling the US to potentially reassert leadership in this area. The White House, Congress, and the Department of Energy (DOE) should consider policies to accelerate industry-led, economic, and secure recycling of the nation's UNF as part of a comprehensive national strategy. The remainder of the paper looks at the three main challenges to UNF recycling— economics, waste management, and proliferation—and shows how the US has overcome them or is in the process of doing so. The paper also includes recommendations for policymakers that could enhance or accelerate recycling.

Improved economics

Current large-scale UNF recycling facilities around the world use the mature PUREX (plutonium uranium reduction extraction) process, which separates plutonium and uranium from other fission products in high-level waste. Uranium is by far the largest product of this process by weight, comprising about 95% of the output.[7]

Countries have used PUREX for decades to recycle most of their inventories of discharged UNF as well as that of allies; France uses PUREX currently, and the United Kingdom used it until recently. The long duration this practice is a testament to the reliability of the process and its ability to create decades-long partnerships. In the United States, several factors have combined to disincentivize efforts to restart commercial recycling: fluctuating national policy decisions, decades of low uranium prices, abundant uranium resources, and a general lack of financial drivers. For example, a 2003 study suggested that uranium prices would have to grow to a level ten times higher than today's prices, to $370/kg, for a new PUREX facility to break even.[8]

Nevertheless, the recent strong growth of the nuclear energy sector globally, the expected demand of advanced reactors requiring HALEU (particularly fast neutron reactors such as Oklo's Aurora powerhouse), and development of modern advanced recycling technologies may change the economics of recycling.

Lower projected capital costs

In the several decades since the PUREX process was first developed and implemented on a production scale, DOE (and its predecessor, the Atomic Energy Commission) has funded and supported the development and refinement of advanced recycling technologies such as pyroprocessing, which is a nonaqueous electrochemical separation technique pioneered at what is now part of the Idaho National Laboratory (INL).[9] For the last 30 years, INL has been demonstrating pyroprocessing on an engineering scale. It is currently using pyroprocessing to recover and downblend UNF to produce an interim supply of HALEU for advanced reactors.

Compared with PUREX, pyroprocessing is a smaller and simpler partitioning process. It is also amenable to modularization, which could lead to cost savings. Though no one has operated a production-scale pyroprocessing facility, conceptual facility designs are sufficient for cost studies. The Pyroprocess Integrated Inactive Demonstration (PRIDE) facility in Korea also provides valuable data. For a first-of-its-kind pyroprocessing-based recycling facility with a capacity of 400 metric tons (MT)/year,[10] with or without associated fuel fabrication facilities, the estimated cost ranges from approximately $0.5 billion to $1 billion.[11]

Since 2022, ARPA-E (Advanced Research Projects Agency–Energy) has sponsored transformational research on recycling, safeguards, and waste management via the Optimizing Nuclear Waste and Advanced Reactor Disposal System (ONWARDS) and Converting UNF Radioisotopes Into Energy (CURIE) programs; the intention is to reduce both the construction and operating costs of recycling facilities while maintaining safe operations. As with other complex systems, operating such facilities would also generate important technical and commercial lessons.

Alternative fuel source

As of October 2025, there were 70 commercial nuclear reactors under construction globally, which would add a combined 76.8 gigawatt-electric (GWe) in generation capacity. An additional 100 reactors are planned and would add a combined 112 GWe in capacity.[12] China is building 33 reactors and planning 43, and so accounts for the largest share of reactors in both categories. When all the reactors under construction and being planned are operational, they will join the 438 reactors operating globally today (including 94 in the United States, representing the largest share) and will materially increase uranium demand.

In 2024, the global annual requirement for uranium ore was approximately 67,500 MT, virtually all of which was used either at natural, LEU, or LEU+ enrichment levels. At that rate of usage, the global supply of identified uranium ore (which can be produced for less than three times the spot price of uranium) would last approximately 90 years.[13]

However, with planned increases in nuclear reactor construction approaching half the capacity of the existing global fleet, existing uranium supplies will not last as long as previously expected.[14] Additional projected demand for HALEU to fuel advanced reactors will further strain these uranium resources, as HALEU's higher concentration of U-235 requires significantly more natural uranium ore per mass of enriched fuel than fuels for existing light water reactors (LWRs).

The US ban on importing Russian natural or enriched uranium has created a gap between domestic uranium demand and available supply, as Russia holds 44% of the world's uranium enrichment capacity and provided 35% of the US supply of uranium prior to the ban.[15] In addition, while the United States government is supporting domestic HALEU production, Russia is currently the sole producer of commercial-scale HALEU, albeit at low levels.

Commercial recycling in the United States would allow companies to recover uranium and transuranic elements from UNF to enable the production of uranium/transuranic (U/TRU) fuel, which can be used in certain advanced reactors in place of HALEU. This could serve as a stopgap fuel until sufficient domestic HALEU enrichment capabilities are established and could continue to supplement fuel material needs thereafter.

In addition, as HALEU-fueled reactors begin producing used HALEU fuel in the future, used HALEU fuel could also be recycled.[16] A 2024 study sponsored by DOE's Office of Nuclear Energy shows that recycled HALEU having more than 7% remaining enrichment (i.e., U-235 content) at discharge is more economical than a once-through HALEU fuel cycle.[17] The higher the residual remaining enrichment content, the more favorable the economics of recycling. Additionally, any use of material recovered via recycling for fuel reduces the amount of natural uranium ore resources requiring enrichment to make fresh fuel, just as mixed oxide fuel produced using recycled UNF in France is expected to reduce French demand for uranium ore by 25%.

Increased uranium fuel utilization

A 2014 DOE-sponsored fuel cycle options study explored using thermal or fast reactors and recycling to improve fuel cycle performance.[18] The authors of the study evaluated thousands of scenarios involving combinations of different reactors and either partial or full recycling. They determined that several of the most promising fuel cycles combine fast-neutron reactors with continuous recycling of uranium, plutonium, and minor actinides (i.e., U/TRU). According to the study, this configuration should lead to significant reductions in the amount of fuel cycle waste requiring disposal, and greatly improved fuel utilization. Other studies have highlighted the savings in front-end costs related to uranium mining, conversion, and enrichment.[19]

Domestic supply of radioisotopes and critical minerals

The nation's 94,000 MT of UNF contains myriad isotopes of nearly every element on the periodic table.[20] Figure 1 shows the average elemental breakdown of UNF assemblies from LWRs.[21] UNF includes zirconium, lanthanides, cesium, strontium, cobalt, platinum group metals (e.g., palladium, rhodium), tritium, uranium, tellurium, xenon, and krypton. Many of these elements are present in sufficient quantities that they could be recovered and sold economically for a range of industrial, medical, and space applications.

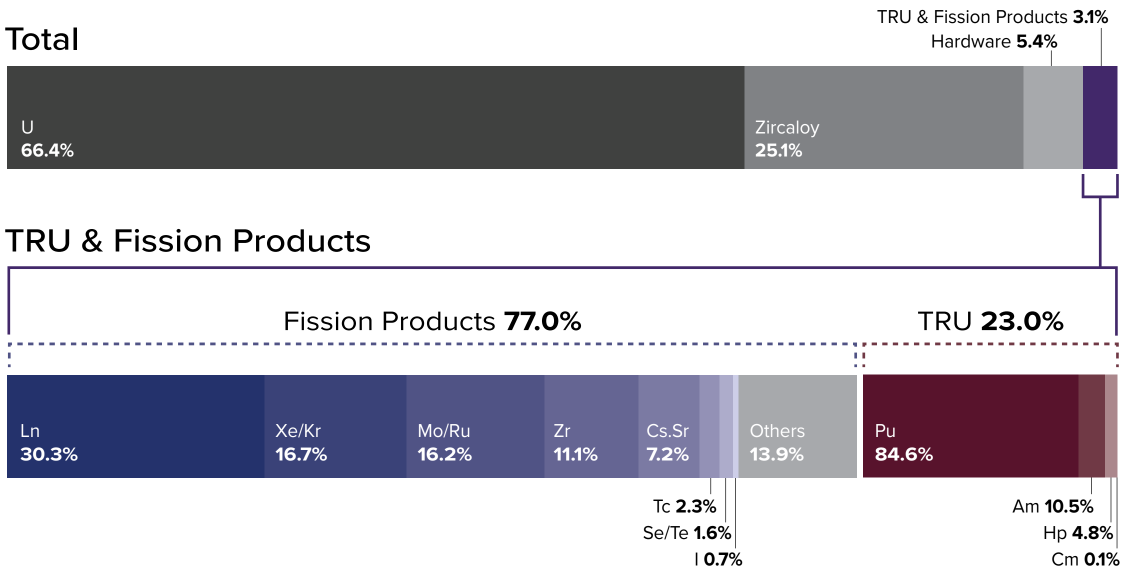

Figure 1: Average elemental composition of 40-year-old light water reactor UNF with an average burnup of 33 gigawatt-days per MT. Reproduced from E. D. Collins et al., "A Practical Solution to Used Nuclear Fuel Treatment to Enable Sustained Nuclear Energy and Recovery of Vital Materials," Oak Ridge National Laboratory, ORNL/TM-2010/81, April 2010.

Notably, several of these elements are considered critical minerals that the nation relies upon for economic and national security purposes. These minerals are used in several important sectors, such as the electronics, solar, and nuclear energy industries. In 2024, the US sourced 100% of five critical minerals and 50% or more of 28 additional critical minerals from foreign nations, including China and Russia.[22] Recent US administrations have sought to reduce the reliance on imports of critical minerals. To that end, the Trump administration has released three executive orders since January 20, 2025, to address reliance on imports.[23] In response to the January 20, 2025, executive order, DOE announced nearly $1 billion in funding opportunities to enable recovery of critical minerals.[24]

Several of these targeted critical minerals, as well as other valuable isotopes, are byproducts from recycling UNF. Recovery of such isotopes, in some cases after a suitable decay time, could create an additional revenue stream for recycling facilities. Isotope recovery can also improve repository management by reducing the heat load[25] and generally reducing the amount of waste requiring permanent disposal.

Reduced high-level waste

Approximately 94,000 MT of UNF is safely stored in spent fuel pools and in dry storage casks at 79 sites in over 30 states; this quantity grows by approximately 2,000 MT each year.[26] Despite decades of concern, a solution to the "waste problem" has remained elusive. UNF recycling is not the sole solution—but it could make a comprehensive approach more feasible by reducing both volumes and radioactivity.

The UNF currently in storage is classified as high-level waste (HLW) and has been designated for permanent disposal in a deep geologic repository (DGR).[27] The National Academy of Sciences recommended DGR disposal in 1957;[28] in 1982, the US Congress passed the Nuclear Waste Policy Act, which established federal responsibility for permanent disposal; created a process to site, license, build, and operate DGRs; created a federal waste fund supported by industry fees; and directed DOE to recommend at least two sites.

DOE evaluated several potential sites before the United States selected Yucca Mountain, Nevada, as the location for the permanent repository. Legislation in 1987 abandoned the idea of a second site. However, the Obama administration halted the project in 2010. Since then, the US has made no significant progress toward siting and constructing a repository or implementing a comprehensive waste management program. In the last few years, however, the DOE has embarked upon a collaboration-based siting program for a DOE-operated consolidated interim storage facility.[29] Finland has successfully used a consent-based process to site a permanent repository.[30]

Many argue that UNF recycling does not obviate the need for a permanent disposal solution. For example, a 2023 National Academy of Sciences report evaluated the impacts of various advanced reactor fuel cycle options (including recycling) on waste management, proliferation risks, costs, and other parameters. This report concluded that (1) all UNF could be safely stored in a system of one or more DGRs without recycling; (2) transitioning to an advanced reactor fuel cycle with recycling does not solve the waste problem, which is large and multifaceted; and (3) additional R&D on advanced reprocessing technologies is warranted.[31]

The National Academies report is correct that sufficient DGRs could be created to store all UNF. But scientific and technical possibility do not automatically generate political reality. In practice, building a single DGR has been a decades-long challenge that the United States has so far failed to meet. Reducing the quantity of waste needing long-term disposal—and especially reducing the length of time during which that waste will be radioactive—could make successful waste disposal easier to achieve.

Indeed, the nation's current UNF inventory would more than fill the Yucca Mountain repository if it were operational today. Considering the time and expense that went into identifying Yucca Mountain as the final site for a DGR, and into constructing an unfinished and politically unusable facility there, it is difficult to understand how siting and building multiple DGRs at an unknown future time is preferable to reducing the quantity of waste needing long-term disposal in the near future.

A practical strategy would be to work on building a DGR while at the same time supporting deployment of the advanced recycling technologies emerging from America's national labs, with the goal of transitioning toward full recycling of UNF and the recovery of U/TRU and surplus uranium. This approach would substantially reduce the volume of HLW requiring disposal and could thereby limit the quantity to what might be stored at a single site. It would thus offer significant long-term economic and societal benefits.

According to a 2021 study by the Organisation for Economic Co-operation and Development's Nuclear Energy Agency, a closed fuel cycle that combines multi-recycling with fast reactors reduces the volume of HLW requiring DGR disposal by 95%.[32] Notably, this study did not include the recovery of cesium and strontium isotopes, which have useful space and medical applications. Recovery of those isotopes would further reduce the volume of waste requiring permanent disposal and enhance repository management.

A major OECD Nuclear Energy Agency study--prior to recent technological advances--found that multiple approaches to recycling UNF could reduce volumes of conditioned HLW for disposal by over 80%.[33] As of the end of 2016, after 40 years of recycling its own annual inventory of UNF, France had accumulated just 3,650 m^3 of HLW.[34] France is planning to construct the Cigeo DGR in the eastern part of the country to hold 10,000 m^3 of HLW,[35] sufficient for many decades of nuclear power that will meet the majority of electricity demand in France. In comparison, without recycling, the US has already accumulated 94,000 MT of HLW intended for a repository that was designed to hold just 70,000 MT of HLW.

Recycling paired with advanced reactors would be a responsible component of an optimized waste solution, one that would enable the US to achieve substantial reductions in the volume of HLW requiring permanent disposal. A comprehensive US waste management policy that included recycling, particularly if colocated with interim storage or disposal facilities, would lower the cost of waste management for taxpayers. Some communities, especially those already hosting other nuclear sites and familiar with their safety, might compete to host such a facility, as it would be a meaningful source of well-paying jobs and tax revenue.

Enhanced proliferation resistance

Any nuclear facility (including nuclear reactors, on-site UNF dry cask storage and spent fuels, and recycling facilities) that handles enriched uranium, plutonium, and/or TRU elements in any form must establish robust material control and accountability (MC&A) protocols along with physical protection protocols to prevent proliferation, misuse, theft, or diversion of these materials. The Nuclear Regulatory Commission is responsible for this in the United States.

Internationally, the International Atomic Energy Agency (IAEA) has similar responsibilities for nuclear facilities in member states, and the NRC and IAEA have a strong decades-long history of cooperation on international safeguards and nuclear security. To date, there have been no confirmed instances of plutonium being diverted from domestic reprocessing plants, which is a testament to the robustness of the NRC and other U.S. oversight frameworks. Both domestic and international safeguards have been effective.

Setting aside the possible diversion of fissile materials, a US recycling program will not meaningfully help or encourage other nations seeking to develop nuclear weapons. A government decision to pursue a nuclear weapons program is not a casual one; on the contrary, it is among the most grave any leaders can take. The reasons for this are obvious—developing a nuclear weapons program carries risks including preventive attacks by established nuclear powers or non-nuclear rivals, punitive economic sanctions, and other diplomatic, financial, and political costs. A private sector recycling effort in the United States—which will join existing government-led French and Russian recycling—will not change this. In fact, US abstention from recycling has visibly not discouraged other nuclear weapons states from using the technology and does not seem likely to do so, especially in an era of escalating geopolitical tension. That said, if US firms are able to develop cost-competitive technical approaches to recycling UNF, the United States government should ensure appropriate technology export controls.

The Idaho National Laboratory hosts a significant stockpile of used HEU fuel from naval reactors and other sources that awaits disposal in a geologic repository. Recycling also presents the opportunity to use these valuable materials as fuel in advanced reactors, which would remove the proliferation and security risks associated with storing the material while harnessing its energy content.

The mixed actinide U/TRU recovered from UNF could, theoretically, be further processed to isolate plutonium for misuse. However, theft or diversion of such materials, for which robust MC&A and physical protection measures are legally mandated, would be inefficient, technically complicated, and impractical, since an entity capable of carrying out diversion would likely be able to produce weapons-grade material more easily by other means.

Recommendations

While President Donald Trump's recent executive orders signal potential support for UNF recycling, additional policies could further accelerate and enable recycling:

- **Adopt a national policy statement in support of nuclear fuel recycling** that builds upon the content of Executive Order 14302 (Reinvigorating the Nuclear Industrial Base) and is similar to the 2001 National Energy Policy administered by the Bush administration.[36] This would provide strong signals to DOE, industry, and investors to accelerate commercial recycling efforts.
  The Global Nuclear Energy Partnership (GNEP), which was a product of the National Energy Policy, galvanized interest and investment in recycling. After GNEP's establishment in 2006, several entities interested in commercial recycling via the public-private partnership established by DOE's Office of Nuclear Energy submitted letters of interest or support to both the NRC and DOE. In addition to collaborations between DOE and industry, the NRC began an accelerated parallel effort in consultation with DOE to develop an efficient regulatory framework for recycling facilities in anticipation of future license applications. Though the succeeding administration ended GNEP and thus eroded interest in pursuing commercial recycling, this history illustrates how national policy can encourage private sector investment.
- **Develop a comprehensive, integrated, long-term nuclear waste strategy** that incorporates recycling. A nuclear waste road map would restore public trust in the government's ability to meet its obligations and would advance nuclear energy domestically. Commercial UNF recycling, once established, could reduce HLW volume and aid in DGR management over time—but recycling alone is not intended to be the sole solution to permanent waste disposal. It can reduce the waste burden and thus improve the feasibility of DGR, but both recycling and DGR are critical elements of a comprehensive waste strategy.
- **Support construction of production-scale commercial recycling facilities** by adopting various measures, such as increasing congressional funding for the DOE Office of Nuclear Energy, incorporating DOE Office of Energy Dominance Financing financing guarantees for recycling facilities, issuing DOE service contracts to companies for UNF recycling services, and providing tax credits or other incentives for utilities that recycle UNF. Given that the federal government is responsible for the long-term disposal of commercial UNF, federal support could, at a minimum, be tied to the expected savings to the government in reduced disposal costs from recycling UNF.
- **Update the legislative framework for recycling**, such as the Atomic Energy Act of 1954 (AEA) and the Nuclear Waste Policy Act, to support current and pending recycling technology and its applications. Careful, targeted modernization of this framework could be important. For example, when the Atomic Energy Act was passed in 1946 and amended in 1954, all recycling facilities were designed to recover weapons-grade pure plutonium in quantities of "significance to the common defense and security, or in such manner as to affect the health and safety of the public."[37] The Act accordingly considered any recycling facility to be a plutonium production facility, and the US government provided licenses to commercial recycling facilities on that basis. In contrast, new advanced recycling facilities may not recover pure plutonium and would not

pose the same safety and environmental risks as older recycling facilities; consequently, they do not need to be licensed in the same manner. The proposed REFUEL (Recycling Efficient Fuels Utilizing Expedited Licensing) Act seeks to address this issue.

Conclusion

The current nuclear industry landscape is ripe for restarting commercial recycling and closing the domestic nuclear fuel cycle. Multiple US recycling companies are pursuing commercial recycling to bolster the economic fuel supply for reactors, extract valuable radionuclides, and reduce the waste disposal needs of nuclear power. Each of these companies is proposing modern, advanced recycling techniques that have simpler flowsheets and footprints, are more resistant to proliferation, and should prove more economical than the current legacy large-scale PUREX recycling facilities in operation internationally.

The Trump administration should take the lead in enabling the transition to the first fully-closed fuel cycle in the world in which uranium and TRU elements are recycled. National policy should support advanced recycling as part of a comprehensive waste strategy, with clearly defined near-term actions and funding. Congress should consider modernizing legislation such as the Atomic Energy Act to account for modern recycling technologies—a step that would facilitate efficient licensing of recycling facilities.

Policies to support a strong US domestic recycling capability are a key component of a broader national strategy to reestablish American leadership in civilian nuclear energy markets. The strategic, energy, and economic benefits of such leadership would be considerable—as would be the costs of failing to secure it.

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Dr. Christina Leggett is the Director of Fuel Cycle Technology at Oklo Inc. In this role, she oversees the team that is designing Oklo's Fuel Recycling Facility, which will be sited in Oak Ridge, TN. Prior to working at Oklo, she was a lead engineer at Booz Allen Hamilton, where she worked as a nuclear technology advisor for the Department of Energy's (DOE's) Advanced Research Projects Agency-Energy (ARPA-E). In this role, she served as the lead technical advisor for the ARPA-E CURIE program, which focused on enabling the economic and secure recycling of the Nation's existing used nuclear fuel; supported the development and implementation of several ARPA-E nuclear programs, most notably the ONWARDS and NEWTON programs focused on reducing advanced reactor and fission product waste; and provided technical oversight for approximately two dozen ARPA-E-funded nuclear fission and fusion projects. Dr. Leggett also worked as a federal program manager in the DOE Office of Nuclear Energy and as a nuclear engineer and reactor systems engineer at the US Nuclear Regulatory Commission. She holds a Ph.D. in nuclear engineering from the University of California-Berkeley and is very passionate about UNF recycling coupled with advanced reactors as an integral part of a sustainable nuclear future and mentoring the next generation of nuclear professionals. She is also very active in the American Nuclear Society (ANS), having served on the ANS Board of Directors and as Chair of the Fuel Cycle and Waste Management Division.

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Thernstrom's writing has been published in the *Wall Street Journal*, *Washington Post*, *Los Angeles Times*, *The New Republic*, *The American*, *The Hill*, *Bloomberg*, and nytimes.com, and he has appeared on ABC News, BBC News, CNN, Fox News, MSNBC, NPR, *The News Hour with Jim Lehrer* on PBS, and the *Daily Show with Jon Stewart*.

Thernstrom holds a Bachelor of Arts degree from Harvard University.

Endnotes

1 Types of advanced reactors include non–light water reactors and small modular reactors. For more information, see US Nuclear Regulatory Commission, “New Reactors,” https://www.nrc.gov/reactors/new-reactors/advanced.

2 High-assay low-enriched uranium (HALEU) is uranium whose U-235 content ranges from 5% to approximately 19.75%. Existing commercial nuclear reactors generally use low-enriched uranium (LEU), with U-235 content between 3% and 5%; the amount of U-235 in natural uranium is usually only about 0.7%. Highly enriched uranium (HEU) has over 20% U-235; weapons-grade HEU is usually over 90% U-235. See Nuclear Innovation Alliance, “Advanced Nuclear Reactor Technology—A Primer,” November 2024, https://nuclearinnovationalliance.org/sites/default/files/2024-11/Primer%20-%202024.pdf.

3 Transuranic elements are actinide elements on the periodic table that are heavier than uranium. For the purposes of this white paper, these elements include neptunium, plutonium, americium, and curium.

4 Russian uranium imports are banned under the Prohibiting Russian Uranium Imports Act of 2024. See Congress.gov, https://www.congress.gov/bill/118th-congress/house-bill/1042/text.

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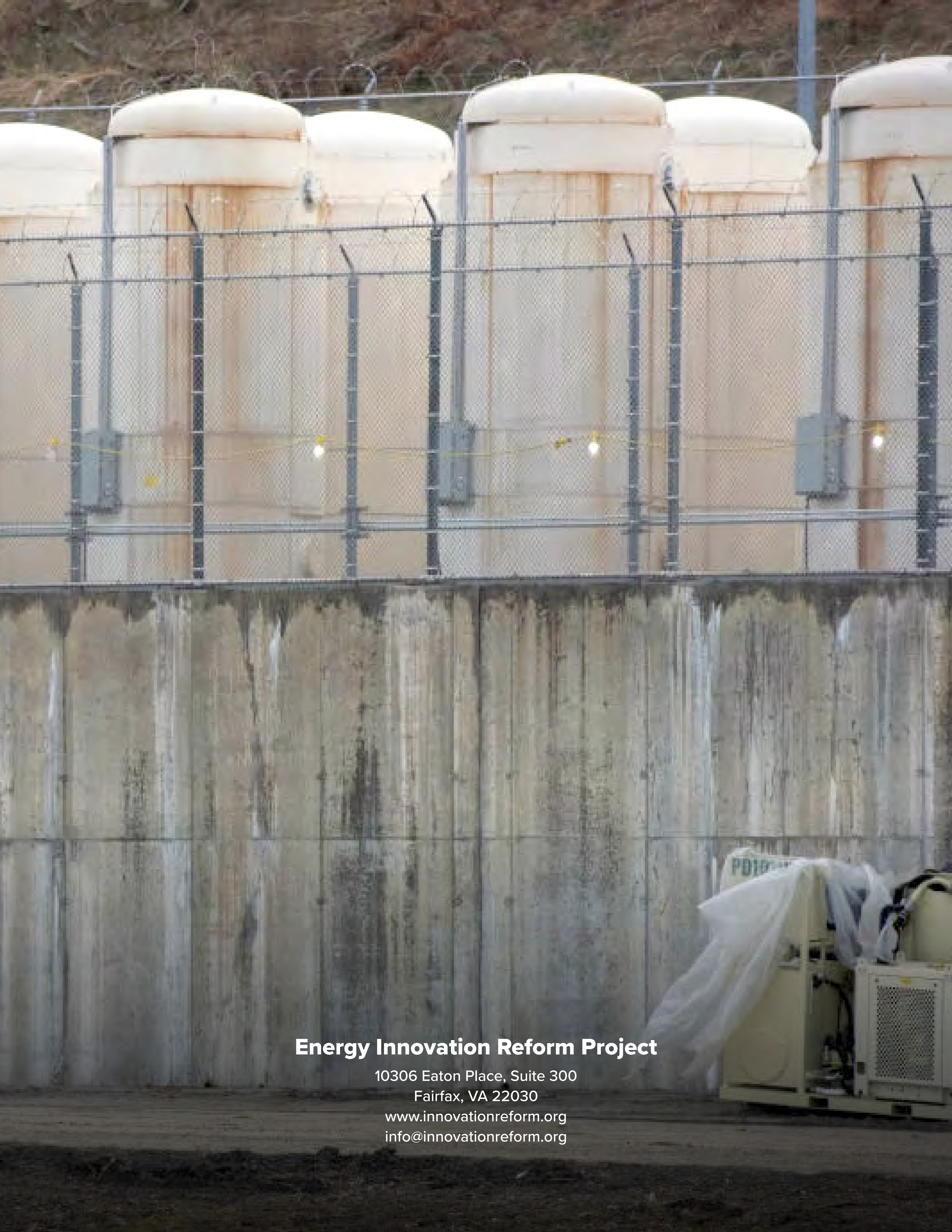

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