John C Wagner - House Energy and Commerce Committee - April 10, 2024

American Nuclear Energy Expansion: Spent Fuel Policy and Innovation Hearing Testimony Summary

Our nation's nuclear reactor fleet generates the nation's most reliable and resilient electricity, providing 24/7 power. Last year, 92 reactors generated nearly 20% of America's electricity and roughly half the nation's carbon-free electricity. America's nuclear industry is poised to play a leading role in the global expansion of nuclear energy. America's nuclear innovators are partnering with our national laboratories to develop and deploy advanced nuclear reactors and related technologies to usher in a new era of economic prosperity and environmental stewardship.

At the same time, our nation has an obligation to address its nuclear-waste management responsibilities. We have the technical capacity and knowledge to manage spent nuclear fuel responsibly and safely – and are doing so today at the current and former nuclear power generation sites, but that is not a permanent solution. The present nuclear-waste stalemate inhibits the U.S. nuclear industry from fully meeting the challenges of today and tomorrow.

The important question of how we manage our nation's spent nuclear fuel is guided by policies enacted decades ago. Those policies no doubt reflected the national priorities and concerns of the time. The questions for this subcommittee, and for our nation as a whole, are whether those policies continue to reflect our nation's priorities and if they enable or impede the development and deployment of the advanced nuclear technologies our nation needs.

Even though it no longer violates U.S. policy to commercially recycle nuclear fuel, no commercial nuclear fuel recycling occurs in the United States because the once-through fuel cycle is considered the cheaper option for obtaining nuclear fuel, and the Nuclear Waste Policy Act provides no financial incentives or mechanisms for reprocessing. Consequently, our nation lacks the commercial infrastructure required to recycle spent fuel.

Nuclear power is set to play a vital role in and the world's energy future by providing abundant, reliable, and resilient energy without carbon emissions. The important work of revising our spent-fuel management policies cannot come at the expense of advanced-reactor development and deployment.

TESTIMONY OF DR. JOHN C. WAGNER

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BEFORE THE UNITED STATES HOUSE COMMITTEE ON ENERGY AND COMMERCE ENERGY, CLIMATE, AND GRID SECURITY SUBCOMMITTEE

"AMERICAN NUCLEAR ENERGY EXPANSION: SPENT FUEL POLICY AND INNOVATION."

April 10, 2024

Chair Rodgers, Ranking Member Pallone, Subcommittee Chair Duncan and Ranking Member DeGette, and members of the subcommittee, thank you for your interest in this topic and for the opportunity to be here today. My name is John Wagner, and I am the director of the Idaho National Laboratory (INL), the nation's nuclear energy research and development center. In this role, I lead a United States (U.S.) Department of Energy (DOE) national laboratory with approximately 6,100 scientists, engineers and support staff, multiple nuclear and nonnuclear experimental facilities, and an annual budget of more than $1.8 billion, with a mission focused on nuclear energy, national and homeland security, and energy and environmental science and technology.

To give you some idea of background expertise relevant to this hearing, I hold a Bachelor of Science degree in nuclear engineering from the Missouri University of Science and Technology and Master of Science and Doctorate degrees in nuclear engineering from the Pennsylvania

State University. Throughout my career, I have been intimately involved in technical issues related to the nuclear fuel cycle. My first position following graduate school was with a private company designing and licensing spent nuclear fuel storage and transportation systems. Later, during my employment at Oak Ridge National Laboratory (ORNL), I supported the DOE and the Nuclear Regulatory Commission (NRC) on a variety of technical issues related to long-term storage, transportation, and disposal of spent nuclear fuel, including serving as the national technical director of the DOE's Nuclear Fuels Storage and Transportation Planning Project—a project established to implement the recommended near-term actions in the Blue Ribbon Commission on America's Nuclear Future (BRC) report, and to lay the groundwork for implementing interim storage, including associated transportation. While at ORNL, I held various positions of increasing responsibility, ultimately serving as director of the Reactor and Nuclear Systems Division. In February 2016, I joined INL as the chief scientist for the Materials and Fuels Complex before becoming the associate laboratory director for the Nuclear Science and Technology Directorate. I have authored or co-authored more than 170 refereed journal and conference articles, technical reports, and conference summaries. I am a fellow of the American Nuclear Society and the American Association for the Advancement of Science.

Thank you for this opportunity to discuss the nuclear fuel cycle, and more specifically, challenges and opportunities associated with spent nuclear fuel management in the context of nuclear energy expansion. This is a timely issue of great importance to our nation and the world as we seek to expand the use of nuclear energy. Just last month more than 30 nations gathered in Brussels for the first ever Nuclear Energy Summit. There, they pledged support for "unlocking the potential of nuclear energy." I want to thank the members of this subcommittee, including our own Rep. Fulcher of Idaho, for your longstanding and unwavering support for the U.S. commercial nuclear industry and for helping maintain and expand America's global leadership in nuclear technology.

Background

As we speak, our nation's nuclear reactor fleet is excelling. It generates the nation's most reliable and resilient electricity, providing 24/7 power to American homes, hospitals, schools, businesses, and critical industries. Last year, 92 reactors generated nearly 20% of America's electricity and roughly half the nation's carbon-free electricity. With Vogtle Unit 3 coming online last year, Vogle Unit 4 synchronizing and connecting to the electric grid for the first time in February, and several advanced-reactor projects progressing, nuclear energy is positioned to play an increasingly important role in America's energy future. In fact, the U.S. recently led a group of 24 countries calling for the tripling of global nuclear capacity by 2050. America's nuclear industry is poised to play a leading role in this global expansion of nuclear energy. But we face stiff competition from state-owned entities, including those in Russia and China.

As we speak, America's nuclear innovators are partnering with our national laboratories to develop and deploy advanced nuclear reactors and related technologies to usher in a new era of economic prosperity and environmental stewardship. Our nation moves forward, driven by technological advancements not envisioned during prior generations.

And yet, the important question of how we manage our nation's spent nuclear fuel is guided by policies enacted decades ago. Those policies no doubt reflected the national priorities and concerns of the time. The questions for this subcommittee, and for our nation as a whole, are whether those policies continue to reflect our nation's priorities and if they enable or impede the development and deployment of the advanced nuclear technologies our nation needs.

Before we discuss those policies, I would like to address the need for advanced nuclear technologies and the growing realization that nuclear must contribute an increasingly significant portion of the world's energy generation.

Bisconti Research, Inc., which has been tracking public sentiment on nuclear energy since 1983, found that 76% of the U.S. public supports nuclear energy for electricity generation, 86% believe it will play a crucial role in future energy needs, 87% advocate for preparations to ensure the availability of advanced reactors, and 71% express a definite interest in constructing more nuclear power plants.

This is reflected in policies enacted in recent years by Congress and efforts taking place today in states across the nation to enable advanced nuclear technology deployment. A great example of this is TerraPower's Natrium project in Wyoming, which will be built at a site where the coal plants are scheduled to retire. These sites often have a capable and supportive workforce and existing infrastructure like transmission and distribution infrastructure that can be repurposed. The company reached an important milestone when it submitted its construction application to the NRC on March 29, bringing closer to fruition the nation's first commercial Natrium sodium-cooled reactor.

Industry giants and major energy users such as Dow Chemical, Nucor, Amazon Web Services, Meta, Google, and Microsoft are increasingly turning to nuclear to secure uninterrupted, carbon-free power for their operations. Longtime nuclear leaders, like Westinghouse, General Electric, and Southern Company, and a growing number of nuclear startups are collaborating with national laboratories on innovative reactor designs, fuel development, and associated technologies to address an expanding variety of energy use-cases.

The Nuclear Energy Institute recently conducted a survey among 19 member companies operating 80 nuclear reactor facilities in the U.S. These industry leaders projected a need for over 100 gigawatts of new nuclear power—an effective doubling of domestic nuclear capacity—by 2050 to support decarbonization efforts. This translates to approximately 100 new large light-water reactors (LWRs) or 330 new small modular reactors (SMRs) within the next 25 years. Finally, a U.S. Department of Energy "Liftoff Report" identified the need to triple the amount of nuclear energy by 2050 to meet carbon reduction goals.

Our nation is making a conscious decision to move forward with nuclear energy. However, we continue to be guided by outdated polices concerning spent fuel management and disposition.

Let's begin with the Nuclear Waste Policy Act (NWPA).

Enacted in 1982 and amended in 1987, the NWPA guides our nation's spent-fuel management responsibilities. However, opposition by the state of Nevada to the Yucca Mountain project halted progress, and U.S. nuclear-waste management policy is in limbo until the NWPA is amended, a new policy is enacted, or the federal government can reach a consent agreement with Nevada. There have been various attempts to amend the NWPA to better reflect today's nuclear waste management realities, policies, and needs, but none has been successful. DOE is attempting to move forward with consolidated interim storage of spent nuclear fuel, but has limited authority to do so. In addition, multiple private companies are pursuing private storage facilities, but those efforts in Texas and New Mexico face legal challenges driven by opposition in those states.

Our nation has an obligation to address its nuclear-waste management responsibilities. We have the technical capacity and knowledge to manage spent nuclear fuel responsibly and safely – and are doing so today at the current and former nuclear power generation sites, but that is not a permanent solution. The present nuclear-waste stalemate inhibits the U.S. nuclear industry from fully meeting the challenges of today and tomorrow. More on that later. First, let's address our nation's policy on nuclear-fuel recycling.

The U.S. originally intended to recycle nuclear fuel, thereby "closing" the nuclear fuel cycle. Recycling was envisioned as the prudent and sustainable option given the anticipated high growth in nuclear energy and concerns about uranium supply. The Nuclear Fuel Services Company initiated domestic commercial nuclear-fuel recycling in the mid-1960s in West Valley, New York. However, America's commercial nuclear fuel recycling industry was short lived.

In 1974, India tested a nuclear device, which exacerbated proliferation concerns related to the potential diversion of recycled plutonium from commercial fuel.

In 1976, President Ford deferred plans for commercial nuclear-fuel recycling due to uncertainties associated with technical feasibility and proliferation concerns.

A year later, President Carter announced that the U.S. would indefinitely defer the reprocessing of spent nuclear fuel. Thereby changing the U.S. nuclear fuel cycle approach from being "closed" to being "once-through", also referred to as "direct disposal". While the U.S. stood down and sponsored an international examination of alternate fuel cycles, other nations went ahead with reprocessing and breeder-reactor (a reactor that generates more fissile material [fuel] than it consumes) development.

In 1981, President Reagan lifted the indefinite ban on reprocessing activities, but that action did not yield results, and the NWPA of 1982 assigned DOE responsibility for disposing of commercial spent fuel, essentially eliminating industry's incentive to reuse fissile materials. And the anticipated limited growth for nuclear at the time was not expected to challenge uranium supplies.

In 2023, President Biden signed National Security Memorandum 19, which states that it is the policy of the United States to: "Refrain from the use of weapons-usable materials in new civil reactors or for other civil purposes unless that use supports vital U.S. national interests."

A full history of America's evolving nuclear fuel recycling policy is included as Appendix A.

Even though it no longer violates U.S. policy to commercially recycle nuclear fuel, no commercial nuclear fuel recycling occurs in the United States because the once-through fuel cycle is considered the cheaper option for obtaining nuclear fuel, and the NWPA provides no financial incentives or mechanisms for reprocessing. Consequently, our nation lacks the commercial infrastructure required to recycle spent fuel. Meanwhile, DOE continues reprocessing and recycling DOE-owned nuclear materials for various applications using limited and aging infrastructure.

Regarding regulatory activities, the NRC started developing a framework for commercial nuclear fuel recycling in 2013, driven by industry interest. NRC suspended this rulemaking in 2021 due to lack of continued concern from the nuclear industry. However, recently renewed interest from companies such as Oklo and Curio—plus a joint announcement between Orano and SHINE to establish commercial nuclear fuel recycling facilities—reignited discussions regarding the licensing approach for such facilities.

In terms of international policy, while the U.S. initially terminated its commercial recycling program with the belief that such actions would persuade other nations to follow suit, that has not been the case. Other nations have moved forward with their recycling programs.

France developed its recycling capability and uses recycled fuel in its LWRs. France envisions a future with closed fuel cycles powering advanced reactors. Japan uses recycled fuels obtained from materials processed in France and the United Kingdom and is developing its own domestic recycling infrastructure. State-owned entities in China and Russia recycle fuel and offer their services to other nations. Russia and China use nuclear energy to establish century-long relationships with countries around the world. Because they are state-owned, Russian and Chinese companies can offer comprehensive "build, own, operate" packages to countries seeking to enter the nuclear market. These offerings also typically include fuel takeback and/or fuel recycling. The United States' inability to provide comprehensive services for spent fuel from internationally deployed reactors places our nuclear-industry vendors in a competitive disadvantage, making it more difficult for our nation to maintain the non-proliferation and safety standards we have advocated around the world.

With this background in mind, I would like to address four questions relating to our nation's spent fuel management, our recycling capabilities, and the benefits of recycling, as well as our need to develop and deploy advanced nuclear technologies.

1. *Should we update our nuclear-waste management policies to reflect the realities of today and needs of tomorrow?*

Simply put, yes, Congress and the executive branch should work together to address America's nuclear-waste stalemate. This is not only an issue for the nuclear industry, but also for U.S. taxpayers.

In the early 1980s, consistent with the NWPA, the federal government decided to consolidate all accumulated spent nuclear fuel at a single national repository at Yucca Mountain in Nevada. When DOE decided to terminate the Yucca Mountain project in 2010, more than $12 billion in federal funds had already been spent on the project. Additionally, between $400 and $800 million in civil damages are now paid annually to utilities to offset their costs for on-site spent nuclear fuel storage. The federal government will continue paying on average $1-2 million per day in civil damages to electric utilities until the nuclear-waste stalemate is resolved.

The near-term deployment of consolidated interim storage would be a useful component of an integrated waste-management system, but the need for deep-geologic-disposal capacity remains.

Congress directed DOE to use a consent-based siting approach in the pursuit of federal, consolidated interim storage for the nation's spent nuclear-fuel inventory. However, federal interim storage facilities of sufficient capacity cannot be constructed without revising the NWPA to remove the prerequisite for repository-construction authorization and inadequate capacity limits.

While recycling of advanced-reactor spent fuels is certainly possible and even anticipated for some designs, the fact remains that there will always be a need for deep-geologic-disposal capacity. In the United States, as in the rest of the world, deep geologic disposal of spent nuclear fuel and/or high-level waste is the long-term endpoint, and the time has come to move forward.

To provide for the fulfillment of our legacy spent-fuel management responsibilities, and to fully realize the potential of our existing and future nuclear energy systems we must have a functioning nuclear-waste-management policy framework.

Addressing our nuclear-waste management obligations would boost public confidence in the nuclear energy industry and offer certainty to plant operators, utilities, and the communities where spent fuel is being safely stored.

Private-sector companies contemplating investments in nuclear energy find themselves in a difficult situation. More certainty in the back end of the fuel cycle, including a sustainable path forward in nuclear-waste management and a consistent and lasting policy on nuclear fuel recycling, would inspire additional innovation and investment in nuclear energy.

As the nation's nuclear laboratory, we contribute to the *technology* for interim storage, recycling, and geologic disposal, and *inform* the policy debates thereof. But the eventual resolution of those longstanding debates will require direction and associated funding that only Congress can provide.

2. *What role could nuclear fuel recycling play in the United States?*

The two primary motivations for recycling spent nuclear fuel are: 1) improved fuel resource utilization and 2) reduction in waste volume and corresponding geologic repository requirements.

Commercial spent LWR fuel contains about 96% of its original uranium. The remaining approximately 4% includes about 3% waste products and 1% plutonium produced while the fuel is in the reactor. In the once-through fuel cycle, reactors consume approximately 1% of the original mined uranium. By simply recovering uranium and plutonium from the spent LWR fuel and recycling them into fresh fuel, as is currently done in France, the amount of natural uranium needed to make LWR fuel can be reduced by up to 30%.

Recycling increases uranium utilization, thereby reducing mining and enrichment needs. Fuel cycles that involve fast reactors and continuous recycling increase uranium usage in a closed loop that consumes up to 99% less uranium and produces up to 95% less high-level waste than the open-ended once-through cycle. However, no fuel cycle will completely eliminate the need for a geologic repository, nor are they likely to eliminate the need for sustained uranium extraction, especially considering the anticipated global growth of nuclear energy.

Many different fuel recycling[i] scenarios have been analyzed; historically, the following benefits of recycling are generally agreed upon.

U.S. competitiveness: Recycling enhances the global competitiveness of U.S. nuclear-industry vendors in relation to other state-owned (e.g., Chinese and Russian) enterprises that offer comprehensive fuel services.

Global nuclear leadership: Recycling would expand U.S. leadership and influence in the global nuclear market, which is important to our nation's efforts to sustain the non-proliferation and safety norms it advocates around the world. This would also establish long-lasting state-to-state relationships that span decades.

Resource utilization: As the world expands its use of nuclear energy, demands on uranium resources will increase, making nuclear fuel recycling a more attractive option, in combination with sustained uranium extraction and related conversion and enrichment to ensure long-term fuel availability.

Waste management: Nuclear fuel is designed for reactor performance, not long-term geologic performance. Waste forms resulting from recycling are designed for long-term stability over tens of thousands of years; this offers disposal-management benefits. Also, recycling plutonium and americium into fuels for fast-spectrum reactors, rather than sending them to a repository, would significantly reduce the long-term heat load, thereby supporting more-efficient waste emplacement in a geologic repository.

In addition to the aforementioned benefits, we are observing a paradigm shift in public perceptions and support of nuclear fuel recycling. This shift introduces additional motivation for considering nuclear fuel recycling in the U.S. Emerging factors, and the need to consider a wholistic socioeconomic evaluation, and not just simple supply-and-demand economics, warrant a renewed consideration of the merits of domestic nuclear fuel recycling.

First, there is growing demand for nuclear energy – highlighted recently by the COP28 call led by the U.S. and more than 20 other countries—to triple nuclear capacity by 2050. In addition, advanced nuclear fuels using higher enrichments are being pursued to fuel existing and advanced reactors. These more-highly enriched fuels are expected to make nuclear fuel recycling more economical.

Additionally, there is a growing need for isotopes for medical, industrial, and innovative energy applications, some of which could be extracted from spent nuclear fuel. Considering these and other factors, a fresh look at commercial nuclear fuel recycling may be warranted.

Now, let's talk about the recycling research being conducted at INL.

From recovering high-assay, low-enriched uranium (HALEU) from DOE-owned fuels and scrap materials to ensuring the availability of special nuclear materials and strategic isotopes, INL excels at the development of economic recycling and treatment concepts aimed at reducing proliferation risk and minimizing waste.

Examples of INL's fuel-recycling-related research, development, and demonstration (RD&D) efforts include:

- **Interim supply of HALEU:** By using pyrochemical separation techniques to process Experimental Breeder Reactor (EBR)-II spent fuel, INL recovers the remaining highly enriched uranium (HEU) and downblends it to HALEU metal in support of advanced-reactor demonstrations. INL demonstrated further cleaning of the recovered metal product and conversion to oxide fuel, which is needed by some advanced-reactor vendors. The accelerated processing of EBR-II spent fuel to meet near-term HALEU needs also benefits environmental-management objectives by accelerating the processing of this material by six years. Significant additional HALEU supply could be provided by recovering uranium from other DOE-owned irradiated fuels, such as from the Advanced Test Reactor.

- **Downblending:** INL is demonstrating an advanced process that enables recovery and downblending of HEU from spent research reactor fuels such as INL's Advanced Test Reactor. This process offers the additional benefit of reducing proliferation risk by downblending HEU to HALEU prior to product recovery.
- **Recycling technologies:** INL develops and demonstrates recycling technologies that do not separate pure plutonium using advanced aqueous and electrochemical processing. INL also leads the development and implementation of advanced safeguards-and-security approaches tailored to reprocessing technologies, advanced-reactor designs, and their associated fuel cycles.
- **Fuel-cycle RD&D testbeds:** INL testbeds serve as user facilities that support multiple diverse programs and mission-partner agencies.

3. *What could we do to enhance U.S. recycling capabilities?*

The United States' global leadership position in the area of nuclear energy has been eroding for decades, primarily due to our inability to compete with state-owned enterprises that provide comprehensive fuel services, including recycling. In the meantime, countries such as France, Russia, China, and India continue to develop and influence the nuclear fuel cycle. Opportunities to address America's fuel-cycle and waste-management challenges include:

- **Integrated Policy Framework:** A clear, cohesive, and lasting federal policy on commercial nuclear fuel recycling that balances non-proliferation, energy independence/security, global competition interests, as well as socioeconomic benefits of commercial nuclear-fuel recycling would reduce uncertainty around continued nuclear investment and could contribute to finally addressing the federal government's responsibility to manage nuclear waste.

- **Innovation:** Sustained funding support could be provided to continue existing activities and support expanded RD&D and related coordination of nuclear-fuel-recycling RD&D programs across DOE, including for activities that support development of advanced technologies for commercial applications, international nuclear non-proliferation programs, and environmental management missions. In addition, recycling spent fuels from advanced reactors may require novel methodologies and technologies to enact proper safeguards, including nuclear-material control and accountancy.
- **Nuclear Workforce and Supply Chain Proficiencies:** Domestic spent-fuel recycling proficiency should be revitalized to enhance U.S. global competitiveness. Continued investments are needed to develop expertise and enable infrastructure to support the recovery, reuse, and repurposing of recycled nuclear products in collaboration with industry.
- **Regulatory Framework:** A decision should be made regarding the regulatory approach for commercial recycling facilities, as was recently done for anticipated fusion facilities. While a completely new regulatory framework may not be needed to license nuclear-fuel recycling, changes to existing frameworks, such as updating Part 70, may be needed.
- **Competitiveness:** Economic models and technology options should be developed that allow U.S. nuclear industry vendors to provide competitive comprehensive fuel services in the

global market. This will require political and multi-agency policy support, as well as subject-matter experts with economic, policy, and industrial backgrounds.

Recycling spent fuel would enhance U.S. global leadership, strengthen the U.S. fuel supply chain, including our needs pertaining to HALEU, and enhance the private-public partnerships that facilitate the development and deployment of innovative technologies. Importantly, recycling would help build our nuclear infrastructure by establishing processes that reduce costs, waste, and proliferation risks.

4. *How do we balance spent-fuel management and disposition with the need to develop and deploy advanced reactors?*

The United States has been safely managing and storing spent fuel for decades. We know what we're doing. And while this does not alleviate the need for a national repository, modernized waste management policies, or changes to our approach on recycling, it would be counterproductive to delay advanced-reactor development while formulating new fuel-management and disposition policies.

As I previously mentioned, the world needs a significant expansion of nuclear energy in the coming decades. That's why INL is working with such urgency. We know the clock is ticking. We know industry needs advanced nuclear technologies to meet domestic and global demand. That's why, with support from Congress, DOE, and our industry partners, we have laid out an aggressive advanced reactor demonstration timeline.

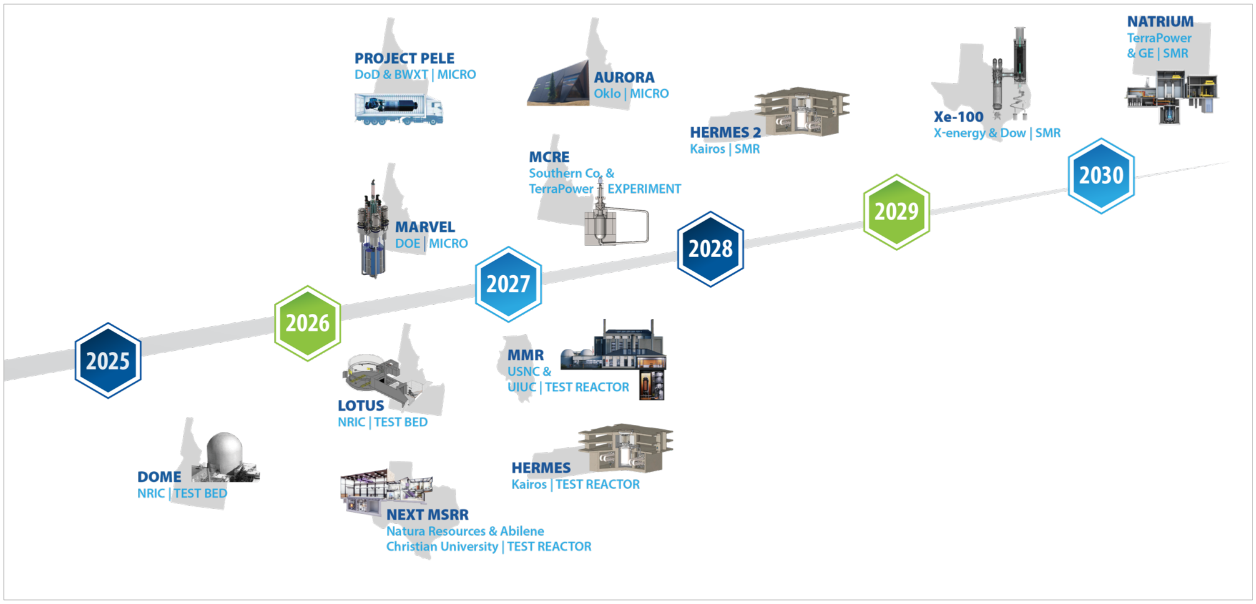

Figure 1: A timeline of advanced reactor demonstration and deployment projects.

That begins with MARVEL, an 85 kW DOE test reactor that will reestablish our ability to execute novel reactor projects. MARVEL will provide an important R&D platform for industry to support the use of microreactors for a variety of potential applications, while providing information to support licensing, environmental assessments, improved performance, and deployments.

Next up will be PELE, a partnership with the U.S. Department of Defense and BWXT that will help our armed forces reduce their dependance on diesel fuel. PELE will pave the way for small, advanced reactors for other military applications, as well as for private sector uses.

INL, working with Southern Company and TerraPower, is making progress on the Molten Chloride Reactor Experiment (MCRE), which will become the world's first fast-spectrum molten salt system to achieve criticality.

These first three systems will use DOE safety-authorization authorities, as opposed to NRC licensing. The first planned NRC-licensed reactor on the INL Site is the Oklo Aurora microreactor, which by the way is enabled by using the HALEU material that is being recovered from EBR--II spent fuel discussed earlier.

Many reactor projects will follow, demonstrating a variety of technologies for a variety of applications. These include the TerraPower Natrium Reactor in Wyoming, which will repower a retiring coal plant, and the X-energy Reactor to be deployed in Texas by Dow Chemical to support decarbonization of the energy-intensive industrial sector. Further, myriad additional reactor-demonstration projects have not yet reached the level of maturity to satisfy our criteria for inclusion on our timeline, but will in time.

Nuclear power is set to play a vital role in the world's energy future by providing abundant, reliable, and resilient energy without carbon emissions. I say all this because the important work of revising our spent-fuel management policies cannot come at the expense of advanced-reactor development and deployment.

At INL, we conduct the science needed to usher in a new era of nuclear energy. Just as we did in the past, with the 52 test reactors on the INL Site, we will work with industry to develop and demonstrate these advanced technologies to enable deployment.

The future of nuclear energy is small, medium, and large. It is flexible, resilient, and reliable. Reactors of all sizes and fuel types will be used to stabilize the grid with 24-7-365 electricity and to power clean industrial, transportation, and manufacturing processes.

I appreciate the opportunity to be a part of this important process, and I want to thank the committee again for its attention to this important issue for our nation. I look forward to your questions.

Appendix A: U.S. Policy on Commercial Recycling Chronological Timeline

1964: Federal Law

- Public Law 88-489 amended the Atomic Energy Act of 1954 and authorized the Atomic Energy Commission (AEC) to issue commercial licenses to possess special nuclear material subject to specific licensing conditions. Law text: https://www.govinfo.gov/content/pkg/STATUTE-78/pdf/STATUTE-78-Pg602-2.pdf#page=4

1974: AEC Determination

- The AEC determined that any decision to permit nuclear-fuel reprocessing on a large scale would require an environmental impact statement under Section 101(2)(c) of the National Environmental Policy Act (U.S.C. 4332(2)(c)).

1976: Presidential Statement

- In a nuclear policy statement, President Ford announced his decision to delay commercialization of reprocessing activities in the United States until uncertainties were resolved. Statement text: https://www.nrc.gov/docs/ml1209/ML120960611.pdf

1977: Presidential Statement

- President Carter announced, "We will defer indefinitely the commercial reprocessing and recycling of plutonium produced in the U.S. nuclear power programs." Statement text: https://www.nrc.gov/docs/ML1209/ML120960615.pdf

1978: Federal Law

- The Nuclear Nonproliferation Act (P.L. 95-242) amended the Atomic Energy Act of 1954 to establish export-licensing criteria that govern peaceful nuclear exports by the United States, including restrictions on transfers of certain information related to enrichment, reprocessing, and heavy-water production (i.e., "sensitive nuclear technology"). The Act also includes a requirement of prior U.S. approval for retransfers and reprocessing and a guaranty that no material retransferred will be reprocessed without prior U.S. consent. Law text: https://www.govinfo.gov/content/pkg/STATUTE-92/pdf/STATUTE-92-Pg120.pdf#page=1

1981: Presidential Statement

- President Reagan announced that he was "lifting the indefinite ban which previous administrations placed on commercial reprocessing activities in the United States." Statement text: https://www.reaganlibrary.gov/research/speeches/100881b

1982: National Security Decision Directive 39

- President Reagan approved the United States Policy on Foreign Reprocessing of Plutonium Subject to U.S. Control as National Security Decision Directive 39. Although specific details of the directive have not been declassified, the policies approved pertain to the nonproliferation and statutory conditions for safeguards and physical security for a continued commitment by Japan to nonproliferation efforts. Text declassified in part: https://www.cia.gov/library/readingroom/docs/CIA-RDP10M02313R000100830001-8.pdf

1982 Nuclear Waste Policy Act, as amended in 1987.

- The language of the Act assumes reprocessing as an option since high-level waste is a byproduct of reprocessing.

1990: Federal Law

- In the National Defense Authorization Act for Fiscal Year 1991 (P.L. 101- 510, Sec. 3142 and 3143), Congress declared that "the United States is observing a *de facto* moratorium on the production of fissile materials" and "has ceased operation of all of its reactors used for the production of plutonium for nuclear weapons." The law also urged "an end by both the United States and the Soviet Union to the production of plutonium and highly enriched uranium for nuclear weapons." Bill text: https://www.congress.gov/bill/101st-congress/house-bill/4739/text

1992: Presidential Statement

- President G. H. W. Bush halted weapons reprocessing in a policy statement on nuclear nonproliferation, announcing his "decision not to produce plutonium and highly enriched uranium for nuclear explosive purposes." Statement text: https://www.govinfo.gov/content/pkg/PPP-1992-book1/html/PPP-1992-book1-doc-pg1110-2.htm

1992: Presidential Statement

- President G. H. W. Bush disapproved Long Island Power Authority's attempt to enter into a contract with the French firm Cogema to reprocess the slightly irradiated initial core from the decommissioned Shoreham reactor.
- https://crsreports.congress.gov/product/pdf/RS/RS22542 page 5

1993: Presidential Statement

- President Clinton issued a policy statement on reprocessing stating that "[t]he United States does not encourage the civil use of plutonium and, accordingly, does not itself engage in plutonium reprocessing for either nuclear power or nuclear explosive purposes. The United States, however, will maintain its existing commitments regarding the use of plutonium in civil nuclear programs in Western Europe and Japan." Fact sheet text: https://www.rertr.anl.gov/REFDOCS/PRES93NP.html

2001: National Energy Policy

- President Bush's National Energy Policy included the recommendation that "[t]he United States should also consider technologies (in collaboration with international partners with highly developed fuel cycles and a record of close cooperation) to develop reprocessing and fuel treatment technologies that are cleaner, more efficient, less waste intensive, and more proliferation resistant." Report: https://www.nrc.gov/docs/ML0428/ML042800056.pdf

2006: DOE Announcement

- President Bush proposed, and DOE announced the Global Nuclear Energy Partnership (GNEP), which included an effort to speed the deployment of commercial reprocessing in the United States, to support the safe, secure, and sustainable global expansion of nuclear power. DOE document: https://www.energy.gov/sites/prod/files/edg/news/archives/documents/GNEP/06-GA50035b.pdf

2009: Presidential Decision

- President Obama ends the environmental review that was to set the ground for future commercialization of nuclear reprocessing in the United States.

2016: Presidential Policy Directive

- PPD-42, *Preventing and Countering Weapons of Mass Destruction Proliferation, Terrorism, and Use*, is a comprehensive document that addresses proliferation, terrorism, and use of WMD and strengthening nonproliferation regimes and provides a framework for civil nuclear cooperation and countering WMD threats. PPD-42 provides detailed guidance on nuclear threat reduction, technologies, and capabilities to prevent and counter the proliferation and use of WMD, national technical nuclear forensics, and countering WMD terrorism.

2017–2022: ARPA-E Research and Development (R&D) Efforts

- ARPA-E established the Modeling-Enhanced Innovations Trailblazing Nuclear Energy Reinvigoration (MEITNER) Program to identify and develop innovative technologies that can enable designs for lower-cost, safer advanced nuclear reactors.[1]
- In 2019, ARPA-E launched the Generating Electricity Managed by Intelligent Nuclear Assets (GEMINA) Program to develop digital-twin technology for advanced nuclear reactors and transform operations and maintenance systems in the next generation of nuclear power plants.[1]
- Charged with providing "transformative solutions to improve the management, clean-up, and disposal of radioactive waste and spent nuclear fuel" by the 2019 ARPA-E Reauthorization Act, the agency, in May 2021,

launched the Optimizing Nuclear Waste and Advanced Reactor Disposal Systems (ONWARDS) Program to develop and demonstrate breakthrough technologies that will facilitate a 10x reduction.[1]

- In March 2022, ARPA-E rolled out the Converting UNF Radioisotopes Into Energy (CURIE) Program in order to develop innovative separations technologies, material accountancy, and online-monitoring technologies, as well as designs for a reprocessing facility that will enable group recovery of actinides for advanced-reactor feedstocks, incorporate *in situ* process monitoring, minimize waste volumes, enable a 1¢/ kWh fuel cost for AR fuels, and maintain disposal costs in the range of 0.1¢/kWh.[1]

2023: National Security Memorandum (NSM) 19

- In March 2023, President Biden signed NSM 19 to Counter Weapons of Mass Destruction Terrorism and Advance Nuclear and Radioactive Material Security.[1] The Fact Sheet discussing NSM 19 states, "…The Biden-Harris Administration is committed to managing the benefits of emerging technology for future peaceful applications with the proliferation risks of these technologies, and has established forward-looking U.S. policies that support enduring clean energy and nuclear material security goals while aggressively seeking to reduce the future production and accumulation of weapons usable materials worldwide." NSM 19 supports enduring clean energy and nuclear material security goals while aggressively seeking to reduce the future production and accumulation of weapons usable materials worldwide. NSM 19 establishes U.S. policy to refrain from the use of weapons-usable nuclear material in new civil reactors unless that use supports vital U.S. national interests. Hence the U.S. Government does not encourage commercial reprocessing but supports research and development. The NSM establishes the policy "... for securing radioactive materials, which present continuing domestic and global risk, along with new domestic guidelines for the management and security of nuclear material by prioritizing efforts to protect and permanently dispose of weapons-usable materials of greatest concern and transition from high-activity radioactive sources to alternative technologies when technically and economically feasible."

Appendix A: U.S. Policy on Commercial Recycling Chronological Timeline

1964: Federal Law

- Public Law 88-489 amended the Atomic Energy Act of 1954 and authorized the Atomic Energy Commission (AEC) to issue commercial licenses to possess special nuclear material subject to specific licensing conditions. Law text: https://www.govinfo.gov/content/pkg/STATUTE-78/pdf/STATUTE-78-Pg602-2.pdf#page=4

1974: AEC Determination

- The AEC determined that any decision to permit nuclear-fuel reprocessing on a large scale would require an environmental impact statement under Section 101(2)(c) of the National Environmental Policy Act (U.S.C. 4332(2)(c)).

1976: Presidential Statement

- In a nuclear policy statement, President Ford announced his decision to delay commercialization of reprocessing activities in the United States until uncertainties were resolved. Statement text: https://www.nrc.gov/docs/ml1209/ML120960611.pdf

1977: Presidential Statement

- President Carter announced, “We will defer indefinitely the commercial reprocessing and recycling of plutonium produced in the U.S. nuclear power programs.” Statement text: https://www.nrc.gov/docs/ML1209/ML120960615.pdf

1978: Federal Law

- The Nuclear Nonproliferation Act (P.L. 95-242) amended the Atomic Energy Act of 1954 to establish export-licensing criteria that govern peaceful nuclear exports by the United States, including restrictions on transfers of certain information related to enrichment, reprocessing, and heavy-water production (i.e., “sensitive nuclear technology”). The Act also includes a requirement of prior U.S. approval for retransfers and reprocessing and a guaranty that no material retransferred will be reprocessed without prior U.S. consent. Law text: https://www.govinfo.gov/content/pkg/STATUTE-92/pdf/STATUTE-92-Pg120.pdf#page=1

1981: Presidential Statement

- President Reagan announced that he was “lifting the indefinite ban which previous administrations placed on commercial reprocessing activities in the United States.” Statement text: https://www.reaganlibrary.gov/research/speeches/100881b

1982: National Security Decision Directive 39

- President Reagan approved the United States Policy on Foreign Reprocessing of Plutonium Subject to U.S. Control as National Security Decision Directive 39. Although specific details of the directive have not been declassified, the policies approved pertain to the nonproliferation and statutory conditions for safeguards and physical security for a continued commitment by Japan to nonproliferation efforts. Text declassified in part: https://www.cia.gov/library/readingroom/docs/CIA-RDP10M02313R000100830001-8.pdf

1982 Nuclear Waste Policy Act, as amended in 1987.

- The language of the Act assumes reprocessing as an option since high-level waste is a byproduct of reprocessing.

1990: Federal Law

- In the National Defense Authorization Act for Fiscal Year 1991 (P.L. 101- 510, Sec. 3142 and 3143), Congress declared that “the United States is observing a *de facto* moratorium on the production of fissile materials” and “has ceased operation of all of its reactors used for the production of plutonium for nuclear weapons.” The law also urged “an end by both the United States and the Soviet Union to the production of plutonium and highly enriched uranium for nuclear weapons.” Bill text: https://www.congress.gov/bill/101st-congress/house-bill/4739/text

1992: Presidential Statement

- President G. H. W. Bush halted weapons reprocessing in a policy statement on nuclear nonproliferation, announcing his “decision not to produce plutonium and highly enriched uranium for nuclear explosive purposes.” Statement text: https://www.govinfo.gov/content/pkg/PPP-1992-book1/html/PPP-1992-book1-doc-pg1110-2.htm

1992: Presidential Statement

- President G. H. W. Bush disapproved Long Island Power Authority’s attempt to enter into a contract with the French firm Cogema to reprocess the slightly irradiated initial core from the decommissioned Shoreham reactor. https://crsreports.congress.gov/product/pdf/RS/RS22542 page 5

1993: Presidential Statement

- President Clinton issued a policy statement on reprocessing stating that “[t]he United States does not encourage the civil use of plutonium and, accordingly, does not itself engage in plutonium reprocessing for either nuclear power or nuclear explosive purposes. The United States, however, will maintain its existing commitments regarding the use of plutonium in civil nuclear programs in Western Europe and Japan." Fact sheet text: https://www.rertr.anl.gov/REFDOCS/PRES93NP.html

2001: National Energy Policy

- President Bush's National Energy Policy included the recommendation that "[t]he United States should also consider technologies (in collaboration with international partners with highly developed fuel cycles and a record of close cooperation) to develop reprocessing and fuel treatment technologies that are cleaner, more efficient, less waste intensive, and more proliferation resistant." Report: https://www.nrc.gov/docs/ML0428/ML042800056.pdf

2006: DOE Announcement

- President Bush proposed, and DOE announced the Global Nuclear Energy Partnership (GNEP), which included an effort to speed the deployment of commercial reprocessing in the United States, to support the safe, secure, and sustainable global expansion of nuclear power. DOE document: https://www.energy.gov/sites/prod/files/edg/news/archives/documents/GNEP/06-GA50035b.pdf

2009: Presidential Decision

- President Obama ends the environmental review that was to set the ground for future commercialization of nuclear reprocessing in the United States.

2016: Presidential Policy Directive

- PPD-42, *Preventing and Countering Weapons of Mass Destruction Proliferation, Terrorism, and Use*, is a comprehensive document that addresses proliferation, terrorism, and use of WMD and strengthening nonproliferation regimes and provides a framework for civil nuclear cooperation and countering WMD threats. PPD-42 provides detailed guidance on nuclear threat reduction, technologies, and capabilities to prevent and counter the proliferation and use of WMD, national technical nuclear forensics, and countering WMD terrorism.

2017–2022: ARPA-E Research and Development (R&D) Efforts

- ARPA-E established the Modeling-Enhanced Innovations Trailblazing Nuclear Energy Reinvigoration (MEITNER) Program to identify and develop innovative technologies that can enable designs for lower-cost, safer advanced nuclear reactors.[i]

- In 2019, ARPA-E launched the Generating Electricity Managed by Intelligent Nuclear Assets (GEMINA) Program to develop digital-twin technology for advanced nuclear reactors and transform operations and maintenance systems in the next generation of nuclear power plants.[i]

- Charged with providing “transformative solutions to improve the management, clean-up, and disposal of radioactive waste and spent nuclear fuel” by the 2019 ARPA-E Reauthorization Act, the agency, in May 2021, launched the Optimizing Nuclear Waste and Advanced Reactor Disposal Systems (ONWARDS) Program to develop and demonstrate breakthrough technologies that will facilitate a 10x reduction.[i]

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