S. HRG. 118–4

THE NUCLEAR FUEL CYCLE

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED EIGHTEENTH CONGRESS

FIRST SESSION

MARCH 9, 2023

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THE NUCLEAR FUEL CYCLE

THURSDAY, MARCH 9, 2023

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The Committee met, pursuant to notice, at 10:03 a.m. in Room SD–366, Dirksen Senate Office Building, Hon. Joe Manchin III, Chairman of the Committee, presiding.

OPENING STATEMENT OF HON. JOE MANCHIN III, U.S. SENATOR FROM WEST VIRGINIA

The CHAIRMAN. The Committee will come to order.

Today we will be discussing the U.S. nuclear fuel life cycle and the issues that our Committee must work to address this Congress. With the passage of the Energy Act, Inflation Reduction Act, the Bipartisan Infrastructure Law, and the CHIPS and Science Act, Congress has authorized new programs and provided significant financial investments to ensure the continued operation of our current nuclear fleet and the development of the next generation of advanced reactors and technologies. We have also created programs to ensure the energy communities which have powered our country to greatness have the opportunity to lead the way forward by building advanced nuclear reactors at shuttered fossil fuel sites. Before the enactment of the bills, half of our nuclear fleet faced premature retirement by the end of this decade. But now, the approximately 95 gigawatts of reliable, baseload generation from our existing 92 reactors can be preserved into the next decade. This is an important accomplishment that highlights a win-win for our energy security and our climate goals. Without these critical pieces of legislation, the U.S. nuclear future would be grim, yet we still have a lot of work to do.

Putin's war in Ukraine has brought the geopolitical risk of not having energy independence from those who do not share our values into clear focus. But it is not just Europe that became reliant on cheap Russian energy. We, as the superpower of the world, are still dependent on Russian nuclear fuel. Right now, our country is deficient in nearly every aspect of the fuel cycle. This must change and it must change quickly. Whether it is uranium, mining, milling, conversion, enrichment, nuclear fuel fabrication, power generation, or nuclear waste storage and disposal, there is much work to be done, starting with conversion and enrichment. Simply put, Russia dominates the global market, representing nearly half of the international capacity for both processes. We have bipartisan bills to remedy this situation, and I look forward to continuing to work

closely with my friend, Ranking Member Barrasso, Senator Risch, and Senator Warner on this important issue.

The U.S. has become dependent on Russian enriched uranium to meet our commercial nuclear generation requirements. Prior to the war, we planned to supply our advanced reactors using Russian high-assay low-enriched uranium (HALEU). This must change, and initial steps have been taken to alleviate these issues. We included $700 million in the IRA to supply our advanced reactors with American HALEU, however, more needs to be done, including working closely with our allies and partners to increase nuclear fuel production and greatly expanding our efforts to onshore both uranium conversions and enrichment activities.

Last month, I introduced the Nuclear Fuel Security Act with Senators Barrasso and Risch, which provides the authority required to expand our uranium conversion and enrichment capacity to meet our domestic fuel requirements. We very nearly got this enacted at the end of last year with the support of the Department of Energy. And I hope we can move quickly on it this year. Nuclear energy currently constitutes just about 20 percent of our electricity generation, and it represents half of our clean electricity, and it is clear, nuclear will continue to be an essential part of the mix well into the future. The baseload power it provides is an integral part of our energy security and it will be impossible to reach our emission reduction goals without the continued operation of the current fleet and the construction of the next generation of advanced reactors. But that means we need to stop kicking the issue of nuclear waste down the road. And by that, I mean what to do with all the waste that is accumulated to date and waste that is yet to come.

We must act to provide a path forward to safely and responsibly dispose of our nation's nuclear waste. It is Congress's responsibility to act. Specifically, it is this Committee's responsibility to come to an agreement on legislation to provide a fair path forward. Nuclear waste is not a technical problem, it is a political problem. Since the 1957 National Academy of Sciences report, we have known the safe and responsible solution for disposing of our nuclear waste is in deep geologic disposal.

Inaction is also fiscally irresponsible. About $8.6 billion has been paid in settlements and final judgments because Congress has not provided a solution. That is approximately $2 million a day, or $167,000 over the course of today's hearing, due to our inability to establish a permanent program to handle our nuclear waste. There are sites in the U.S. that present ideal conditions for safe disposal, but we must have a consent-based program in place that can thoughtfully and effectively engage with state, local, and tribal governments to find a suitable means to site a repository. We have text ready to go, the Nuclear Waste Administration Act, which incorporates recommendations from the Blue Ribbon Commission, the Department of Energy, the national labs, the Government Accountability Office, and the National Academy of Science, on how to properly site, construct, and operate nuclear waste storage and repository facilities. It is my hope that we can finally find a path forward on this critical issue that we cannot ignore any longer.

Finally, we also must extend the Price-Anderson Act, which expires at the end of 2025. For almost 70 years, this law has helped

protect our commercial nuclear and R&D activities from civil litigation. Without extending this act, it is not an exaggeration to say our nuclear industry will cease to exist. I know members of our Committee and the communities you represent hold strongly held beliefs regarding nuclear energy. I also know that our constituents sent us here to create solutions to tough problems. So I look forward to a lively and productive discussion today.

We have a wonderful group of witnesses representing both commercial and federal stakeholders whose viewpoints are critical for having this discussion today. I appreciate our witnesses joining us to discuss these important issues.

With that, I am going turn to Ranking Member Barrasso for his opening remarks.

OPENING STATEMENT OF HON. JOHN BARRASSO, U.S. SENATOR FROM WYOMING

Senator BARRASSO. Well, thanks so much, Mr. Chairman. Thank you for holding today's very important hearing.

Nuclear power is our nation's largest source of carbon-free electricity. It is also the most reliable, operating over 90 percent of the time. Nuclear energy is fundamental to meeting our energy, our environmental, and our national security objectives. It is also critical to global security. The United States generates more electricity from nuclear power than any other nation in the world. We are the global leaders in nuclear technology development. Yet, we are heavily reliant on foreign sources of uranium to fuel our existing nuclear reactors, and we lack the ability to fuel our advanced nuclear reactors. Russia seeks a commanding share of the global nuclear energy market. It wants to undermine America's nuclear industry, and by several metrics, Russia is succeeding.

For decades, Russia has unfairly dumped uranium into our market. It has undercut America's nuclear fuel producers, driving our companies out of business. American uranium production is now at a level not seen, as a low level, since the 1940s. That is why I am introducing today legislation, along with Chairman Manchin and Senators Risch, Heinrich, Lummis, Coons, and Marshall, to ban Russian uranium imports. Russia also controls half of the world's enrichment capacity. We are on the brink of finding ourselves completely reliant on foreign nations to fuel our nuclear power plants. This is completely unacceptable. We must reestablish the United States as the global leader in nuclear energy. America's advanced reactor developers are ready to accept the challenge. They are making strides in the United States and around the world to deploy their innovative reactors. This includes TerraPower, which will build its first Natrium reactor in my home State of Wyoming. Advanced reactor developers do not want to depend on Russia for their fuel supply. They want to purchase American nuclear fuel.

We need to revitalize our nation's uranium mining industry. U.S. uranium is critical to America's energy security. It is required for our national security. We need to restart our nation's lone conversion facility. This is the facility that transforms mined uranium into the form needed for the enrichment plant. We also need to expand uranium enrichment. Thanks to Russia, our one domestic enrichment facility provides just a fraction of the low-enriched ura-

nium needed for America's existing reactors. We need to protect this facility from Russia's abusive trade practices. We also need a commercial capability to enrich uranium to the levels needed for advanced reactors. Currently, there are only two sources of high-assay low-enriched uranium—Russia and the Department of Energy. This has to change. Last year, Chairman Manchin, Senator Risch, and I pursued legislation to accomplish all of these objectives. And in December, the Senate did pass the bill by voice vote. We reintroduced the legislation last month.

We also have work to do on nuclear waste, as the Chairman just mentioned. Since the inception of nuclear power, nuclear waste has been safely stored onsite at existing reactors. On-site storage does not meet Congress's mandate to establish a permanent repository, and American taxpayers are paying dearly for it. As the Chairman mentioned, each day without a permanent waste solution costs taxpayers up to $2 million. At a minimum, we must allow the Nuclear Regulatory Commission to finish its review of the Yucca Mountain license application. Getting past the nuclear waste stalemate is important. We owe it to the taxpayers to move forward with a solution.

So I want to thank the witnesses for joining us today. I look forward to the testimony. And Mr. Chairman, right before I turn this back over to you, Senator Risch regrets that he is not able to attend today's meeting. He is such a big supporter of the Idaho National Lab, he wanted to personally welcome Dr. Wagner here today, and so I am doing that on his behalf. And I ask unanimous consent to enter Senator Risch's entire statement into the record.

[Senator Risch's statement follows:]

Senate Energy and Natural Resources Committee
Hearing to examine the nuclear fuel cycle
Statement from Senator James Risch
March 9, 2023

Thank you to the Chairman and Ranking Member for allowing me to enter a brief statement for the record and for holding this important hearing regarding the nuclear fuel cycle. As I have discussed many times before this Committee, nuclear energy holds a special place in the heart of Idahoans. The first nuclear reactor to produce electricity was located in Idaho, and today we are home to the Idaho National Lab, the Department of Energy's premier nuclear research laboratory. Nuclear energy development presents boundless clean energy potential and the opportunity for the United States to exert energy leadership globally. However, for both to be possible, we need to secure our nuclear fuel supply and reduce our dependence on Russia.

I introduced legislation with Chairman Manchin and Ranking Member Barrasso earlier this year to address this very issue. I am also pleased that we have Dr. John Wagner, Director of the INL, before the Committee today to discuss both the importance of fuel supply to advanced reactors and the work INL is doing to produce fuel for these demonstrations by down-blending high-enriched uranium. I look forward to working with my committee colleagues to address the issues facing the front-end of our nuclear fuel supply and continuing to support the important work INL is doing to advance nuclear energy.

Senator BARRASSO. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator.

And I would like to turn to our witnesses. We are going begin with Assistant Secretary, Dr. Kathy Huff. Then, she will be followed by Idaho National Laboratory Director, Dr. John Wagner, and finally, Constellation President and CEO, Joe Dominguez.

So we will start, Dr. Huff, with you.

STATEMENT OF HON. KATHRYN HUFF, ASSISTANT SECRETARY FOR NUCLEAR ENERGY, U.S. DEPARTMENT OF ENERGY

Dr. HUFF. Thank you, Chairman Manchin, Ranking Member Barrasso, and distinguished members of the Committee. It is an honor for me to appear before you today and represent the Department of Energy at this hearing related to the nuclear fuel cycle and supply chain.

To meet our ambitious carbon reduction goals and rebuild U.S. leadership globally, the Biden-Harris Administration is prioritizing activities that keep the existing fleet of nuclear reactors in operation, deploy advanced reactor technologies, and sustain the fuel supply, as well as expand international nuclear energy cooperation. Nuclear energy will play a major role in the transition to a carbon-free energy economy by fundamentally underpinning our nation's targets for carbon-free electricity as well as non-electric energy markets. Ensuring this future for our nation and our allies must include a secure and reliable source of fuel for today's nuclear power plants as well as those of tomorrow.

The Russian Federation's brutal invasion of Ukraine has demonstrated the grave threat to global energy security posed by dependence on Russian-supplied fuels. Russia is the largest supplier, globally, of enriched uranium, and currently supplies a significant portion of the nuclear supply chain to the United States, as well as our international allies and partners. Today, conversion and enrichment services from trusted sources are insufficient to replace current imports from Russia to the United States. The United States cannot reliably make sufficient low-enriched uranium or high-assay low-enriched uranium available to support the needs of today's power reactor fleet, advanced reactors, research reactors, or medical isotope production facilities, without expansion of the domestic fuel cycle capacity and the capacity of our international allies and partners.

The Department is working to address these energy security challenges in the face of ongoing global events. We cannot continue to infuse the Russian State with this source of income and must eliminate U.S. reliance on Russia in the nuclear energy area. To do this, we must act swiftly to kick-start investment in domestic enrichment capabilities. DOE greatly appreciates Congressional support for stimulating a sustainable and diverse commercial supply of high-assay low-enriched uranium. Ending our reliance on Russian supplies also requires additional appropriations and authorization to implement this program via a revolving fund that could reduce the need for additional appropriations and address our national security vulnerability as well as that of our allies and partners looking to reduce their reliance on Russian nuclear low-enriched uranium.

I want to thank this Committee for its leadership in the development of proposed legislation aimed at tackling this critically important issue facing our nation and the world. The department supports the continued safe operation of our existing reactors, but also supports a very robust and aggressive uranium strategy for low-enriched uranium, including HALEU. We are preparing to issue a draft HALEU acquisition strategy pursuant to the Energy Act of 2020 within the context of a broader uranium strategy for the department. The investments provided in the Inflation Reduction Act for HALEU are allowing the Department to begin helping the private sector establish a U.S. HALEU production and supply chain capability for the long-term, and thus begin mitigating U.S. reliance on Russia for various uranium products, including both low-enriched uranium and HALEU needed to support the current fleet and advanced reactors.

The department held the first meeting of the HALEU Consortium, as directed by the HALEU Availability Act, with over 50 members from across the nuclear industry. But the promise of new advanced reactors can only responsibly be realized in conjunction with progress on the management of their spent nuclear fuel. The department believes a consent-based siting process should be used for developing interim storage and disposal options to fulfill our obligations to safely and securely dispose of spent nuclear fuel and high-level radioactive waste generated by these reactors. Consistent with direction provided by Congress, DOE is making progress on consent-based siting for one or more federal consolidated interim storage facilities. DOE is actively working with national laboratory experts and reactor designers to collect data on proposed advanced reactor fuel forms to prepare and manage spent nuclear fuel from those reactors. More work in this area will be needed to fully understand how these fuels can safely and securely be incorporated into an integrated waste management system.

Thank you for the opportunity to appear before the Committee today. I greatly appreciate your leadership and the support of the programs and policies that my office and the Department of Energy conduct. I look forward to continuing work with you toward a more sustainable, equitable, reliable, affordable, safe, and secure energy system for our nation. I look forward to your questions.

[The prepared statement of Dr. Huff follows:]

Testimony of Dr. Kathryn Huff

Assistant Secretary for Nuclear Energy

U.S. Department of Energy

Before the Committee on Energy and Natural Resources

U.S. Senate

March 9, 2023

Introduction

Thank you, Chairman Manchin, Ranking Member Barrasso, and distinguished Members of the Committee. It is an honor for me to appear before you today and represent the Department of Energy (DOE) at this hearing related to the nuclear fuel cycle and supply chain.

Nuclear Energy

To meet our ambitious carbon reduction goals and rebuild U.S. leadership globally, the Biden-Harris Administration is prioritizing activities that keep the existing fleet of nuclear power plants in operation, deploy advanced reactor technologies, secure and sustain the nuclear fuel supply, strengthen nuclear safety, security, and safeguards, and expand international nuclear energy cooperation and non-proliferation. Nuclear energy will play a major role in the transition to a carbon-free energy economy by fundamentally underpinning our nation's target for carbon-free electricity as well as non-electric energy markets. New nuclear reactor deployments also have the potential to decarbonize many industrial sectors in the United States and abroad. Ensuring this future for our nation and our allies must include a secure and reliable source of fuel for today's nuclear power plants and those of tomorrow. As prioritized by President Biden in his recently released National Security Memorandum on *Countering Weapons of Mass Destruction Terrorism and Advancing Nuclear and Radioactive Material Security*, the United States is committed to lead the way in the responsible development and deployment of advanced nuclear reactors by championing the development and export of technology that incorporates the highest standards of safety, safeguards, and security by design while minimizing the use and accumulation of weapons-usable nuclear materials. I greatly appreciate the committee's support of these important programs and other policies that support the continued deployment of clean energy that nuclear energy provides.

The Russian Federation's brutal invasion of Ukraine has demonstrated the grave threat to global energy security posed by dependence on Russian-supplied fuels. This is also the case in the nuclear area. Russia, the largest global enricher of uranium, currently supplies a significant portion of the nuclear fuel supply chain to the United States and our international allies and partners. In particular, conversion and enrichment services from trusted sources are insufficient to replace current U.S. imports from Russia. Without expansion of the domestic and international allies' and partners' fuel cycle capacity, the United States cannot reliably make sufficient low enriched uranium (LEU) or high-assay LEU (HALEU) available to support the needs of today's power reactor fleet, advanced reactors, research reactors, and medical isotope production facilities. This strategic vulnerability is unsustainable.

In addition, Russia's military attacks on and subsequent seizure of Ukraine's Zaporizhzhya Nuclear Power Plant (ZNPP) and the associated heightened risks of a nuclear incident underscore the nuclear safety, security, and nonproliferation concerns of doing business with Russia in the nuclear energy area.

The Department is working to address these energy security challenges in the face of ongoing global events. As noted, the United States currently purchases a significant amount of enriched uranium from Russia. We cannot continue to infuse the Russian state with this source of income and must begin to reduce and ultimately eliminate U.S. reliance on Russia in the nuclear energy area, especially as it irresponsibly engages in strikes that disregard nuclear safety and security and a nuclear incident in Ukraine.

I want to thank this Committee for its leadership in the development of proposed legislation aimed at tackling this critically important issue facing our nation and the world. As you know, there is no quick, easy path to reduce our dependence on Russian-supplied fuels. Expanding our domestic fuel capacity will require strategic investments coupled with import restrictions that protect those investments well into the future. We must act swiftly to support domestic enrichment capabilities and prepare our industry for this transition. The Department welcomes the opportunity to work with Congress to address this national security vulnerability.

HALEU

We are developing an acquisition strategy for HALEU pursuant to Section 2001 of the Energy Act of 2020 within the context of a broader uranium strategy for the Department. The investments provided in the Inflation Reduction Act for HALEU are allowing the Department to begin helping the private sector establish a commercial U.S. HALEU production and supply chain capability for the long term, and thus begin mitigating U.S. reliance on Russia for various uranium products, including both low enriched uranium and HALEU needed to support the current fleet and future advanced reactors. The nuclear industry's response to the Department's planned acquisition strategy and financial assistance opportunities under development has helped inform the Department's uranium strategy. We are working closely with our colleagues in the National Nuclear Security Administration and Department of Defense with an eye to enabling national security missions over the longer-term.

The Department has now established a HALEU Consortium as directed by the HALEU Availability Act with over 50 members from across the nuclear industry. In addition, the Department has awarded a contract to continue the demonstration of a U.S. technology for producing HALEU and the production of a minimum of 900 kg of HALEU in the form of uranium hexafluoride. We understand that the project is on schedule to meet a milestone for completion of the demonstration and beginning of additional production later this calendar year. Finally, the Department is preparing to issue its draft HALEU acquisition strategy and will consider comments from industry in preparing the final funding announcement. In addition, we have initiated the National Environmental Protection Act (NEPA) process review for the program to establish a U.S. domestic supply chain for HALEU.

The Department supports the continued safe operation of our existing reactors, and we support a very robust and aggressive uranium strategy for low enriched uranium and HALEU. We appreciate the Committee's leadership on this issue.

Nuclear Waste

The promise of new advanced reactors can most responsibly be realized in conjunction with progress on the management of their spent nuclear fuel. The Department believes a consent-based siting process should be used for developing interim storage and disposal options to fulfill our obligations to safely and securely dispose of spent nuclear fuel and high-level radioactive waste generated by these reactors. Consistent with direction provided by Congress in the Consolidated Appropriations Act, 2023 report language, DOE is making progress on consent-based siting for one or more Federal consolidated interim storage facilities under existing authority. In December 2021, DOE issued a request for information on consent-based siting and received over 200 responses. A summary of those responses was published in September 2022 and is available at Energy.gov/consent-based-siting. The feedback DOE received recommended that funding and technical assistance be provided to enable communities and Tribes to build internal capacities to meaningfully engage with DOE in a consent-based siting process. In September of 2022, DOE issued a $16 million funding opportunity to provide resources for communities and other stakeholders interested in learning more about consent-based siting, management of spent nuclear fuel, and interim storage facility siting considerations. Applications were due in January of 2023, and we now expect to release up to $26M toward 6-16 corresponding awards this year. While the Department is working to make as much progress as it can under existing authorities, further constraints need to be addressed before DOE can construct and operate a federal interim storage facility and begin removing spent nuclear fuel from nuclear power plant sites.

Additionally, DOE is actively working with National Laboratory experts and reactor designers to collect data on proposed advanced reactor fuel forms - which typically possess multiple advantages over standard LWR fuel forms- to prepare to manage spent nuclear fuel from those reactors. More work in this area will be needed to fully understand how fuels from advanced reactors can be safely and securely incorporated into an integrated waste management system.

Price-Anderson Report

As noted in the Department's 2023 Price-Anderson Report, we recommend that the broad and mandatory coverage of the DOE indemnification remain unchanged and undiminished with respect to contractual activity within the United States and be expanded to include additional contractual activity by DOE contractors on behalf of DOE outside the United States to reflect changed circumstances. The Department stands ready to assist in extending The Price-Anderson Act (PAA), which has been a cornerstone of nuclear activities in the United States since the 1950s. In particular, the DOE indemnification of its contractors pursuant to the PAA has been a longstanding and critical component of DOE's ability to achieve its statutory missions. The PAA provides a comprehensive and equitable system of financial protection to address the concerns of both participants in nuclear activities and persons who may be injured by a nuclear incident. The PAA expires on December 31, 2025. In its recent Report to Congress on the need for continuation or modification of the PAA, the Department recommended that: (1) the PAA should continue; (2) the DOE indemnification of our nuclear enterprise should continue and expand

upon its broad and mandatory coverage; and (3) the PAA should continue in effect in a manner compliant with the Convention on Supplementary Compensation for Nuclear Damage. The Report found that renewal of the PAA would be in the best interests of DOE, its contractors, its subcontractors and suppliers, and the public. I would be happy to work with you as you consider renewal of this important Act.

Conclusion

Thank you for the opportunity to appear before the Committee today. I look forward to continuing to work with you toward a more sustainable, equitable, reliable, affordable, safe, and secure energy system for our nation. I look forward to your questions.

The CHAIRMAN. Thank you, Dr. Huff.
Now we will have Dr. John Wagner.

STATEMENT OF DR. JOHN WAGNER,
DIRECTOR, IDAHO NATIONAL LABORATORY

Dr. WAGNER. Thank you.

Chairman Manchin, Ranking Member Barrasso, and members of the Committee, it is a pleasure and an honor for me to be here with you today. My name is John Wagner. I am the Director of the Idaho National Laboratory, the national center for nuclear energy research and development.

The United States once maintained a robust domestic nuclear fuel cycle capability, from mining to conversion, to enrichment, to fuel fabrication. That is no longer the case. In the United States, uranium mining has decreased 92 percent since 1980. The only U.S. conversion facility was idled in 2017. Only one enrichment facility currently operates domestically, with the capacity to support about one third of the current reactor fleet. As we look to the future of nuclear energy in the United States, I would encourage members of this Committee to consider three questions related to the nuclear fuel cycle.

First, how do we leverage our existing nuclear energy industry to ensure our domestic energy security? Today's nuclear reactors run on what we call low-enriched uranium (LEU). This is fuel that is enriched up to five weight-percent in uranium–235. The U.S. currently imports over 90 percent of the uranium needed to support our current nuclear reactor fleet of 92 reactors. Of that, approximately 14 percent is from Russia. The Russian invasion of Ukraine puts the United States and many other countries, including our allies, in a precarious situation. Developing new domestic mining, conversion, and enrichment capabilities would provide fuel certainty to our existing fleet and help ensure our energy security.

Second, how do we ensure successful deployment of new nuclear energy that is critical to our energy security, global leadership, and climate objectives? Advanced nuclear technologies will run on something called high-assay low-enriched uranium, or HALEU, fuel that is further enriched, enriched up to 20 weight-percent in uranium–235. HALEU enables reactor developers to achieve smaller designs with higher power densities and to optimize their systems for increased efficiency.

The Department of Energy projects that the initial deployment of advanced reactors will require more than 20 metric tons of HALEU before the end of the decade. Currently, the only commercial source for HALEU is Russia. This presents both a challenge and an opportunity for our nation. Ideally, we would expand from a LEU fuel cycle to a HALEU fuel cycle, but this is not possible given the crippled state of our domestic capabilities. By developing a 100 percent domestic HALEU fuel cycle, which would include mining, conversion, enrichment, and deconversion capabilities, we would address both LEU and HALEU needs.

In the meantime, at INL we are actively working to supply HALEU from legacy spent fuel materials and are making it available to companies such as Oklo for their microreactor demonstration, literally turning waste into the needed resource. With private

and government investments supporting the deployment of advanced reactors, the global HALEU market is projected to significantly expand.

Third, how do we address the back-end of the fuel cycle? We have the technical capacity and knowledge to responsibly manage spent nuclear fuel, but we need the support from an appropriate policy solution. The Nuclear Waste Policy Act of 1982 and as amended in 1987 reflects the national priorities and concerns of the time. Several attempts have been made to amend the Nuclear Waste Policy Act, but none have yet succeeded. The Blue Ribbon Commission report provides a comprehensive review of the issues, as well as thoughtful recommendations. The near-term deployment of consolidated interim storage would be a useful component of an integrated waste management system. And while recycling of advanced reactor spent fuels is possible, there will always be a need for deep geologic disposal capacity. The time has come to revisit this approach. I appreciate your leadership on that. And to fulfill our spent nuclear fuel management responsibilities, and further, to support nuclear expansion, a new nuclear waste management policy framework is very much needed.

I will conclude with this: Private-sector companies and investors contemplating investments in nuclear energy, many of them drawn to the clean, reliable, and firm power attributes, understandably have concerns. A fuel supply dependent upon imports and a broken Nuclear Waste Policy Act are sources of significant uncertainty that stifle investments. Gaining more certainty in the fuel cycle by developing a 100 percent domestic HALEU supply and actions to develop a workable Nuclear Waste Policy Act would inspire investments in microreactor technologies, small modular reactors, and other advanced nuclear technologies our nation needs. Thank you for this opportunity to testify and for this Committee's attention to this important issue. I look forward to your questions.

[The prepared statement of Dr. Wagner follows:]

TESTIMONY OF DR. JOHN C. WAGNER

LABORATORY DIRECTOR

IDAHO NATIONAL LABORATORY

BEFORE THE UNITED STATES SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

"Full Committee Hearing to Examine the Nuclear Fuel Cycle"

March 9, 2023

Chairman Manchin, Ranking Member Barrasso, and members of the committee, it is an honor and privilege to be here today. My name is John Wagner, and I am the director of 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 more than 5,700 scientists, engineers and support staff, multiple nuclear and nonnuclear experimental facilities, and an annual budget of more than $1.6 billion with a mission focused on nuclear energy, national and homeland security, and energy and environmental science and technology.

I hold a Bachelor of Science degree in Nuclear Engineering from the Missouri University of Science and Technology and Master of Science and Doctorate degree in Nuclear Engineering from Penn State. 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 U.S. Department of Energy (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 the 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 Associated Laboratory Director for the Nuclear Science and Technology Directorate (NSTD). I am the author and co-author of more than 170 refereed journal and conference articles, technical reports, and conference summaries, some of which have more than one hundred citations. 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 an issue of great importance to our nation: the nuclear fuel cycle and its role in ensuring our future energy security.

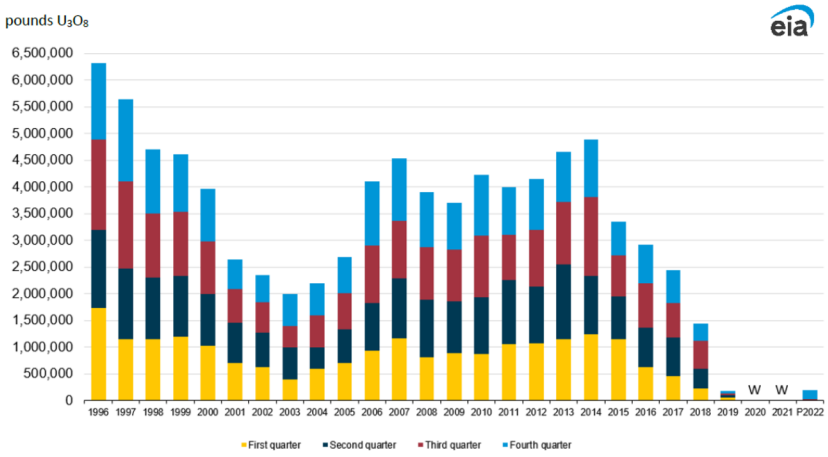
I want to thank members of this committee, including our own Sen. Risch of Idaho, for their longstanding and unwavering support for the U.S. commercial nuclear industry and for maintaining and expanding our global leadership in nuclear technology.

Background

I would like to begin today by addressing how we arrived at this point, where the vast majority of the uranium and processes involved with nuclear fuel production are not available domestically, making the United States dependent on international sources of nuclear fuel, including nations that do not have our best interests at heart.

As members of this committee well understand, the United States once built and deployed nuclear reactors regularly. And we maintained a robust domestic fuel cycle capability, from mining to conversion, to enrichment, to fuel fabrication.

That is no longer the case (Figure 1). In the United States, uranium mining has decreased 92% since 1980. For example, in 2021, the United States domestically produced only 5% of the uranium purchased, according to the U.S. government's Energy Information Administration (EIA).



P = Preliminary data

Source: U.S. Energy Information Administration, Form EIA-851A, *Domestic Uranium Production Report (Annual),* and Form EIA-851Q, *Domestic Uranium Production Report (Quarterly)*

Figure 1. Uranium concentrate production in the United States, 1996 to fourth-quarter 2022.

The only U.S. conversion facility was idled in 2017. Only one enrichment facility currently operates domestically, with the capacity to support about one third of the current reactor fleet, according to information compiled by the Urenco Group, which supplies nuclear power stations in 15 countries, including the United States.

The bipartisan passage of key nuclear energy-related legislation in recent years demonstrates that there is a broad understanding and consensus on nuclear energy's importance to our nation's economy, environment, national security, and power grid stability, security, and resiliency.

But our lack of domestic fuel cycle capabilities is already negatively impacting efforts to deploy the next generation of technologies needed to expand the ability of our commercial fleet to produce 24/7, carbon free power more than 92% of the time – more reliably than any other source of generation.[1] TerraPower recently extended the timetable on its Wyoming-based natrium reactor because of concerns about fuel availability.[2]

As we look to the future of nuclear energy in the United States, I would encourage members of this committee to consider the following questions related to the fuel cycle needs for the sustainment of the current nuclear reactor fleet and the expanded deployment of advanced reactor technologies, and waste storage and disposition.

1. How do we leverage our existing nuclear industry to ensure our domestic energy security?

Today's nuclear reactors, the 92 that make up the high-performing U.S. fleet, run on low enriched uranium (LEU), uranium fuel that is enriched up to 5% with uranium-235. Today, the United States imports over 90% of the uranium needed for our reactor fleet, which provides nearly 20% of the electricity produced for our power grid and more than half of our carbon-free electricity. That's more than solar, wind, hydro, and geothermal combined.

According to the EIA, owner and operators of U.S. nuclear power reactors purchased the equivalent of roughly 47 million pounds of uranium in 2021. Of that, 35% came from Kazakhstan, 15% from Canada, and 14% from both Australia and Russia.

Essentially, we no longer have sufficient capabilities to produce LEU in our nation, and our nuclear energy industry has become dependent upon foreign nations.

The Russian invasion of Ukraine puts the United States, and many other nations, in a precarious situation. The deteriorating relationship between our nations has resulted in increasing pressure, including from members of Congress, to call for an end to uranium imports from Russia. This step would require us to identify a path to operate our existing and future reactors without Russian imported uranium and supporting enrichment services.

In the short term, a reduction in supply, naturally, drives up costs. Given the already tenuous financial status of many U.S. nuclear power plants, this could result in even more premature

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[1] *What is Generation Capacity?* Office of Nuclear Energy, U.S. Department of Energy. https://www.energy.gov/ne/articles/what-generation-capacity#:~:text=The%20Capacity%20Factor&text=It%20basically%20measures%20how%20often,of%20the%20time%20in%202021.

[2] *Wyoming Nuclear Plant* Delayed. Nicole Pollack. December 25, 2022. Wyoming Business Report. https://www.wyomingnews.com/wyomingbusinessreport/current_edition/wyoming-nuclear-plant-delayed/article_3e898b50-7c37-11ed-8a07-fb56a5bad803.html.

closures, resulting in more carbon emissions from other generation sources and a less reliable and resilient power grid.

Developing new domestic mining, conversion, and enrichment capabilities, with urgency, will ensure the availability of a domestic supply of fuel, provide certainty to our existing fleet of nuclear power plants, and help ensure our domestic energy security.

2. How do we ensure successful deployment of new nuclear energy that is critical to our energy security, global leadership, and climate objectives?

While we must secure the sustained operations of our existing commercial reactors, at the same time we need to look to the future and support the advanced technologies that will help power American prosperity for decades to come.

Advanced nuclear technologies will run on high assay low enriched uranium (HALEU), uranium fuel that is enriched up to 20% with uranium-235. HALEU enables reactor developers to achieve smaller designs with more power per unit of volume, and to optimize their systems for increased efficiencies and better fuel utilization. DOE projects that deploying a new fleet of advanced reactors will require more than 40 metric tons of HALEU before the end of this decade.

This presents both a challenge and an opportunity.

Ideally, we would expand from a LEU fuel cycle to a HALEU fuel cycle. But current conditions are far from ideal because of the crippled state of our domestic LEU production capabilities.

The HALEU fuel needed to run advanced nuclear technologies, including microreactors and small modular reactors, offers our nation a real opportunity to reinvigorate our LEU fuel cycle. We can start by developing a 100% domestic HALEU fuel cycle which will add needed domestic mining, conversion, enrichment, and deconversion capabilities. According to a joint INL, Pacific Northwest National Laboratory, Argonne National Laboratory, and ORNL analysis, the HALEU fuel market is projected to be about 10% of the current LEU market by 2050.[3]

We also need to support the current needs of advanced reactor developers while new capabilities are deployed. At INL, we are actively working to supply HALEU from Experimental Breeder Reactor II origin and are making it available to companies such as Oklo for their microreactor demonstration. We are doing this by processing the high-enriched uranium (HEU) spent fuel to recover the uranium and down-blend it to HALEU. This material is not the only existing spent fuel in the DOE system that could be applied to beneficial use for HALEU production.

We are seeing real progress in our HALEU fuel cycle. In recent years, we have improved our understanding of the market and identified the demand, which is driven by government and private sector needs such as demonstration reactors, medical isotopes production, reactor

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[3] Dixon, Brent; Kim, Son H.; Feng, Bo; Kim, Taek; Richards, Scott; and Bae, Jin Whan. (Dec. 2021). *Estimated HALEU Requirements for Advanced Reactors to Support a Net-Zero Emissions Economy by 2050.* Prepared for the U.S. Department of Energy, Office of Nuclear Energy. https://inldigitallibrary.inl.gov/sites/sti/sti/Sort_53484.pdf.

conversions, and space applications. With new private and government investments supporting the deployment of advanced reactors, the HALEU market is projected to significantly expand. INL is supplying small quantities of HALEU to industry to support fuel qualification and testing, and the Centrus enrichment demonstration is ongoing.

But much more remains to be done. As we move toward deployment of advanced reactors, to power our economy, combat climate change, and bolster national security, we need to accelerate the deployment of a self-sufficient, domestic HALEU fuel cycle.

3. How do we address the back end of the fuel cycle?

I began my remarks by talking about how decisions made decades ago, under far different conditions and circumstances, are impacting the fuel cycle today as we operate our nuclear reactor fleet and work to develop and deploy advanced technologies. The same can be said for spent fuel management and disposition.

The need to address our near- and long-term spent fuel management responsibilities remain. This is true for the existing and future DOE-managed and commercial inventory, and for the inventory arising from the anticipated deployment of advanced reactors. We have the technical capacity and knowledge to responsibly and safely manage spent nuclear fuel, but we need the support of an appropriate policy solution.

The Nuclear Waste Policy Act (NWPA of 1982), and as amended in 1987, understandably reflects the national priorities and concerns of the time. Various attempts have been made to further amend the NWPA to better reflect the nuclear waste management realities, policies, and needs of today, but none have yet succeeded. Simply put, the present framework for interim storage and disposal of the U.S. spent fuel inventory, as set forth in the NWPA, is inadequate to meet the challenges of today or tomorrow and a new policy framework is needed.

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 has directed DOE to use a consent-based siting approach in the pursuit of federal consolidated interim storage for the nations spent nuclear fuel inventory. However, federal interim storage facilities of sufficient capacity cannot be constructed without first 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 revisit our approach.

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 nuclear waste management policy framework that addresses the issues of today.

As a national laboratory, we are enabled to contribute to the *technology* for interim storage, recycling, and geologic disposal, and to *inform* the policy debates thereof. But the eventual resolution of those long-standing debates will require a new nuclear waste management framework, a framework that only Congress can provide.

I will conclude with this:

Private-sector companies contemplating investments in nuclear energy find themselves in a difficult situation. A fuel supply dependent upon imports, and now in doubt considering the Russian-Ukraine conflict, breeds uncertainty and stifles investments in the advanced technologies our nation needs.

More certainty in the fuel cycle, by developing a 100% domestic HALEU supply, would help alleviate uncertainty and inspire investments in microreactor technologies, small modular reactors, and other advanced nuclear technologies now in development.

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

The CHAIRMAN. Thank you, Doctor.
And now, we have Mr. Joe Dominguez. Joe.

STATEMENT OF JOSEPH DOMINGUEZ, PRESIDENT AND CHIEF EXECUTIVE OFFICER, CONSTELLATION ENERGY

Mr. DOMINGUEZ. Good morning, Chairman Manchin, Senator Barrasso, and members of the Committee. My name is Joe Dominguez. I am President and CEO of Constellation Energy. We are the largest private nuclear company from an operations standpoint in the world. We operate about a quarter of the nation's reactors. Last year, we produced about 11 percent of the nation's clean energy from our reactors—vital, reliable, clean energy. So on behalf of the 13,000 talented women and men that work in our company, I just want to thank you for the privilege to appear before you today. It is from a personal and professional standpoint, quite an honor.

I want to distill my testimony, really, down to three points, and they are points that have already been made this morning. The critical nature of nuclear energy, and I want to give you some real-life, recent examples where this has played out. Second, of course, talk about the issue regarding fuel, the cycles of fuel that we do not have from mining, enrichment, conversion, domestic capability, and the challenges that presents to the industry. Third, I want to speak very briefly about the need for DOE funding for laser technology, for enrichment. This is different than the centrifuges that typically separate the 235 and 238 through centrifugal force and use a laser excitation process, and it presents an excellent opportunity for us to enhance and really develop technologies.

First, let me talk about the importance of nuclear energy. You know, we have had a pretty spotty ten-year record of electric reliability if we pay careful attention to it. A lot of focus on California, a lot of focus on Texas, but frankly, in 2014, we almost lost the PJM system to blackouts during the middle of the polar vortex that year. We thought we fixed it. But then, leading into the Christmas holidays this year, we again got into an emergency situation where a lot of generation failed to operate, and we were going to go into emergency measures. Fortunately, that was averted. The reason, if you look at a common thread through all these events, where we either averted a crisis or prevented a deeper crisis, it has been the performance of the U.S. nuclear fleet. Happily, our assets performed at 100 percent of their capability during this most recent crisis. Had they not, Christmas would have been affected for millions and millions of Americans and businesses.

So what we are dealing with is vital to the energy security of the nation. And we often talk about the energy transition, but we saw in this last year that if we do not get affordability right, if we do not get reliability right, we are not really going to be able to make the full-throated effort at the transition that we all want to make. And I believe, and I think most experts believe, that the importance of having a firm fuel source that is also zero emission, a baseload fuel source, is only going to grow in importance. I am afraid to say that the challenges we recently faced are not the last challenges we are going to face as we transition to more intermittent resources. I like to say we are in an "everything, every time,

anywhere" business, right? Anything you want to power, anywhere it exists in the grid, anytime you want power, whether it is a blow dryer or an electric vehicle, or a steel factory, all of it depends on the electric grid functioning, and that depends on a robust nuclear industry.

Right now, that industry is dependent on fuel sources that are not domestically produced. And the risk of that is—a cutoff by the Russians to those fuel sources could, in turn, turn into a reliability crisis and would particularly be felt when we need the energy most during some of these events that I alluded to earlier. So we strongly support the work that this Committee has done. We got very close, as Chairman Manchin mentioned, to the finish line last year. But we have got to get over the finish line. Five years is a blink of an eye. Right now, internationally, we have a gap from a conversion standpoint of about 25 percent that would be realized if the Russians stopped delivering to us and allies, of conversion services. Twenty percent of the international market is dependent on the Russians. If we are going to address those gaps, we have to begin that work immediately.

So I am here to just emphasize that the industry, and Constellation in particular, wants to be a strong partner. We believe a cost sharing model makes a great deal of sense, but what we are addressing here is not just a fuel issue, that is a commercial issue, but an issue that reverberates through national security and electric reliability issues that the country is facing presently. So I look forward to the discussion and to any of your questions. Thank you.

[The prepared statement of Mr. Dominguez follows:]

Testimony Of Joseph Dominguez
President & Chief Executive Officer, Constellation Energy
March 9, 2023

Chairman Manchin, Senator Barrasso, Members of the Committee,

Thank you for the opportunity to appear before the committee today. I am Joseph Dominguez, and I am President and CEO of Constellation Energy Corporation.

My message to the committee today is threefold:

First, nuclear power is critical to the nation's energy security, environmental security, and national security.

Second, the United States is on the verge of a crisis in conversion and enrichment markets; it is critical that we re-shore our capabilities to overcome global dominance by Russia in these areas. We do not have time to wait: In the world of nuclear fuel, 2028 is tomorrow. Congress must authorize and fund a $3.5 billion investment as part of a public-private cost-share partnership with conversion and enrichment providers. It is important that we have both a diversity of supply and a diversity of suppliers.

Finally, the Department of Energy should use their existing authority to accelerate deployment of new enrichment technologies using funds previously made available for High Assay Low Enriched Uranium (HALEU) production. DOE has made one award for HALEU production, and the Department should fund an additional project that uses laser enrichment technology that could also be used to produce low-enriched uranium for the fleet of existing reactors.

Constellation

Headquartered in Baltimore, Constellation is the nation's largest producer of carbon-free energy, providing 11% of America's clean electricity, and is the leading competitive retail supplier of energy products and services for businesses and homes across the United States. Our generation fleet produces enough clean, carbon-free energy to power the equivalent of 15 million homes and is helping to accelerate the nation's transition to clean energy with more than 32,355 megawatts of capacity and annual output that is nearly 90% carbon-free. Constellation has set a goal to achieve 100% carbon-free generation by 2040 by leveraging innovative technology and enhancing its diverse mix of hydro, wind and solar resources paired with the nation's largest carbon-free nuclear fleet. Constellation's commercial business serves approximately 2 million residential, public sector and business customers, including three-fourths of the FORTUNE 100.

Constellation was created a little over a year ago when we spun off from Exelon Corporation and became a stand-alone, publicly traded company. Overall, Constellation is the third largest power generator in the United States, and we own and operate the nation's largest fleet of nuclear reactors, with 21 reactors operating in Illinois, Maryland, New York, and Pennsylvania, and partial ownership of two units in New Jersey. Finally, we are a global leader in nuclear operations. Our 94.8% capacity factor in 2022 marks the seventh year in a row with a capacity factor over 94%, the best in the industry for over a decade. Our 11 refueling outages last year averaged an industry-leading 21 days, matching our fleet record.

Our skilled workforce of approximately 13,370 people nationwide is an essential component of our operations, and allows us to safely run the largest, most reliable and resilient carbon-free energy fleet in America.

Importance of Nuclear Power

The U.S. nuclear fleet provides nearly 20% of the nation's electric generation and accounts for 50% of the nation's emissions-free generation. Nuclear provides an around the clock supply of emissions-free energy, even in severe weather conditions that result in grid emergencies, and is critical to ensuring a clean and reliable grid for the United States.

At the end of 2022, Winter Storm Elliott brought record-setting low temperatures to the PJM region, threatening the reliability of the grid and safety of 65 million of Americans. Always-on nuclear power provided the resiliency and reliability needed by the grid to prevent catastrophic blackouts. During the storm, Constellation's 16 nuclear reactors in PJM operated at 100% capacity while nearly a quarter of PJM generation was knocked offline by extreme conditions, with 90% of that being fossil generation.

State and Federal policymakers are increasingly recognizing the value of nuclear power in the face of disastrous policy decision to shutter nuclear plants before the end of their licensed lives. Germany is a poster child for what happens when short-term political considerations overrule sound policy. Germany mandated a shutdown of nuclear units and tried to replace that generation with renewable resources. Instead, they were forced to rely on high-emitting generation to keep the lights on and saw their power sector emissions jump five percent in 2021. The United States saw similar increases in emissions in states that prematurely closed nuclear plants.

Nuclear power is also vital for national security. The Department of Defense (DOD) notes that small modular reactors (SMRs) and other advanced reactors are ideal for powering bases in remote and austere environments. The partnership between the Idaho National Laboratory and DOD to develop a mobile microreactor in Project Pele offers what Defense officials call a potential "strategic game changer" for the United States.[1] Advanced nuclear technologies can offer still broader national security benefits at home and abroad as such efforts go forward.

Members of this committee have long recognized the importance of clean, affordable, and safe baseload nuclear power, and we thank you for your leadership in ensuring that we won't need to close additional plants prematurely for economic reasons. The Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA) took concrete steps to begin to put all non-emitting generation, including nuclear, on a level playing field. Mr. Chairman, I particularly want to thank you and Senator Wyden for championing the production tax credit for existing nuclear plants.

For Constellation, these measures are transformational, enabling us to seek to relicense our nuclear units, preserving thousands of jobs and thousands of megawatts of emissions free generation for 20 years. The long-term investment certainty provided by this legislation and initiatives in several of the states in which we operate allowed Constellation to add 2,000 new employees in 2022. Extending the life of Constellation's nuclear units (about a quarter of overall nuclear generation in the U.S.) will create as much clean energy as all the renewable energy built in America over the last 40 years. From a jobs standpoint, extending the licenses of Constellation's plants to 80 years will create over 453 million

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[1] Department of Defense, "DoD to Build Project Pele Mobile Microreactor and Perform Demonstration at Idaho National Laboratory," April 13, 2022, https://www.defense.gov/News/Releases/Release/Article/2998460/dod-to-build-project-pele-mobile-microreactor-and-perform-demonstration-at-idah/

person-hours of work in high-paying jobs across the country, making the nuclear energy provisions of the IRA one of the largest creators of family-sustaining wages.

Looking forward, we recently announced plans to invest $800 million in power uprates at two of our nuclear stations that will create 135 additional megawatts — the equivalent of adding 216 intermittent wind turbines but without using a single additional acre of land. We also have plans to invest $900 million in hydrogen production at one of our nuclear units to create approximately 35,450 tons per annum of clean hydrogen that will help decarbonize other industries. These projects will contribute to our clean energy economy and will create thousands of additional high-paying jobs in our communities. Appropriate implementation guidance on the IRA will be particularly important to ensuring that these investments, and more like them, can be made.

Nuclear Fuel

Given that we have the most nuclear units in the nation, Constellation is the naturally largest consumer of nuclear fuel in the United States. In the coming years, we will spend more than $1 billion annually on uranium, conversion, enrichment, and fabrication. In an average year, our plants require 10 million pounds of uranium, about 4 million kilograms of conversion, and 3 million SWU. Total U.S. demand is roughly 50 million pounds of uranium, 18 million kilograms of conversion, and 15 million SWU annually.

Global events in the last three years, including COVID and Russia's invasion of Ukraine, have exposed critical supply chain gaps in nearly every sector of America's economy, including the nuclear fuel industry. It is imperative that we work together urgently to reestablish the United States as a world leader in providing conversion and enrichment services.

After dominating the nuclear fuel supply sector for the first 40-plus years of the atomic age, the United States largely ceded a presence in the global enrichment market after the end of the Cold War. The enrichment market is now served by four providers: China, Russia, Orano (France) and Urenco (an Anglo-Dutch-German consortium with a U.S. affiliate, LES, operating in New Mexico).

The United States opened nuclear fuel markets to Russia in the early 1990s after the fall of the Berlin Wall. Sales of nuclear fuels served as an important source of income for the nascent Russian Republic. In 1991, an antidumping petition was filed against Russia, which resulted in the Russian Suspension Agreement to cap Russian imports of uranium and nuclear fuel services which was put in place in 1993.

In 1993, the U.S. and Russia signed the landmark United States-Russia Highly Enriched Uranium Purchase Agreement, also known as the Megatons to Megawatts program, which has been hailed as the most successful nonproliferation program in history. Under the program, high enriched uranium from the Russian nuclear weapons program was downblended for use in commercial nuclear reactors in the United States. At the height of the program, material from former Soviet warheads provided half of the nuclear fuel used in U.S. reactors, accounting for 10% of all the electricity generated in the United States. Over the 20-year history of the program, 500 metric tons of Soviet high enriched uranium – enough material for 25,000 warheads, was downblended and used in U.S. reactors.

With the Cold War over and government stockpiles for naval propulsion and the weapons program plentiful, the U.S. government decided to privatize the Department of Energy's uranium enrichment program, creating the U.S. Enrichment Corporation (now Centrus Energy) in 1996 to operate gaseous diffusion plants that were originally constructed for the Manhattan Project. These plants were old and energy intensive first-generation technology, putting them at a competitive disadvantage to French and European companies and state-owned enterprises in Russia and China that use newer, cheaper gaseous centrifuge technology.

The case of Iran notwithstanding, a well-functioning worldwide nuclear fuel market has helped discourage development and deployment of enrichment technology as numerous commercial nuclear power projects come online across the globe. As I mentioned earlier, the scale of Russian access to the U.S. market has been governed by the Russian Suspension Agreement, a government-to-government agreement that was most recently extended in 2020. Russia is currently capped at approximately 20% of the U.S. enrichment market, with that amount scheduled to drop to 15% in 2028. For conversion and uranium, imports are currently capped at approximately 20%, dropping to 5% in 2026.

As the obsolete U.S. plants closed, the United States went from being the world's largest exporter of nuclear fuel to the world's largest importer. Today, Russia has 46 percent of the world's enrichment capacity.[2] There is not enough non-Russian enrichment capacity to fuel the world's reactors, and the gap is large.[3]

The lack of adequate domestic enrichment capabilities poses an urgent national security challenge. Dr. Kathryn Huff, Assistant Secretary of Energy for Nuclear Energy, testified before the committee in December 2021 that "American dependence on Russian uranium threatens our energy security. Energy security is national security and untrustworthy state-sponsored programs have no place in our energy policy."[4] We should begin immediately on the long-lead work necessary to reduce our dependence on Russian uranium, and partner with our allies to build a shared strategy for resilient fuel supplies.

Constellation has long supported domestic suppliers of uranium, conversion, and enrichment as part of our robust risk management strategy to rely on a diversified supply as protection against natural disasters such as earthquakes, transportation risk, and political risk.

On the enrichment front, we have supported all private enrichment capacity projects undertaken in the U.S. Constellation and its predecessor companies signed contracts and made an equity investment in 2003 to support Urenco's LES project in New Mexico; in 2007, we signed contracts to support Orano's Eagle Rock project in Idaho; and in 2009, and we signed contracts to support Centrus's American Centrifuge Project. We have also worked with Global Laser Enrichment for the last 10 years in an effort to bring diversified technology options to market. We are currently in discussion with multiple enrichment providers about signing long-term contracts to support new domestic capacity. We believe it is important to have both new domestic supply and a diversity of domestic suppliers.

Constellation stands with Ukraine against Russia's unprovoked invasion, and we support U.S. and international efforts to end the war. In response to the Russian-Ukraine conflict, our nuclear fuels team has worked diligently over the past 15 months using their deep relationships to secure enough nuclear fuel inventory and future contracts to meet our needs through 2028 even if existing contracted Russian

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[2] Data from the World Nuclear Association website: Uranium Enrichment | Enrichment of uranium - World Nuclear Association (world-nuclear.org)

[3] World Nuclear Association 2019 Fuel Market Report, Table IV.1 Total world enrichment requirements (excluding Russia) are ~48 million SWU/year. Total non-Russian enrichment capacity, including China, France, and URENCO, is ~33 million SWU/year. This leaves a potential supply gap of 15 million SWU/year if Russian supply were removed from the global market. 15M SWU is equivalent to the entire annual enrichment requirements of the United States.

[4] Testimony of Dr. Kathryn Huff, Assistant Secretary for Nuclear Energy and Douglas MacIntyre, Deputy Director for the Office of Petroleum Reserves, U.S. Department of Energy, Before the Committee on Energy and Natural Resources U.S. Senate December 1, 2022, https://www.energy.senate.gov/services/files/145546FD-49A2-4DE9-A9AE-3027A7C6FC8A

fuel supply was disrupted. This inventory build will bridge our new fuel supply from now through 2028, at which point, multiple Western providers have stated they are able to have additional supply online. Not every reactor operator is as well-positioned as Constellation in this regard, and an interruption of supply before new capacity is operating would almost certainly leave some reactors without fuel. In addition, while Western suppliers have said that new capacity could be available as early as 2028, that date could easily slip if legislation to support new capacity is not enacted soon.

I want to underscore the urgency of immediate action to spur additional domestic conversion and enrichment capacity. As I noted in my opening comments, in the world of nuclear fuel, 2028 is tomorrow. Tweaking current capacity to add marginal amounts of production will not be enough; we need new domestic capacity online as soon as possible. We need action today if we are to avoid the potential for a supply shortfall in 2028. To begin production by 2028, enrichers have just five years to secure contracts, obtain financing, receive licensing and permitting approval, construct facilities, and begin operation. It's easy to imagine that process taking 10 years rather than five without immediate bipartisan support.

To the Department of Energy's credit, the Office of Nuclear Energy has been conducting extensive outreach on this issue to determine the extent of the challenges faced by both consumers and producers and to understand the best way to secure new conversion and enrichment capacity. DOE has also worked through its Office of International Affairs to facilitate discussions with foreign utilities that have small amounts of surplus material.

Congress has provided funding to the Department of Energy for the production of High-Assay Low Enriched Uranium (HALEU) to support fuel for advanced reactors, and DOE announced an award to Centrus last month for a HALEU demonstration program. Similarly, DOE could facilitate the deployment of innovative new technologies and diversify domestic enrichment supply capabilities for both low-enriched uranium for existing reactors and HALEU for advanced designs by supporting an effort by North Carolina-based Global Laser Enrichment (GLE) to deploy laser enrichment technology. GLE is currently preparing a commercial-scale pilot demonstration in its Test Loop facility in Wilmington, North Carolina, and with timely and modest cost-share support from DOE, GLE could accelerate commercialization of its next-generation technology and advance its prospective enrichment facilities in Paducah, Kentucky, to 2028. Supporting a demonstration of laser enrichment capabilities would facilitate GLE's ability to move more quickly to supply multiple forms of enriched uranium and natural UF_6 to meet critical nuclear fuel needs in the United States.

The case for federal investment is strong. Indeed, every enrichment plant ever built, anywhere in the world, has been built by governments and state-owned corporations. New domestic enrichment capabilities would advance the public interest in ways that aren't reflected in the market. It would strengthen America's energy security, reduce Russia's leverage in energy markets, and give the United States a stronger hand in global nonproliferation efforts. Finally, the U.S. government will need new enrichment capacity for its own purposes, including important missions in national security, nonproliferation, space exploration, and supporting next generation reactor designs. We must act now.

As we have with past projects, Constellation will do its part: we are in active discussions with potential Western enrichers to sign long-term contracts to give them the certainty they need to secure financing and proceed with the large-scale investments necessary to build these facilities. Enrichers are ready to do their part as well by making large-scale investments of their own, but they need policy certainty and government support as well.

Spent Nuclear Fuel

It has been 40 years since Congress passed the Nuclear Waste Policy Act of 1982 that governs spent nuclear fuel policy in the United States. The law required reactor owners to enter into contracts with the Federal government for the disposal of spent nuclear fuel and required the Federal government to begin removing fuel from reactor sites by January 31, 1998. The Federal government is now 25 years overdue in meeting that statutory obligation to begin removing fuel from sites.

The Federal government's program to site a permanent repository is not broken; it's effectively nonexistent. I believe we owe it to nuclear communities, whether they are commercial reactor sites, national labs, or Federal facilities, to do more than wait for volunteers to step up to host a site. In recent years, Congress has provided DOE with little guidance, and even less funding, to try to address this issue.

It is important to emphasize that while we wait for Federal action to identify a permanent disposal site, reactor owners continue to safely manage and store this used fuel at more than 70 sites in 35 states, including roughly a dozen sites with shutdown reactors.

Nuclear is the only large-scale energy producing technology that takes full responsibility for all of its waste, plans for its eventual disposal, and prefunds plant retirement obligations. When it comes to spent fuel, we know where every gram of high-level waste is located and how it is packaged, tagged, and tracked. Storage of spent fuel, both in spent fuel pools and in dry casks, is regulated by the Nuclear Regulatory Commission.

Nuclear energy is extremely energy dense and produces less waste than other types of energy. For context, all of the spent nuclear fuel produced in the United States from the 1950s until now could fit inside a single Super Walmart.

After the fuel is used to produce energy, it is placed in pools more than 20 feet deep to cool down for several years. The fuel is then placed in 16-foot stainless steel containers that are surrounded by helium gas and then placed in a concrete container that is 20 to 30 inches thick. These casks are designed to withstand earthquakes, storms and projectiles. There has never been any unplanned radiation released from the casks and they are designed to produce less radiation than a frequent flyer receives in a year. While we advocate for a permanent repository, these dry casks are safe for hundreds of years and do not pose a risk to the public.

It has been over seven years since the nuclear industry reviewed and issued principles for used nuclear fuel management. At that time, the industry endorsed the concepts of "a new management and disposal organization outside the Department of Energy (DOE) dedicated solely to executing a high-level radioactive waste program and empowered with the authority and resources to succeed." The full statement of policy principles is appended to my testimony.

In closing, I want to thank the committee for focusing on this critically important topic and I look forward to continued collaboration to ensure that the U.S. nuclear fleet can continue its role as the workhorse of our efforts to decarbonize the electric power grid and other sectors of the economy.

Policy Principles for Used Nuclear Fuel Management

The industry supports an integrated used nuclear fuel management strategy, consisting of ten basic elements:

1. A new management and disposal organization outside the Department of Energy (DOE) dedicated solely to executing a high-level radioactive waste program and empowered with the authority and resources to succeed.
2. Access to the Nuclear Waste Fund for its intended purpose, without reliance on the annual appropriations process but with appropriate Congressional oversight.
3. Develop a consolidated storage facility for used nuclear fuel and DOE's high-level radioactive waste in a willing host community and state. Used fuel from shutdown commercial reactor sites without an operating reactor should have priority when shipping commercial used fuel to the storage facility. Assigning priority to shutdown plants shall not affect the right to damages for DOE's failure to perform absent such priority.
4. In parallel with developing a consolidated storage facility, complete the Nuclear Regulatory Commission's (NRC) review of the Yucca Mountain repository license application, followed by construction and operation of the repository and developing a second geologic repository, if necessary.
5. Research, development and demonstration on improved or advanced fuel cycle technologies to close the nuclear fuel cycle, thereby potentially reducing the volume, heat and toxicity of byproducts placed in the repository, recognizing that a geologic repository will be required for all fuel cycles. All funds for this RD&D must come from DOE's budget and not the Nuclear Waste Fund. In addition to RD&D, the Nuclear Regulatory Commission (NRC) should develop a regulatory framework for the licensing of advanced fuel cycle technologies.
6. A legislative determination that, for the period after the licensed term for reactor operation until removal for disposal, no consideration of environmental impacts of used nuclear fuel storage shall be required by the NRC in connection with any reactor licensing.
7. The Nuclear Waste Fund (NWF) fee should not be raised above $0 unless (1) the annual expenses for the program's ongoing projects exceed the annual investment income on the NWF and (2) the projected life-cycle cost demonstrates that the fee must be reinstated to achieve full cost recovery over the life of the program.
8. Communities and states hosting the Yucca Mountain repository and/or consolidated storage facilities shall be eligible for benefits. The Nuclear Waste Fund can be used for these benefits if they are reasonable and do not result in an excessive increase in overall program costs.
9. Standard contract holders should not be required to waive their right to recover damages or settle claims resulting from DOE's breach of contract as a condition of the federal government accepting used nuclear fuel for consolidated storage or permanent disposal.
10. The industry will fulfill its one-time fee obligations consistent with the provisions in the Nuclear Waste Policy Act.

The CHAIRMAN. Thank you, all. We appreciate you very much for your input and also making an effort to be here today. It is much appreciated.

We'll start with the questioning, and I will begin.

You know, we made a lot of extraordinary progress during the last Congress, maintaining that the U.S. is going be an energy leader, a nuclear energy leader. We did everything we could to save the industry and to propel it so it will be totally reliable as we need it and also helping all of us in so many different areas, as far as dependability, reliability, and also emissions. So with that, I am going ask kind of rapid-fire questions, a few of them for all of you.

Do you all believe, and I will go down the line, do we need to eliminate our dependence and allies' dependence on Russian nuclear fuel and conversion of enrichment? Are we too dependent right now? Do we need to eliminate that?

Dr. HUFF. Yes.

The CHAIRMAN. Yes.

Dr. WAGNER. Yes.

The CHAIRMAN. Okay.

Mr. DOMINGUEZ. Yes.

The CHAIRMAN. How about do we need to extend Price-Anderson?

Dr. HUFF. Yes.

Dr. WAGNER. Yes.

Mr. DOMINGUEZ. I almost went out of turn. Yes.

The CHAIRMAN. That's okay.

[Laughter.]

The CHAIRMAN. That's okay. You were getting anxious.

Do we need to create a federal agency to use the community consent-based approach to establish nuclear waste facilities?

Dr. HUFF. Yes.

Dr. WAGNER. Yes.

Mr. DOMINGUEZ. Yes.

The CHAIRMAN. Okay.

Finally, do you believe that we are eliminating baseload fuels faster than we are replacing with dependable, reliable energy?

Dr. HUFF. Are we, or should we?

The CHAIRMAN. I mean, you know the statistics as well as I do.

Dr. HUFF. Could you repeat the question?

The CHAIRMAN. Do you believe that we are eliminating baseload faster, and I will just—PJM just filed a report. I am relying on PJM's report.

Dr. HUFF. Yes.

The CHAIRMAN. If you want to go to that one. They are taking off coal-fired because in our state——

Dr. HUFF. Yes.

The CHAIRMAN [continuing]. They are trying to accelerate elimination of baseload, which we have nothing to replace it with, and they are running—and I think, Mr. Dominguez, you mentioned how close you are running to that blackout. So I am just asking your questions.

You said yes?

Dr. HUFF. Yes.

The CHAIRMAN. Okay.

Dr. WAGNER. Yes.

Mr. DOMINGUEZ. Senator, yes, I do.

The CHAIRMAN. Mr. Dominguez, if you would like to elaborate a little bit since you are in this mix right now. I have always understood there are only two baseload fuels. They are totally dependable, reliable, and affordable, but there are only two that you can count on 24/7, and those are nuclear and coal. Now, we have replaced coal with gas. That is great. We have a lot of that. Okay. But we have seen what happens because then you have pipelines that can freeze up. You got pump stations. You have got a lot of things that might not be as reliable.

Are we getting ourselves into position—and my other concern, the reason this whole Committee, both Democrats and Republicans, came to the aid of nuclear—we knew that we had to save that industry. But here is my concern—I don't know if you all can make it in a merchant market. Day-to-day pricing, coming on, you know, when renewables come on, they have to go because they can't hold them. They have to use it. But you can't ramp down, I know that. So it puts you in a very precarious situation where your cost is going be pretty constant and higher.

So if you can address how the pricing of nuclear, how we can maintain it and build it in on our national grid?

Mr. DOMINGUEZ. Senator, if I could start, just with your point. Look, I think we are getting dangerously close to papering over what is going to be one of the most difficult engineering challenges our nation will face, and that is, again, trying to replace an energy system that has these guarantees to families and businesses that it will be on all the time, with resources that do not operate when people dispatch and when Mother Nature permits them to operate. And I do believe that we have overlooked these problems in the early days of the introduction of some of these intermittent resources, and the consequence has been fairly small so far because the percentage of penetration has been minimal.

So the issue you pointed out around the coal plants is pretty evident. We have replaced them with natural gas, but it is notable that in the 2014 incident with the polar vortex event and PJM, we lost about 40 percent of the natural gas resources. Again, we thought we had addressed that, and here again, just now, a matter of months ago, we lost over 30 percent of the natural gas resources when we needed the power.

The CHAIRMAN. I'm just saying that people need to understand.

Mr. DOMINGUEZ. It is a big issue.

The CHAIRMAN. We are depending, and we are taking for granted that the system has been very robust, if you will, and predictable, but basically, it is very fragile.

Let me just say this—we passed the Bipartisan Infrastructure Law. We passed the Inflation Reduction Act. Can you tell me, from a professional standpoint, what effect do you think that has had on our energy grid, energy mix, and the amount of attraction as far as investments in our country?

Dr. Huff.

Dr. HUFF. I think, in particular, the prospect of the tax credits is expanding the likelihood, from our assessment, that existing nuclear power plants will extend their licenses and that new nuclear power plants will have the financial incentives to be built out. I ex-

pect that similar expansion on the grid, based on some of the provisions in those bills, will also increase grid reliability and security and sustainability.

The CHAIRMAN. Right.

Dr. Wagner.

Dr. WAGNER. There is a lot in those bills. I will say, briefly, the Civil Nuclear Credit Program is incredibly important for some of the reactors in the fleet. The Production Tax Credit and the Inflation Reduction Act, is already being very much welcomed, and particularly the fact that the Production Tax Credit and the Investment Tax Credit include nuclear, where nuclear had been excluded from some of these credits in the past, is very, very helpful.

The CHAIRMAN. Have you seen overseas investments coming?

Dr. WAGNER. Yes.

The CHAIRMAN. And——

Mr. DOMINGUEZ. Senator, total game changer. It allows our investors to support us when we are extending the lives of the assets. The conversation for the last ten years has been about closing nuclear plants. Now, we are in this welcome discussion about continuing their operation for generations to come.

And as to your question about international investment, I would simply say that what the U.S. has done is recognized the gap in so-called ESG investing around clean energy resources that many investors have now closed. In other words, they have included nuclear energy as a part of that picture. That is important to our investor base and ultimately, to our success as a company. So total game changer, transformational.

The CHAIRMAN. Thank you.

Senator Barrasso.

Senator BARRASSO. Well, thanks so much, Mr. Chairman.

Dr. Huff, thanks so much for being here again. Great to see you. You know, for the past couple of years, I have urged the Department to accelerate its efforts to establish a U.S. source for high-assay low-enriched uranium. As a result of the inaction by the Department, TerraPower recently announced that it anticipates a two-year delay in the operation of the Natrium reactor. When will the Department request proposals from industry to establish commercial production of high-assay low-enriched uranium?

Dr. HUFF. Thank you, Senator. I really appreciate your support of the funds to move forward in this. Our initial acquisition and strategy to support the DOE needs for enriched uranium products, including everything you have mentioned, is in progress. It is currently under interagency review, and we expect it to be out very soon. We are getting very close to the release of that acquisition strategy.

Senator BARRASSO. Yes, you use the phrase interagency review, which is the whole process, because I actually believe that you, and I believe the Secretary of Energy, really want to speed this up and are not the cause of the inaction. So who's slowing it down?

Dr. HUFF. You know, we want get this exactly right, and it is critically important that the whole of government have an opportunity to review. So of course, it goes through a process where, you know, other agencies and the Office of Management and Budget and everyone has an opportunity to weigh in, and I expect that

when we do release it, it will be exactly right and there will be no question across the entire whole of government.

Senator BARRASSO. So then in the whole of government, are you facing pushback from the White House or another agency?

Dr. HUFF. There is certainly support from the White House that we release this soon, but getting it right is even more important.

Senator BARRASSO. Is the Office of Management and Budget delaying the progress?

Dr. HUFF. The Office of Management and Budget is involved in this interagency review, sir.

Senator BARRASSO. It does seem that there is some roadblock there and I think it's not you and I think it's not the Secretary. So then, I am looking to see where that is. There are some people that just oppose nuclear energy. And I am wondering to see if there is somebody that is out there trying to slow things down intentionally because of their concerns regarding the issue of nuclear energy.

Dr. HUFF. My understanding and hope is that it is collectively a desire to get it out, get it out soon, and get it out correctly.

Senator BARRASSO. Okay.

Mr. Dominguez, domestic suppliers can produce nuclear fuel for our reactors. They need clear market signals to justify the increased production. America's nuclear utilities have helped send these signals by committing to buy U.S. uranium. What is Constellation doing to provide America's nuclear fuel suppliers with these market signals?

Mr. DOMINGUEZ. Senator, it is not only what we are doing but what we have done for some time. We were a part of Exelon before the split in the company about a year ago. And we traditionally have been helping at all cycles—the miners, we have done some work with miners, converters, and enrichers, to continue to create that capability. We understand that that commercial signal is a critical part of making progress in getting this domestic production and we have done it for years and years. The details of all of that are spelled out on page four of the testimony in terms of all of the different steps we have taken, but we recognize we have a big role here.

Senator BARRASSO. You know, Chairman Manchin and Senator Risch and I introduced legislation to authorize the Department to execute its plan to ensure U.S. nuclear fuel availability, but the program needs to be funded. Last month, the Nuclear Energy Institute and three other organizations sent letters endorsing a proposal to use funds from the Civil Nuclear Credit Program to ensure U.S. nuclear fuel availability.

Mr. Chairman, I ask unanimous consent to enter these letters into the record.

The CHAIRMAN. Without objection.

[The letters referred to follow:]

CLEARPATH ACTION

February 6, 2023

Chair Cathy McMorris Rodgers
Energy and Commerce Committee
The House of Representatives
Washington, DC 20515

Ranking Member Frank Pallone
Energy and Commerce Committee
The House or Representatives
Washington, DC 20515

Dear Chair Rodgers and Ranking Member Pallone

ClearPath Action would like to thank the Committee for its leadership on U.S. nuclear energy and for considering the draft bill, Prohibiting Russian Uranium Imports Act, during the joint legislative hearing on "Unleashing American Energy, Lowering Energy Costs, and Strengthening Supply Chains." A secure and robust nuclear fuel supply chain is critical to ensuring American families receive clean, affordable, and reliable energy from our nation's nuclear power plants.

Reducing reliance on Russian fuel provides the certainty required to incentivize domestic industry, build new capacity, and support our allies. This need for secure nuclear fuel supply chains extends beyond traditional, large light-water reactors. The two flagship advanced nuclear reactor demonstration projects underway through the Department of Energy require high-assay, low-enriched uranium fuel (HALEU), which today is only available from Russia. According to modeling by the International Energy Agency in 2021, to meet our global climate goals, around 500 gigawatts of new nuclear power must be brought online by 2050. The United States has the potential to supply both the technology and the fuel for this massive global market.

While the Prohibiting Russian Uranium Imports Act would create certainty for the low-enriched uranium (LEU) supply market, it could also address the HALEU supply market. This bill has the potential to enable the United States to lead globally across both the LEU and HALEU supply chains. The Committee could allow the Department of Energy to identify the remaining need for the Advanced Nuclear Fuel Availability program, established under section 2001 of the Energy Act of 2020, and reappropriate that amount in addition to the funds made available for the American Assured Fuel Supply program.

This comprehensive approach would complete the intent of this legislation by providing an American alternative to Russian nuclear fuel dominance that addresses both near-term and long-term supply chain security. Thank you again for your interest and leadership in furthering American clean energy leadership in the nuclear power industry.

Sincerely,

Rich Powell
Chief Executive Officer
ClearPath Action

NUCLEAR ENERGY INSTITUTE

NUCLEAR
CARBON-FREE ENERGY

Maria Korsnick
President and CEO

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February 3, 2023

The Honorable Cathy McMorris Rodgers
Chair
Committee on Energy and Commerce
U.S. House of Representatives
Washington, D.C. 20515

The Honorable Frank Pallone
Ranking Member
Committee on Energy and Commerce
U.S. House of Representatives
Washington, D.C. 20515

Dear Chair Rodgers and Ranking Member Pallone,

I write to commend the House Energy and Commerce Committee for taking steps to enhance the domestic nuclear fuel cycle and alleviate the national security issues associated with dependence on Russian nuclear fuel imports.

The U.S. commercial nuclear industry is committed to eliminating the import of uranium and related conversion and enrichment services from the Russian Federation. Our industry will continue to work with the U.S. government to establish a secure supply of nuclear fuel conversion and enrichment capabilities so we can move away from Russian fuel imports as expeditiously as possible without placing the U.S. nuclear fleet and new-reactor deployment at risk.

In addition to several proposals in the draft legislation, we encourage Congress and the Administration to explore the feasibility of redirecting a portion of the unexpended funds authorized through the Civil Nuclear Credit Program to support domestic conversion and enrichment expansion capabilities.

Nuclear energy is an essential element of U.S. infrastructure, providing nearly 20 percent of the U.S. electricity generation and half of our carbon-free generation. If U.S. operators are not able to acquire fuel, there will be significant negative impacts on affordability, reliability, and air quality for millions of Americans. It will also significantly impede our ability to reach our carbon-reduction goals.

Chair Rodgers and Ranking Member Pallone
February 3, 2023

Establishment of a secure fuel supply will allow the U.S. and our allies to make continued progress toward climate and energy security goals through the maintenance of existing reactors and the build-out of new reactors using U.S. technology.

We look forward to continuing to work with Congress on a workable solution to developing a competitive domestic fuel supply to strengthen our energy security.

Thank you very much.

Yours very sincerely,

Maria Korsnick

c: The Honorable Jeff Duncan, U.S. House of Representatives
The Honorable Bill Johnson, U.S. House of Representatives

United States Nuclear Industry Council
1317 F Street NW Washington, DC 20004

Date: February 6, 2023

To:

The Honorable Cathy McMorris Rodgers
Chairwoman
U.S. House Committee on Energy & Commerce
2125 Rayburn House Office Building
Washington, DC 20515

The Honorable Frank Pallone, Jr.
Ranking Member
U.S. House Committee on Energy & Commerce
2125 Rayburn House Office Building
Washington, DC 20515

RE: USNIC Letter to House Energy & Commerce Committee on Russian Uranium Imports

Dear Chairwoman Rodgers & Ranking Member Pallone:

The U.S. Nuclear Industry Council (USNIC) and its members are grateful for the Committee's continued support for the U.S. nuclear industry. A robust U.S. nuclear fuels supply chain is crucial to our industry's health. As we progress steadily toward deployment of advanced reactors, the attention paid by the Committee to the importance of supporting nuclear as a clean energy solution is highly valued.

That is why USNIC welcomes this Committee's strong focus on resilient supply chains to support the Nation's critical infrastructures, including the vital importance to strengthen our domestic capability to enrich uranium to support our own energy infrastructure as well as that of partners and allies. In that connection, USNIC urges the Committee to ensure that there is adequate flexibility to apply funds already appropriated under the Infrastructure Investment and Jobs Act (IIJA) for High-Assay Low-Enriched Uranium (HALEU) and low-enriched uranium (LEU) in the event the Secretary of Energy determines it is necessary or appropriate.

We are also appreciative of proposed legislation "To prohibit the importation into the United States of unirradiated low-enriched uranium that is produced in the Russian Federation, and for other purposes." USNIC and our members have reviewed the proposed legislation carefully and are convinced it can be an important element for continued successful development of our vital national industry. We support the Committee's intent with this legislation that clearly, we cannot, and should not, rely on Russia for the enriched uranium to meet current industry needs, and definitely not to meet the needs for HALEU that is vital to U.S. objectives for advanced reactors.

We also note that the proposed legislation provides for a thoughtful process that will allow for the domestic fuel supply chain to ramp up over the next six years, as well as the criteria provided for potential waiver of restrictions if the Secretary of Energy determines that there is no alternative viable source available, or it is otherwise in the national interest. Given the need to protect American interests as we build domestic capacity, we recommend that the Committee include language to ensure that existing contracts signed prior to the invasion are grandfathered during the transition period to ensure adequate supply and avoid rewarding Russia with an opportunity, to sell at high prices in third markets, enrichment that they are now committed to sell at pre-invasion prices. These provisions should alleviate

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February 6, 2023

The Honorable Cathy McMorris Rodgers
Chair, House Energy and Commerce Committee
United States House of Representatives
Washington, DC 20515

The Honorable Frank Pallone
Ranking Member, House Energy and Commerce Committee
United States House of Representatives
Washington, DC 20515

Dear Chairwoman Rodgers and Ranking Member Pallone,

On behalf of the Uranium Producers of America (UPA), I write to express our support for the "Prohibiting Russian Uranium Imports Act," which your committee is set to consider during a legislative hearing on February 7. This legislation will help stop the funding of Russia's war in Ukraine with U.S. dollar purchases of nuclear fuel, protect our national and energy security, and take critical steps towards reestablishing American nuclear fuel cycle capabilities.

It is long past time to ban uranium imports from Russia, just as the United States has already done with Russian oil, gas, and coal. For too long we have been funding Ukraine's defense with one hand, and Russian aggression through our nuclear fuel purchases with the other. Russia's state nuclear power company, Rosatom, benefits from hundreds of millions of U.S. dollars in nuclear fuel purchases annually. By continuing to rely on Russian nuclear fuel, we are directly subsidizing the Putin regime and the continued devastation in eastern Europe.

In addition to cutting off another U.S. financial spigot for Russia, banning Russian uranium imports will help create the long-term market conditions necessary for U.S. uranium producers to make investments across the nuclear fuel cycle. The legislation's redirection of unspent and unneeded Civil Nuclear Credit Program dollars towards the nuclear fuel supply chain is a common-sense measure to start securing our nuclear power needs now and well into the future. U.S. policymakers must recognize and address the fact that our global competitors, namely China and Russia, treat their nuclear fuel cycle capabilities as strategic assets and deploy them to achieve geopolitical objectives. Restoring America's global nuclear energy leadership is crucial for U.S. security.

We urge the Committee to move with urgency in considering the "Prohibiting Russian Uranium Imports Act." Thank you for considering this important and timely legislation and we look forward to working with you as the bill makes its way through the legislative process.

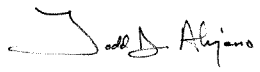
Sincerely,

Jon Indall
Counsel, Uranium Producers of America

any issues for those who may be concerned that Russian enriched uranium might at some future time be needed to meet U.S. requirements.

Thank you very much for the support you consistently provide for our industry, an industry that is crucial for U.S. energy security, economic well-being, and national security.

Sincerely,



Todd Abrajano
President & CEO
U.S. Nuclear Industry Council (USNIC)
Mobile: 913-620-0700
Todd.abrajano@usnic.org

Senator BARRASSO. So Mr. Dominguez, do you agree that we can repurpose a portion of these funds without negatively affecting operating nuclear reactors?

Mr. DOMINGUEZ. You know, I think Dr. Huff is probably the best person to opine on the usefulness of that program. What I can simply tell you, Senator Barrasso, is that we do not intend to use the Civil Nuclear Credit Program. Our focus here is not where the money comes from, necessarily, it is in getting this work started. And so I think that is a question more for the Department and appropriators than for us. But I can tell you the CNC program is not something that we will be using in our fleet. And historically, we have had the most challenged units.

Senator BARRASSO. Maybe in a second round, I will ask Dr. Huff to opine, but first I have one for Dr. Wagner.

The Department of Energy has limited quantities of high-enriched uranium that can be downblended for use in advanced reactors. The Department also has stockpiles of spent fuel and nuclear waste. These resources can be processed and fabricated into fuel to meet the near-term needs of advanced reactors. What is the Idaho National Lab doing to make high-assay low-enriched uranium available to advanced reactors?

Dr. WAGNER. Thank you for the question. There are two categories I would think about, and one is unirradiated high-enriched uranium that could be utilized—potentially downblended into HALEU, and then there are irradiated materials. You can think about high-enriched uranium spent nuclear fuel, fuels such as what was used in the Experimental Breeder Reactor-II (EBR-II), for example. What we are doing, very specifically, is processing that EBR-II material to separate the uranium, clean it, then downblend it to just under 20 weight-percent of the isotope uranium–235 to make that available for small reactor demonstration projects, things like the Oklo reactor demonstration, as well as provide that material for uses in fuels designed to test fuel performance. It is a limited amount, but it actually is serving, or will serve an important need in the near term.

There are additional stocks of those materials that could be utilized for similar purposes. I will note that that material is not ideal for all reactor types and does introduce some complications in fuel fabrication that have to be considered.

Senator BARRASSO. Thanks, Mr. Chairman.

The CHAIRMAN. Thank you, Senator.

Senator Heinrich.

Senator HEINRICH. Thank you, Chairman.

Secretary Huff, as you know, New Mexico is home to a plant that provides roughly a third of the domestic demand for enriched uranium, and the state is certainly poised to play a key role in the DOE's upcoming implementation of its HALEU Availability Program. However, DOE—their previous HALEU demonstration program was awarded as a sole-source contract. That left this plant unable to participate. Can you assure me that this new program will be awarded through a competitive process that would allow this plant to compete for this work?

Dr. HUFF. Thank you, Senator.

I also appreciate the importance of competing these awards. The role that the Urenco facility plays in New Mexico is world class and critically important to this and yes, I can absolutely commit to this being a fully competitive process.

Senator HEINRICH. Thank you. I appreciate that very much.

I want to ask you a bigger philosophical question that you may not want to answer, but given that the NRC has a 48-year record of saying no to nearly—nearly, all the time, is the NRC broken? Do we need to consider a different regulatory framework, especially as we are on the front end of what could be an era of small modular nuclear reactors for at least the last 20 percent of our decarbonization goals?

Dr. HUFF. Senator, I could not agree with you more that the need for our regulatory system to work efficiently to enable these deployments is absolutely critical to get to our carbon reduction goals. It is essential. And the Nuclear Regulatory Commission has a huge job facing it. I do not envy them this task. Their approach to streamline and improve their efficiencies, I hope, will result in success, but in my role in the Office of Nuclear Energy, I cannot really guide that or opine on what they should do, but I will say, I am fully in agreement that they deserve an opportunity to sort of get more efficient, and they are going to need to in order to support our climate goals.

Senator HEINRICH. I think we can all agree on that.

Mr. Dominguez, I wanted to ask you, you know, just to be straightforward and honest about this—one of the challenges with traditional light-water nuclear reactors has been the cost issue. The cost per kilowatt-hour has not been competitive in recent markets. We addressed some of that through the Production Tax Credit, obviously. It is, what, two and a half cents per kilowatt-hour, I believe. But this is mature technology, so how can we bring down those costs, because I think that has been a fundamental limit for deployment, certainly of more traditional designs. It remains to be seen what we can do with future SMR designs.

Mr. DOMINGUEZ. Senator, just a couple points. I don't think the nuclear fleet has been uneconomic. I believe that it is uneconomic in an unlevel playing field. As you pointed out, there have been tax credits.

Senator HEINRICH. I mean, everybody has benefits. You have a tax credit. Price-Anderson was a benefit. I mean, that was basically socialization of insurance cost. And I am not saying that is a bad idea. I am saying, how can we drive down those costs? Because if they were truly competitive, we would have been deploying more than one light-water reactor in the last decade.

Mr. DOMINGUEZ. Yes. I think the issue, in terms of the existing fleet, is probably slightly different than in terms of introducing new technologies. In the case of new technologies, I think it is pretty clear that the cost of building these very large sites, just the cost of money over the period of construction, is prohibitive. There are licensing issues associated with that that contribute to some of the cost pressures, things that we have talked about a little bit already today.

But I think what we need to do is change the philosophy around how we build reactors, and I think these small modular reactors

being built in factories over a much shorter period of time has got to be the way to go here. I think, certainly for our company, and we are the largest in this space, right?

Senator HEINRICH. Right.

Mr. DOMINGUEZ. For our company there is no way we could undertake the construction of a large, dual-unit site. Think about the irony of that. We own 23 of these things already and we cannot build the next two on our balance sheet, okay? Small modular reactors—different story. Smaller bite in capital, but you get the machine up and running and producing energy sooner, meaning revenues are in the door and the cost of interest—carrying costs—are substantially lower. So I think it is already headed in that direction. This fuel issue is also a big part of that. As you look to attract investors, one of the questions that we get constantly is, where are you getting your fuel and what happens if Russia shuts you off?

Senator HEINRICH. I am pretty much out of time, but I do want to just bring up the fact that I also think we need to make sure that small modular reactors are actually small and modular because if they are complicated reactors masquerading as SMRs, because that is popular in the moment to say you are an SMR, then we are going to have some of the same challenges that we have had with traditional light-water reactors.

The CHAIRMAN. What is the size?

Senator HEINRICH. The size is less important than the fact that you can sort of stamp these things out exactly like each other to avoid the complexity that we have experienced with one-off nuclear reactors.

The CHAIRMAN. Yes, my two cents on that—as I am understanding, there are like 300, 340 megawatts. You can stack them, but they will be exactly the same and he was explaining the molten salt cooling. You kind of peak them up and peak them down, which is a little bit, I mean, you get more flexibility than you have now.

Mr. DOMINGUEZ. Yes, that is right, Chairman.

The CHAIRMAN. We are just trying to dumb it down a little bit so that we understand it, but that makes sense to me.

Mr. DOMINGUEZ. Yes, Senator Heinrich, I think, nailed the issue with his point.

The CHAIRMAN. He got it, yes.

Mr. DOMINGUEZ. There is really no definition here. So some of the designs are as small as 50 megawatts, okay, maybe 70, megawatts. Some of the designs are as big as 500 megawatts——

The CHAIRMAN. Yes.

Mr. DOMINGUEZ [continuing]. Which is the size of some of the early generation units. So it gets into which technology are you talking about here.

The CHAIRMAN. Yes.

Thank you so much, Senator Heinrich.

And now, we have Senator Cassidy.

Senator CASSIDY. Dr. Huff, I am excited to see the X-energy and Dow Chemical partnership to use high-heat nuclear reactors to create lower carbon products. My state makes a lot of these products essential for modern life. How is DOE approaching working with these major manufacturers, not just the nuclear technology company, to make sure that the ARDP program is successful?

Dr. HUFF. Thank you, Senator. We are also really excited to see that advanced nuclear capabilities can support industrial decarbonization like this. It is critically important to use these unique sources of high heat for what they are best at and what would otherwise be very hard to decarbonize, as you say.

DOE supports this through lots of research and development at our national laboratories and, of course, through the cost-shared ARDP program, but continued oversight and observation of that ARDP award is now taking place under the Office of Clean Energy Demonstrations. My office, of course, continues to support the TerraPower deployments and the X-energy deployments and NuScale deployments through support at the national laboratories as well, including Dr. Wagner's.

Senator CASSIDY. So this general kind of atmosphere of support doing the R&D et cetera, if you will, Senator Heinrich put it well, everybody gets some benefit. This is the benefit that you think would make this more economically feasible?

Dr. HUFF. Absolutely. We are exploring all kinds of different markets, clean molecules of all types, hydrogen and advanced fuels, enhanced aviation fuels.

Senator CASSIDY. So let me ask, then, to what degree are we going to be able to take this from an occasional sort of, yes, we can do it here into which it is more commonplace?

Dr. HUFF. Well, I am an optimist and I believe that we should and must take it to the fullest degree in order to return net-zero carbon reduction goals by 2050. To get a net-zero economy, we must fully commit to this. Whether it is possible or not, is bound to see, but that is the purpose of these demonstrations is to demonstrate the first-of-a-kind that we hope will be the end-of-a-kind.

Senator CASSIDY. If you had to bet your first-born male child upon it, do you think we will be successful?

[Laughter.]

Dr. HUFF. That's funny.

Senator CASSIDY. I mean, I know you are an optimist, but to what degree, what are the prospects of this? Do we think it is truly possible?

Dr. HUFF. I actually once bet a lot of beer to the American Nuclear Society that we will have a small modular reactor operating by the end of the decade. So quite a bit. I am quite committed.

Senator CASSIDY. I understand you are about to release a request for proposals (RFP) on developing a new high-assay low-enriched uranium development capacity. I think this is positive. There needs to be more than one producer. So can you speak about DOE's commitment to making sure that the RFP results in multiple American developers of HALEU, not just one?

Dr. HUFF. Senator, I absolutely agree with you. Thank you for this question. It is an important and nuanced point that diversity of supply is security of supply. We are committed to ensuring that the acquisition approach is flexible enough to incorporate the possibility of supporting as many suppliers as can make our system as robust as possible.

Senator CASSIDY. To what degree are we creating international markets for all these products that we are developing, which, obvi-

ously, has the ability to lower the marginal costs of producing the next one, but also achieve other goals?

Dr. HUFF. The list of nations interested in engaging with us on this particular topic is growing every day. It is almost exponential. All of our partners and allies involved in the fuel cycle supply chain, I expect, will be engaging with us, you know, over the coming years in really public ways around strategic investments, and of course, the customers are coming every day. I have a long, long list of nations that are interested in small modular reactors, gigawatt-scale reactors, microreactors. Nuclear newcomer counties and nuclear operating countries are all interested in engaging in this and they all need a secure fuel supply.

Senator CASSIDY. That's great. And not just a secure fuel supply, but also in terms of the technology itself.

Dr. HUFF. That is right.

Senator CASSIDY. And you feel, again, optimistic about that?

Dr. HUFF. American technology is well trusted internationally. This is part of the reason why our Nuclear Regulatory Commission is such an excellent resource, but also, you know, our technology is ahead of the game, especially in small modular reactors.

Senator CASSIDY. Last question. As part of the Bipartisan Infrastructure bill, we developed a Civil Nuclear Credit Program, which provided funding to keep existing nuclear online. This may have been discussed before I was here, I apologize. Now, since the creation, we have seen discussions of the funds being used for maintenance in a California nuclear plant, but these were not at risk of being shut down, and of reopening previous closed. Can you just detail how DOE is looking to use this program to otherwise promote nuclear?

Dr. HUFF. Yes, absolutely. So that program started in my office, and has actually moved over to the Grid Deployment Office inside the Department of Energy for its second round and future rounds of credit allocation opportunities. The second round was recently opened for a broader set of plants to apply. We expect that even with the production tax credits in the Inflation Reduction Act, there will still be plants at some economic risk, and competition in merchant markets that will continue to apply for that program. It is a long-term program and there is, you know, plenty of opportunity for those plants to apply for multiple later rounds.

Senator CASSIDY. So the answer is you have matured the ability to deliver the dollars where they are needed and you think there will be an ongoing demand?

Dr. HUFF. I do.

Senator CASSIDY. Okay, thank you. I yield.

The CHAIRMAN. Thank you.

And now we have Senator Cortez Masto.

Senator CORTEZ MASTO. Mr. Chairman, thank you. Thank you to the panelists here.

You know, in one of the hearing rooms across the way there is a hearing going on regarding the train derailment in East Palestine, Ohio. And let me just say, I think we should be doing everything to support the people living there, the businesses there, and hold accountable anybody who contributed to that negligence. But this derailment is one of the many reasons we, in Nevada, have se-

rious concerns with any potential efforts to move spent nuclear fuel and high-level radioactive waste to the proposed repository, Yucca Mountain. It is worth noting that the Yucca Mountain project would not be a small project. It would require the shipment of over 9,000 casks of high-level nuclear waste on 2,800 trains over the next 50 years through some of Nevada's most visited and populated areas and many other communities across this country. It is a prime example of why state consent is critical. Shipments would pass through communities throughout Nevada. It is vital we have a buy-in from all impacted levels of government.

When we are talking about nuclear waste storage, I appreciate the Chairman's comments on this and continued support. I also appreciate, Assistant Secretary Huff, your comments earlier today in your opening statement and the Biden Administration's continued commitment to consent-based siting for nuclear waste storage and disposal facilities. It is something we have to address. We all agree. We have to move forward to address this issue. And I am hopeful we can all work together to find a solution, because I think that is what it is going to require, not just for us, but the future generations, and moving into the 21st century with the technology that is out there that is going to provide us these opportunities to really find a solution here.

Assistant Secretary Huff, let me ask you this: your written testimony touched on existing nuclear waste recycling policies in France, other European countries, as well as Russia, China, and Japan. I am going to ask, and Dr. Wagner, you touched a little bit on this. How do these efforts compare and differ from ongoing U.S. recycling efforts, and Dr. Wagner, can you just speak to, a little bit more, what the laboratory is doing and conducting in this space? Is recycling possible?

So let me start with you, Assistant Secretary Huff.

Dr. HUFF. I will just briefly say that the United States, while we currently do not encourage commercial reprocessing actively, we are continuing and will continue to do research and development as the economics and safeguards and security of that technology evolve. We are supporting lots of research and development in advanced fuel cycles that improve those economics and improve the security of those technologies. I think there is a lot of hope for making sure that there are options in the future.

Senator CORTEZ MASTO. Dr. Wagner.

Dr. WAGNER. If I may, first, let me say the concerns there with the train derailment, I hope that that does lead to reforms. I will note that having been directly involved in designing and licensing spent fuel transportation casks, the level of rigor, as required by the Nuclear Regulatory Commission on those packages, is substantially different. There are some really interesting videos of trains being intersected directly perpendicular with casks and what happens. They are very, very robust systems. So I just would like to share that with you.

Senator CORTEZ MASTO. Thank you.

Dr. WAGNER. In terms of recycling, what are we doing, specifically? So you know, if you look back in history, a lot of that recycling technology, spent nuclear fuel recycling technology, was developed here in the United States. And for years, actually decades, we

did recycle, particularly high-enriched uranium spent fuel from the DOE reactors. That was an active thing that was being done. In many different cases, including naval spent nuclear fuel, as well as the Experimental Breeder Reactor-II, it demonstrated a closed nuclear fuel cycle. So again, a lot of that technology was developed here.

What we are doing currently is, we were already processing the HEU, high-enriched uranium material, for disposal. That was the intention initially. And as this need for HALEU developed, it was realized that rather than preparing this material as waste, we could actually clean it up a little bit further and use it as fuel again. And so that is what we are doing. But what we are doing is limited to the Department of Energy-owned material with specific goals of filling the near-term gap, in some cases, for HALEU.

Senator CORTEZ MASTO. Thank you. I appreciate this. And I appreciate your comments about the trains. And let me just say this, I am third-generation Nevadan. We were also told by the scientists in the Federal Government that atomic testing in Nevada deserts was safe for everyone. And that has proven not to be the case. So my concern is, we need to get this right and we have an opportunity now to really focus on moving forward. We know the science isn't safe at Yucca Mountain. It is proven. We have an opportunity to work together with new technology, moving forward to address this issue. We are operating under an archaic law. It is an archaic law that is basically saying, go back and review the Model T in a Ford manufacturing plant and tell us whether it is safe or not, when we are moving into the 21st century with new technology that gives us the ability to really focus on this for the future. And all I am asking—and I think many of us are—is let's get it right. We spent 40 years not doing anything, and it's wrong. It's wrong. And so let's get it right moving forward. Let's take the science. Let's take it and move this ball forward for everybody in our future.

And finally, and I appreciate, I know I am over my time. There is an opportunity with advanced nuclear reactors. And I am here to tell you, just because we are fighting to protect Nevada and the people and businesses that live there and the over 40 million tourists that come here from a storage site that is not technically sound by the science, does not mean that we do not support clean energy and this idea that this technology is going to take us in a new direction. But we also know that we have to get it right. And that is why we need to work together, not play politics with this important issue.

So I thank you for being here. I appreciate the comments today. And thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator.

Senator Hyde-Smith.

Senator HYDE-SMITH. Thank you, Mr. Chairman and thanks to our panelists for being here.

Mississippi is home to one of the largest U.S. nuclear power reactors at Grand Gulf in Port Gibson, Mississippi. And so nuclear energy is very important to Mississippi. It is not that far from my house. I have church members who work there and tell me about it all the time.

But Dr. Huff, this one is for you. Throughout the past decade, nuclear energy has proven to be one of the lowest cost and most reliable energy sources—things that we have talked about, utilized by the U.S. electric grid. And as we have discussed, the war in Ukraine has made it even more urgent that we reduce our dependence on Russia's enriched uranium. In your testimony you talked about doing just that. However, this Administration has made clear its hesitancy in doing so, given that is still has not sanctioned Russian uranium, unlike oil and the petroleum products, natural gas, or the coal. And I am of the mind that it is critical we cut off all Russian imports, including uranium. That has been discussed by many of my members here. The U.S. should strengthen its domestic nuclear fuel supply chain and again establish itself as a global energy leader.

What is stopping the U.S. from eliminating its reliance on Russia in the nuclear energy area?

Dr. HUFF. Senator, thank you so much for your support of nuclear energy in general, but also for this question. I think it is important and nuanced. And you are absolutely right that we must stop fusing the Russian government with the resources from purchases of uranium. However, it takes a while, a few years, to stand up new fuel cycle capacity to replace the capacity that we currently import from Russia and we have only a finite amount of inventory available inside this country. And so we want to make sure that the timing is appropriate such that we have incentivized the expansion of that fuel cycle capacity at the same time as pairing it with import restrictions. So these two must be paired in order to make the timing work out because it will take longer to stand up new capacity than the resources we have on hand to ensure the continued operation of our existing nuclear power plants without fuel disruption.

And so, what we need is a pairing of the import restrictions and incentives for that fuel cycle capacity to be stood up. Combining those financial incentives with an import restriction protects both. You can't do one without the other, and largely this is because of the very few, countably many, enrichment capabilities in the world. The only ones that are not state-sponsored or state-owned are ours, so, that is why.

Senator HYDE-SMITH. Very good way of articulating that. I am very impressed the way you could deliver an answer that is well said.

And what options could the Federal Government consider to accomplish the goal of increasing domestic capacity for uranium conversion and enrichment without competing with our commercial nuclear operators for a scarce resource, and are you considering other financing tools such as cost shares or loan guarantees?

Dr. HUFF. Thank you, again, for this question. It is an important one. So importantly, loan guarantees are available and I think can be used currently by the enrichers that may be interested in considering that. It would have to be because of rules about those loan program office guarantees. It would have to be separate from anything that I do out of my office, but currently that is available, but would just have to be carefully managed.

In terms of grants or cost shares, we identify the need to ensure some protection to the American taxpayer by structuring a strategy that would use long-term commitments for offtake agreements. We ensure that this is payment on receipt of the material, ensuring that, you know, the United States taxpayers' investment really goes to the production of material from new capacity. So that is the current plan of our uranium strategy. And we did consider, you know, grant opportunities and cost-share strategies, and we decided that the best way to protect the American taxpayer and really ensure that, you know, enrichers and converters get the, kind of, insurance that they need, would be through potentially long-term offtake agreements.

Now, this is all continuing to go through interagency concurrence, but I do expect something with an acquisition strategy to come out soon that does precisely this.

Senator HYDE-SMITH. Okay, thank you. I have got 20 seconds left, so.

The CHAIRMAN. Oh, I thought you wanted to use them.

[Laughter.]

The CHAIRMAN. That is exciting.

Senator King.

Senator KING. First, I want to ask Senator Cortez Masto, because I am a little confused—how do you really feel about Yucca Mountain?

[Laughter.]

Senator KING. I think that came through.

I wrote in big letters in my notes, the word "when." So let me start with small modular reactors, Dr. Wagner. I have been hearing about small modular reactors for a long time. It keeps getting further away. How close are we? Is this going to happen in the reasonably near future?

Dr. WAGNER. Absolutely, it is. And I certainly understand that it feels like it is been a while.

Senator KING. My father used to say if you drive straight at the Pentagon, it keeps getting further away, and that is sort of the way I feel about this.

Dr. WAGNER. Again, I certainly understand that. We, actually, at the Idaho National Laboratory, have published and made available what we see as a timeline of new nuclear reactor operations. And currently on that timeline you will find the UAMPS NuScale project, which is targeted for first commercial modular operation in 2029. They recently received the design certification from the Nuclear Regulatory Commission, which, admittedly, probably took longer than they had anticipated, which is part of the delays that you might see.

Senator KING. Do you think within the decade we are going to see commercial small modular reactors?

Dr. WAGNER. That is the——

Senator KING. This is being taped, you know, so.

[Laughter.]

Dr. WAGNER. Yes, I mean, they have been working toward that schedule of summer of 2029 for the first commercial module for some time now. And as far as I understand, they are on schedule,

provided, you know, they continue to have the financial resources that they need to do that, of course.

Senator KING. Thank you.

The other "when" question is nuclear waste. There are now 21 stranded nuclear waste sites in the country. One of them is in Maine, which is essentially a high-level nuclear waste site, and there are about 80 or 90 others that are operating nuclear plants. So it is not as if to say we do not have nuclear waste storage. We have it. It is scattered all over the country, which is probably the worst solution. When, Dr. Huff, do you anticipate having an answer to a question that has been pending since the early 50s?

Dr. HUFF. Thank you for this question. It is certainly the case that having 76 locations of interim storage is significantly worse than consolidating and having one or two or just a couple of federal interim storage sites. We are excited to be actually making progress now with the appropriations from Congress around consent-based siting. We have released, closed, and are now reviewing applications for a funding opportunity announcement of $26 million that will be sent out to communities to explore their own interests and understanding of spent nuclear fuel interim storage, and we——

Senator KING. There are places in the country that are at least interested in considering hosting one—this site. Is that correct?

Dr. HUFF. Yes. We expect—yes.

Senator KING. And then you have to deal with the transportation issue, which, I think, is a very relevant one.

Dr. HUFF. A couple of years.

Senator KING. A couple of years, Okay. You are on record as well.

Mr. Dominguez, one of the questions about nuclear power—and I realize that you are in the operation, not the construction business—is the cost. Do you have—offhand, do you know a rough figure for cost per megawatt of the construction of a new nuclear power plant?

Mr. DOMINGUEZ. Well, you know——

Senator KING. I have seen the figure $5 or $6 million a megawatt. Is that accurate?

Mr. DOMINGUEZ. My own view, and you rightfully pointed out that this isn't our business model, but my own view is that probably your first-of-a-kind costs are going to be in that area. I think you can trend down to about $3,500 is the ambition. Now that——

Senator KING. $3.5 million, you mean.

Mr. DOMINGUEZ. Yes.

Senator KING. Per megawatt.

Mr. DOMINGUEZ. Yes.

Senator KING. But now let me ask a question you may know the answer to, and that is, what is the cost of maintaining or life extension of an existing nuclear plant per megawatt?

Mr. DOMINGUEZ. The process is about $35 million to $60 million for the entirety of the plant, and the reason for that, Senator, is that throughout the life of the plant we are consistently replacing pumps and other big modules in the plant. So at any given moment, even if we are approaching the end of license life, the plant is in the operating condition that it can continue to operate. So it is effectively licensing. You might have some cable work that you

are doing, some underground piping work that needs to be replaced, but it is an incredibly modest cost there.

Senator KING. It is in the realm of fiscal feasibility.

Mr. DOMINGUEZ. Not only is it feasible, it has been done, and we did it at Peach Bottom to go to 80 years. We are in the process of doing it at other dual-unit sites. It is a very modest cost.

Senator KING. Because one of the problems with our energy markets today is that it favors today cost and does not take into account capital costs. So low capital costs—gas is the example.

Mr. DOMINGUEZ. Right.

Senator KING. Where it is low today, but you are on the fuel roller coaster, but you are talking about investments that are high capital, but low operating once you get going.

Mr. DOMINGUEZ. Right. In our case, again, because the machines are already operating and we are consistently replacing component parts, the machine is as good or better as the day it started, and it is perfectly capable of continuing to operate beyond license life.

Senator KING. One final question, for the record, because I am out of time. What lessons have we learned from Zaporizhzhia about the vulnerability of nuclear plants? Because Zaporizhzhia has not been attacked directly, but just this morning, they cut the power lines and it does not have the energy to cool the plant. They are having to use diesel. They have three weeks supply of diesel. I hope we are learning something from this experience, and I would be interested in your thoughts on that, for the record.

Mr. DOMINGUEZ. Yes, I think——

Senator KING. That means give me a written answer because I am out of time.

Mr. DOMINGUEZ. Okay.

Senator KING. The Chairman will scold me, and I don't want that.

The CHAIRMAN. I am not going to scold you. If you want to answer, you can answer.

Senator KING. Well, there you go.

Mr. DOMINGUEZ. Senator, I think those lessons largely have been learned by the industry through a similar occurrence in Japan, right, where the lack of onsite fuels to support continued operation of cooling systems ended up becoming a pinch point for the operation of bad assets. So I think we have adopted a number of technologies already to ensure that we continue to operate if we are disconnected from the grid. Now, the question of actual, physical military attack on a reactor is quite a different thing, but I think you are focused on——

Senator KING. No, I understand that. I am more worried about a cyberattack that would disable the grid.

Mr. DOMINGUEZ. Yes, and I think we have already built in that capability based on what happened at Fukushima.

Senator KING. Thank you.

The CHAIRMAN. Senator Hawley.

Senator HAWLEY. Thank you, Mr. Chairman.

Dr. Huff, you stated in your prepared testimony the importance of appropriately locating nuclear waste disposal locations. Have I got that right? And you talked with Senator Cortez Masto just a second ago at some length about this. Can you agree—can we agree

that at the very least, wherever we think about locating nuclear waste—probably not a great idea to have it in proximity to school children?

Dr. HUFF. School children are very important and their safety is very important, yes, sir.

Senator HAWLEY. So you are aware, I hope, that is unfortunately exactly what happened, however, in my home State of Missouri. At Jana Elementary School in the Hazelwood School District in the St. Louis area, we have nuclear material that is not only in proximity to a school, it is actually on school grounds. The school has had to be closed as a result of this. I know that this is not your portfolio at the Department of Energy, but you do work for the Department of Energy. So I just want to register, once again, my displeasure at the fact that the parents and teachers at this school cannot get any answers from the Department of Energy. I can't get any answers from the Department of Energy. I can't get any answers from the Army Corps, and currently, the Department of Energy and the Army Corps of Engineers are each blaming each other for this situation, which is decades in the making. And as a result, these school kids, who knows what they have been exposed to, and they can't go to school at this location.

So I am just pointing this out, once again, and you can take this message back that I am serious about this. I have written to the President about it. I need him to get his Administration into line. I don't care whose jurisdiction is what—this, that, or the other. I want this fixed for these school kids, and until we get some answers here, and frankly, some justice for these school kids, I am going to hold every nomination at the Department of Energy. And I have done this before. We have been down this road before. And I will do it as long as it takes. I want to be on the record. I want to be crystal clear about this. I will do this as long as it takes until we get some fidelity for what happened to these school kids. And just because these kids and their parents are not big-time donors, doesn't mean that they can be ignored. And frankly, I am pretty mad about it, and I am tired of getting the run-around, and I am even more mad that they have gotten the run-around for years.

So that is just—you can take that message back and say that Senator Hawley was not in a good mood.

Let's talk a little bit about China, if we could. Just give me a sense, Dr. Huff, how reliant, to your knowledge, are U.S. nuclear power producers on Chinese suppliers, whether that is for the reactors themselves or for components? What's your sense of this?

Dr. HUFF. Yes, so it is increasing, certainly in the context of components, as you think about the amount of supply chain capability that China has. Their ability to supply components for nuclear reactors is increasing over time, but it is pretty limited, actually, in terms of the fuel, and it is actually possible that Mr. Dominguez might be better at describing this in terms of his own company, but——

Senator HAWLEY. Go ahead, Mr. Dominguez, weigh in on this, if you would.

Mr. DOMINGUEZ. I think Dr. Huff said it right. It is, compared to Russia, a relatively minor piece of the supply puzzle, as speaking principally for our company. Look, we are going to buy from every-

one, and we have bought from everyone historically, certainly before this geopolitical event, just from a risk management perspective. So we have got a toe in the water in a lot of places, but China is a very small thing.

Senator HAWLEY. Let me come back to you, Doctor, if I could. What steps is DOE taking to move our nuclear energy supply chains out of China so that we don't have any reliance on them?

Dr. HUFF. Thank you for this question. It is important to the Department of Energy that we diversify these supply chains. We have written a supply chain report, actually, on a number of different energy technologies, including advanced and small modular nuclear reactors that expands on what the bottlenecks are and where industry can contribute to increasing the robustness of those supply chains and which particular components are going to need more, you know, domestic and allied support. So I would refer you to that report, which is pretty great, actually.

Senator HAWLEY. Let me ask you about espionage in this space. Beijing has said that it intends to double China's nuclear power capacity by 2035. We know that they have used—they meaning Beijing—has used economic espionage to advance all aspects of its industrial agenda over decades now and have had, sadly, quite a bit of success at using espionage to do that. Are you aware of Chinese intelligence services targeting employees or others in the U.S. nuclear industry for purposes of gathering intelligence that Beijing that can then use for their own goals?

Dr. HUFF. Thank you, Senator. I take classified information very seriously, and I would refer you to our intelligence colleagues and maybe in a more classified setting for some of this specific information, but I will say the following—that it is certainly the case that the United States has indicted one Chinese company in relation to this a couple years ago.

Senator HAWLEY. Great. Well, my time is expired. I have got a couple more questions for you along these lines for the record and I will give them to you there.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator.

Senator Hickenlooper.

Senator HICKENLOOPER. Thank you, Mr. Chair. Thank all of you for spending time with us today. I appreciate your testimony.

Dr. Huff, let me start with you. So much of today's conversation is focused on how the nuclear fuel cycle supports commercial reactors, but it also supports reactors for research, for education. Small research reactors are, I think, a big part of the U.S. infrastructure, supporting numerous scientific disciplines. Our CHIPS and Science Act passed last Congress. That anticipates more investment in this capacity. Some of these research reactors are held by federal agencies other than DOE—by university partners. One example is the U.S. Geological Survey research reactor in Colorado, which is operated in conjunction with the Colorado School of Mines. As a former geologist, I take this all very close—I hold it very closely.

How can the Department of Energy ensure effective coordination with other agencies to ensure the most intelligent deployment of resources to meet the national need for research and workforce?

Dr. HUFF. I am so grateful for this question. This is in an area really close to my heart, as a former professor. I know personally students and faculty at the Colorado School of Mines that leverage the reactor you are talking about. It is absolutely essential, and is part of my office's university programs, to support those reactors through fuel provision and through infrastructure support. Now, within that, you know, universities and such have an opportunity to ask for infrastructure support to upgrade their capabilities, to digitize their control systems, et cetera, and it's critical for our students and for our workforce to have hands-on experience with a reactor before they go work for Mr. Dominguez at a really big commercial-scale plant.

And so, in our University Programs Office, we are constantly engaging with the TRTR committee, the Test Research Reactor Committee that operates these reactors to get more information about what they need and what should the future be of, perhaps, future reactors.

Senator HICKENLOOPER. Great, thank you.

Dr. Wagner, you talked about how your laboratory can inform policy debates on the technology for interim storage, geological disposal and certainly, the eventual resolution of these longstanding debates is going to require Congressional action to create a consent-based nuclear waste management framework. Obviously, and I think it is not just me that would think this, the key is going to be an informed community. Senator Cortez Masto has already talked about the importance of that. How might your laboratory's technology development and outreach be helpful to a community that might be considering hosting a facility, and how should that be reflected in the framework?

Dr. WAGNER. So first of all, thank you for that question. As Dr. Huff mentioned, the Department is actively processing grant proposals for helping communities do just that. That being to understand the technologies and the issues around spent nuclear fuel storage and transportation and ultimate disposal. And then, we can be a resource to any of those communities through those grants or otherwise for such information, but we would work in coordination with the Department of Energy.

Having said that, one of the things that we do is, as the nuclear energy laboratory, all the time, is to try to help people understand questions that they have about nuclear energy, about spent nuclear fuel, about recycling, you know, whatever is on their minds. So on our own, we frequently host town-hall type sessions in communities to do just that as well. So I can see an opportunity and a need to expand that even further.

Senator HICKENLOOPER. Yes. I think it is going to be one of the real keys of resolving this, is making sure that we have much, much more outreach, and well-structured outreach so it really connects with people.

Dr. Huff, again, I understand spent fuel is being stored safely at sites today, and you said the Department is working under existing authorities to make progress on federal interim storage facilities. You mentioned further constraints that need to be addressed before DOE can construct and operate a federal interim facility. What are

the constraints that need to be addressed? What should we be working on?

Dr. HUFF. Thank you, Senator. I really appreciate that.

The Nuclear Waste Policy Act currently links the siting of a final repository with the construction of an interim storage facility. And so, in order to actually construct an interim storage facility, one may need to reevaluate that linkage. Now, I recognize that it is critically important that an interim storage facility not become the de facto permanent repository. And so that is the motivation that led to that linkage. However, right now, of course, the Nuclear Waste Policy Act also identifies the final repository as Yucca Mountain, which, I think you have heard, you know, is not politically feasible and we do not need to continue to move forward that way.

Senator HICKENLOOPER. Certainly not popular.

Dr. HUFF. There you go.

Senator HICKENLOOPER. Got it. All right. Point made. Thank you. I appreciate it. I yield back.

The CHAIRMAN. Thank you, Senator.

Senator Murkowski.

Senator MURKOWSKI. Thank you, Mr. Chairman. I appreciate the hearing this morning as we are talking about our nuclear fuel cycle. Sometimes I get people looking at me a little bit quizzically, like why would an Alaskan Senator really be caring about nuclear. We do oil. We do gas. We do coal. We do everything else—wind, solar, everything out there. We have tried a little bit with nuclear, but the reality is that given our geography, given our small size, and given our challenges in accessing our own energy resources, we are looking with great, great interest to the small modular reactor, the advanced reactor concepts. And so this is something that when I am going to speak to the state legislature, people want to know when are these going to be commercial? They are excited about it in ways that you can't even imagine. Small villages that are currently dependent on diesel-powered generation are looking to the small modular reactor for that energy lifeline.

And so there is great interest, not only in villages, but remote resource projects where you have extraordinary resource—maybe it is mineral wealth—but what you don't have is any means to power your facility there short of barging in diesel up the river at extraordinary cost, and just not the way of the future. So we are very, very, very keenly interested in it, and the promise of advanced reactors, of course, is set to be realized in the state. We have the Department of Defense and DOE who chose Eielson Air Force Base to pilot a program there to increase resilience in DOD buildings. So there is going to be one microreactor by the end of 2027. So that is coming online sooner. DOD released their RFP in September of last year to supply one microreactor. It's on schedule, we understand to select a vendor, begin the permitting and the licensing process later this year.

But again, when you think about the nexus between energy security and national security, it's right here. It's right now. The microreactor will supplement the current energy sources as a redundant resilience measure, which they really need in the interior there. But it's a big deal for the military to ensure that operational capacity. So there is a lot of interest in this.

So I am going to ask a question to you, Dr. Wagner, and then to you, Dr. Huff, on the advanced reactor. Idaho National Lab is also in the process, again, of the Advanced Reactor Demonstration Project. You have a small modular reactor with six modules planned for deployment. You indicated that by 2029, it will achieve first commercial operation. Can you share with the Committee how the permitting and the licensing is proceeding for this and what more we can do to improve the process out there because, again, there is a great deal of interest, but 2029, 2030, sounds like a long ways off. Do you think these timelines are reasonable?

Dr. WAGNER. There are several questions there.

Senator MURKOWSKI. There are.

Dr. WAGNER. First of all, thank you for the questions, and I am very excited about what is happening in Alaska. I have had the opportunity to visit your state and actually to talk to representatives from different communities up there, particularly remote communities that are very reliant on the diesel fuel situation that you articulated. And also, this gives me an opportunity to maybe elaborate a little bit on the question about SMR timelines. So I specifically responded to that question in the context of what I consider small modular reactors. Small modular reactors, I consider in the order of a few hundred megawatts. So it's the X-energy technology, for example. It's part of the ARDP. It's the TerraPower, also part of the ARDP. It's the NuScale reactor, which will be deployed by UAMPS. GE also has a boiling water SMR, so it's in that size range that I was referring to that timeline, to be clear.

At the laboratory, we are working with several different partners, including the Department of Defense, to demonstrate several reactors this decade, before that 2029 date that I mentioned. The ones coming before that, in particular, are what we call microreactors. So anywhere from several hundred kilowatts in size, to maybe ten or a little bit more megawatts in size, and the kind of microreactors, I think, that you are referring to.

We do intend to have three new microreactors demonstrated on our site by 2025—I will say 2026, at the latest. And those are going to be DOE-authorized. We are a DOE laboratory, and so there is a different authorization process for that, and they are smaller systems than say a gigawatt-scale system that my colleague here operates, so we can move at a much faster pace. I would expect NRC-regulated microreactors to be operational in, say—and I am approximating here, these are commercial schedules—2026 to beyond. That kind of timeframe is what I would expect.

I do think there are opportunities within the Nuclear Regulatory Commission to accelerate the time it takes to license these systems and I would welcome further dialogue on that.

Senator MURKOWSKI. I think we are all interested in that.

Mr. Chairman, I am over my limit, but can I just ask one quick question to Dr. Huff?

The CHAIRMAN. Absolutely.

Senator MURKOWSKI. Thank you.

And this, also, is staying on the topic of advanced reactors, but you had mentioned in your written testimony that advanced reactor fuels have several advantages over standard light-water reactor fuel forms, but that safely and securely storing the waste needs to

be more fully studied, is what you have shared. Can you, very quickly, given the generosity that has been provided here with me for time, share some of the advantages and the challenges on both the front and the back end when we are talking about advanced nuclear?

Dr. HUFF. Certainly. Many advanced nuclear fuels can reach extremely high temperatures, like tri-structural isotropic fuels, which have silicon carbide spheres around the kernels of fuel, keeping them, you know, at robust to extremely high temperatures, well beyond the temperatures of lava or the sun. I mean, this is a real advantage right, because it is well beyond what you would expect in the temperatures of a reactor loss of coolant accident or anything like that.

They also have efficiency improvements, you know, with high-assay low-enriched uranium, you can be much more space efficient with the size of your reactor, which is why we are seeing a number of small modular advanced reactor designs leveraging that higher assay enrichment. And generally speaking, when we talk about the spent fuel question, we have stored, managed, and safely contained spent nuclear fuel from a variety of nuclear reactors, including high-temperature gas reactors and sodium-cooled fast reactors, all the kind of classes of spent nuclear fuel that we expect to see for this new set of advanced commercial reactors, but for every type of new fuel there is certainly a little bit of extra attention that one needs to pay to make sure that every package is fully certified by the Nuclear Regulatory Commission to the fullest extent for those particular fuel characteristics. And so we are ready to support those analyses at national labs like John's.

Senator MURKOWSKI. Very good.

Mr. Chairman, thank you so much for the extra time.

The CHAIRMAN. Thank you.

We are going start our second round while we wait for Senator Hoeven, and I am going to defer and go right to Senator King.

Senator KING. Thank you.

I appreciate Senator Murkowski's question and I just want to point a fine point on it. Is the delay—whatever it is, whether it is three years, six years, eight years, ten years—in commercializing this technology technological or permitting?

Dr. WAGNER. So——

Senator KING. In other words, could one be built tomorrow? Is the technology settled? Is the design—are there completed designs that are shovel-ready, if you will?

Dr. WAGNER. So the most important thing that affects a schedule is to get approval from the safety authority.

Senator KING. So that is permitting.

Dr. WAGNER. Yes, we usually refer to it as licensing, but yes, it is permitting, and for a commercial project that wants to put power on the grid, that has to go through the Nuclear Regulatory Commission, and that does take, you know, a significant period of time. So even if the design is 100 percent set, which usually through a licensing process there are, you know, there are things that change to some degree, you still have to go through that licensing process and also, we haven't talked as much about it—work through the

supply chain issues with actually building and demonstrating the reactor.

Senator KING. Well, no one wants to short-circuit the safety process. On the other hand, it is a question of how long does it take? Eisenhower retook Europe in 11 months. Pretty complicated challenge. So I just hope that is something—I would like to follow up, Mr. Chairman, about the timing of the permitting process and how long that takes.

Second question, I just wanted to follow up, Mr. Dominguez. You mentioned that the U.S. nuclear industry has taken account of what is happening at Zaporizhzhia already. Does that mean that every nuclear plant has onsite fuel storage and diesel generators that would support its operation if there is a transformer taken out or a high-KV line is taken out?

Mr. DOMINGUEZ. Yes, but Senator, I am glad you came back to the issue because the Zaporizhzhia example does give me a little bit of pause because what we are talking about here is a weather event or a grid emergency that prevents the ability to bring on energy from the grid for days.

Senator KING. Right.

Mr. DOMINGUEZ. What they are facing there is, of course, exponentially more challenging, the destruction of the grid, repairs of which could take many weeks. So I don't want to overstate the point. What we have done is a risk analysis for a multi-day event where you don't have offsite power, and all of the stations in the U.S., to my knowledge, are capable of dealing with those emergencies. That is more similar to Fukushima, frankly, than what is going on in the Ukraine, which is unparalleled.

To the extent you are asking the question of whether or not we have taken the next step, and kind of tried to imagine that sort of event occurring where is there is a military attack on the grid that takes it out, or a cyberattack that takes it out for multiple weeks, I wouldn't say the protection would last that long, nor do we see the risk profile the same way, obviously, as the Ukrainians are facing.

Senator KING. Well, if there is anything we have learned over the last 20 years, it is that we have to think the unthinkable. September 11th was a failure of imagination on our part as to what the risk was. So this is one where we are seeing it happen in real life. I hope the industry will take cognizance of this because in case of a conflict, and even short of a conflict, a cyberattack on the grid is likely to be one of the first steps. So I hope that is something that the industry will take account of.

Thank you. Thank you, Mr. Chairman.

The CHAIRMAN. Senator Barrasso.

Senator BARRASSO. Well, thanks, Mr. Chairman, just a couple of quick questions.

Dr. Huff, you know, you led the Department's efforts to ensure domestic supply of uranium for existing and advanced reactors and you are in a leadership role there. This includes having the Department buy uranium. How are we going to ensure the Department's efforts won't compete with utilities, which also need domestic uranium to eliminate their own reliance on Russia?

Dr. HUFF. Yes, so our intent is to buy and then redistribute to those commercial interests, so you know, utilities in need of that fuel would be assured that fuel supply through our purchases, but we would not be amassing it over time, but rather making it available.

Senator BARRASSO. Thank you.

And then, Mr. Dominguez, the Nuclear Energy Institute says that it supports Yucca Mountain as the nation's first repository site. The Nuclear Energy Institute believes that we need to reach a decision on Yucca Mountain. Why is it important for the Nuclear Regulatory Commission to reach a decision on the Yucca Mountain license application?

Mr. DOMINGUEZ. The industry's view is that we need to get through a licensing process, even if, ultimately, that site is never used, that it is important to exercise this muscle and to make sure we get through the licensing process, recognizing the strong opposition, frankly, to Yucca and the reality that it may never be used.

Senator BARRASSO. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you.

Senator CORTEZ MASTO. I am happy to follow up on that.

The CHAIRMAN. Let's go. You go, girl. You go.

[Laughter.]

Senator CORTEZ MASTO. Because, as we all know, short of licensing, there could be legislation that outlaws or does away with a failed site that obviously is not moving forward, that actually puts us on a path to address this waste. Isn't that correct, Mr. Dominguez?

Mr. DOMINGUEZ. Yes.

Senator CORTEZ MASTO. Yes. So there is an option, and obviously there is a role for us in Congress to play and we should just be paying attention to it. Listen, we have been living in the past for a long time now. Let's start moving forward, including bringing our laws with us, and that is the consent-based siting. There is an opportunity here for all of us, including the nuclear industry, to move forward. Don't you think?

Mr. DOMINGUEZ. I should hope so.

Senator CORTEZ MASTO. Yes.

Mr. DOMINGUEZ. To your point, it has been talked about for quite some time. It is time to get to the finish line.

Senator CORTEZ MASTO. I agree.

While I have an opportunity, Assistant Secretary Huff, there are experts that have recommended taking the Civil Nuclear Waste Program out of DOE. And I believe when we talked last time, in December, I had asked you about whether the Administration had taken a position on that. And I am just curious, has there been discussion about a new waste management organization since then or is that off the table?

Dr. HUFF. Thank you for this question. Yes, it is certainly the case that the Blue Ribbon Commission recommendations include a new nuclear waste management organization that would have a more fulsome capability to control the fund. I think that does have significant merit. It is a constant topic of conversation internal to my office because as we explore the full universe of options that a consent-based siting process for interim storage—it would result in,

sort of, informing that permanent storage capability. We expect that this will be definitely on the table and in those conversations, and I think it has some merit, yes.

Senator CORTEZ MASTO. Thank you.

And then finally, going back to Senator Heinrich's conversation about the definition of advanced nuclear technology, I have heard here micro, but also small, but is it an industry term or do we need in Congress to be defining this so others are not having the ability to abuse it somehow based on the conversations that we have had this morning? I am just curious and I don't know if anybody wants to take a stab at that.

Dr. WAGNER. I will throw in with an opinion. The industry does have working definitions for what is a microreactor. I think the common definition, there may be some variations, just to be clear, but I think the common definition is up to 20 megawatts. And then small modular reactors are kind of above that, up to several hundred megawatts. I think at one point the definition might have been up to 600 megawatts. And then, the traditional gigawatt scales are the large reactors.

Senator CORTEZ MASTO. But you say the industry has defined it. So everybody is consistent and believes that? So that's a question—that we in Congress would just automatically use that definition?

Mr. DOMINGUEZ. Senator, what I was saying—referring to earlier—it is a definition, but it is an incredibly broad one, right? We are really talking about over 20 megawatts, and up to 500 or 600 megawatts is an enormous, you know, difference. I think it is less important, ultimately, the size from the commercial standpoint than the ability to manufacture the components in a production line in a way that is going to reduce the time to get these assets built. And while that is largely size-dependent, it is not entirely size-dependent.

Senator CORTEZ MASTO. Okay. Thank you. I appreciate that.

The CHAIRMAN. Well, let me just say thank you to all three of you. It has been tremendously informative and we appreciate—I think you can tell by the questions and the staying for the second round. I truly believe what we have been able to turn around in a very short period of time is the rational, responsible, reasonable thinking of what we are going to do as a nation, how we are going to deliver the dependable, reliable, affordable power we need and continue to do so.

I have one idea. I said, you know, if we don't change the pricing structure basically in merchant markets, we should maybe think of creating a national nuclear market. A national nuclear market will basically—it would not subsidize but it would solidify the normal pricing, because if you are in one state, my state is a cost-reimbursed state. I have no nuclear. Other states that are in, like, let us say, Illinois, which is a merchant state, they have a hard time. They can't ramp up and down and compete. So that is the problem they are facing. We know that, but we have to have nuclear in the mix.

One question I have—do you think 20 percent is the right mix for nuclear, or can it go higher?

Anybody?

Joe, you want to start?

Mr. DOMINGUEZ. Well, look, I think it could certainly go higher.

The CHAIRMAN. It stayed about 20. It has been about 20 for quite a while, right?

Mr. DOMINGUEZ. It has been 20 for a long period of time.

The CHAIRMAN. Yes.

Mr. DOMINGUEZ. But it's 20 percent of what, right?

The CHAIRMAN. Exactly.

Mr. DOMINGUEZ. We are talking about this energy transition——

The CHAIRMAN. Right.

Mr. DOMINGUEZ [continuing]. Where we are electrifying everything, light duty vehicles, everything. That pie is going to get bigger, so the 20 percent is going to be relatively larger. That is where SMRs play. In my view, the need for baseload power is far greater than 20 percent, and I think that has been demonstrated time and again. So if what you are really looking for is a zero-emission resource that is also baseload, start getting in your head replacing the percentage that coal and nuclear together historically occupied in the grid. That is really your target.

The CHAIRMAN. Same question.

Doctor.

Dr. WAGNER. I agree with that completely.

The CHAIRMAN. Yes.

Dr. HUFF. And I will just add that the President's "Pathways to Net Zero" report that does some analysis on this, completely agrees with this assessment that the amount of clean, firm power needs to increase to completely fill what is currently, you know, all firm power.

The CHAIRMAN. Yes, okay.

Well, again, let me say thank you. I appreciate it very much.

Members will have until the close of business tomorrow to submit any additional questions for the record.

And with that, thank you, and the Committee is adjourned.

[Whereupon, at 11:46 a.m., the hearing was adjourned.]

APPENDIX MATERIAL SUBMITTED

U.S. Senate Committee on Energy and Natural Resources
March 9, 2023, Hearing: *The Nuclear Fuel Cycle*
Questions for the Record Submitted to The Honorable Dr. Kathryn Huff,
Assistant Secretary for the Office of Nuclear Energy

QUESTIONS FROM RANKING MEMBER SENATOR JOHN BARRASSO

Q1. You stated in your written testimony that the Department of Energy (DOE) has initiated National Environmental Policy Act (NEPA) reviews associated with its efforts to establish a domestic supply of high-assay, low-enriched uranium (HALEU) for advanced reactors. During DOE's industry day held last year, and in conversations since then, the nuclear industry, key stakeholders, and NEPA experts share a consistent view that DOE's plan to spend two years developing an environmental impact statement (EIS) represents an unnecessary delay and is duplicative of work that has been, or will be, done by the Nuclear Regulatory Commission (NRC). This concern was echoed in an article the nuclear energy advocate group, the Breakthrough Institute.

Q1a. Is the Department coordinating its NEPA review with the NRC to ensure the Department isn't duplicating or engaging in NEPA reviews that should or will be the responsibility of the NRC?

A1a. The Department of Energy (DOE) is committed to complying with its National Environmental Policy Act (NEPA) obligations in an efficient and timely manner. DOE has and will continue, as appropriate, to coordinate with Nuclear Regulatory Commission (NRC) on the Department's efforts related to establishing a commercial domestic HALEU production and supply chain capability for the long term. As planned, DOE's EIS will utilize, wherever appropriate, previous NEPA analysis of NRC or other agencies to avoid duplication of effort.

Q1b. How will the Department's NEPA review impact nuclear fuel suppliers as they work to bring the needed capacity online?

A1b. There are a wide range of actions nuclear fuel suppliers could take relative to bringing capacity online. In general, any action funded by DOE would need to be evaluated by the Department to assess if it would be an allowable interim action pursuant to the Council on Environmental Quality (CEQ) NEPA regulations at 40 CFR parts 1500 et seq., and the DOE NEPA implementing regulations at 10 CFR part 1021. Any activities conducted before the completion of NEPA may not have an adverse environmental impact or limit the choice of reasonable alternatives (40 CFR § 1506.1(a)). Further, DOE may not commit resources to activities that prejudice its selection of alternatives before making a final decision (40 CFR § 1502.2(f)).

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Q1c. Will companies be prohibited from making long-lead-time purchases while they await completion of DOE's NEPA review?

A1c. If the action is to be funded by DOE, DOE would need to make a fact-specific determination as to whether the purchase of the long-lead time equipment is an allowable interim action. If an awardee chooses to proceed with the procurement of such equipment using non-Federal funding, the awardee would be proceeding at its own risk.

Q2. What is the current status of the Department's accident tolerant fuel program, including activities associated with silicon carbide?

A2. The Department continues to support the U.S. nuclear power industry's goal to begin to introduce reload quantities of accident tolerant fuel concepts in commercial reactors in the mid-2020s and achieve wide-spread deployment and full safety and performance benefits several years after that. The Department's support consists of financial assistance as well as the technical expertise and facilities at the national laboratories needed to assist industry to qualify the fuel for use in their reactors.

The three U.S. fuel vendors receiving financial assistance have submitted and continue to submit numerous topical reports to the U.S. Nuclear Regulatory Commission that the Commission reviews and approves in a timely manner. License amendments are being reviewed and approved by the Commission that address modifications to the vendors' fuel fabrication facilities and fresh fuel transportation packages. Test rods of accident tolerant fuel concepts by all three vendors have been placed in eight commercial reactors, the first in 2018. Some are being removed periodically and shipped to the national laboratories for examination. Data from these examinations become part of the vendors' topical reports. Other test samples are being irradiated in DOE facilities and examined, also becoming part of topical reports.

Industry's current focus is on near-term accident tolerant fuel concepts: chrome-coated zircaloy cladding and incorporating small amounts of additives or dopants into the uranium dioxide fuel pellets. Silicon carbide cladding has the potential for greater safety

and performance benefits but requires several more years of research and development to reach the state that the near-term concepts have now achieved. Large and small commercial firms as well as national laboratories and universities are making progress in resolving performance and manufacturing issues. Test samples of silicon carbide cladding are being irradiated in test reactors and examined at the national laboratories. It is expected that the first full size test rods will be placed in a commercial reactor within several years.

Q3. Section 40321 of the Infrastructure Investment and Jobs Act (IIJA) (42 U.S.C. 18751) defines micro-reactors and small modular reactors. Section 327 of the John S. McCain National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2019 (P.L. 115-232) and section 320 of the James M. Inhofe NDAA for FY 2023 (P.L. 117-263) also define these reactors, albeit slightly differently, with the FY 2023 NDAA definition for micro-reactors tailored to transportable micro-reactors. These definitions are not necessarily consistent with what various nuclear organizations use.

Q3a. Why aren't consistent definitions used across the nuclear sector?

A3a. As opportunities for advanced nuclear energy technologies to be deployed expand, the definitions of microreactors and small modular reactors have evolved. The various definitions used by Congress exemplify that evolution. The nuclear energy sector, including an effort led by the Gateway for Accelerated Innovation in Nuclear (GAIN), is working towards development of standard definitions.

Q3b. Do you agree it would make sense for the nuclear community to coalesce around the definitions found in the IIJA? If not, why not?

A3b. Due to the dynamic and contextual nature of language, a continued evolution of these terms can be expected as these reactor families commercialize. Because the IIJA definitions primarily distinguish reactors by size, these definitions of microreactors and small modular reactors will be ideal for many contexts. However, defining reactors only by their electric power production capacity does not consider the importance of other key attributes offered by technologies, such as the output temperature for non-electric industrial applications or a technology's modularity.

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Q4. Section 40321 of the Infrastructure Investment and Jobs Act (IIJA) (42 U.S.C. 18751) directed DOE to submit a report on opportunities for micro-reactors and small modular reactors (SMRs) enhance energy resilience and reduce carbon emissions. The section further directed DOE to offer financial and technical assistance to conduct feasibility studies for deployment of micro-reactors, SMRs and other advanced reactors in isolated communities. What is DOE doing to meet the requirements of this section?

A4. The Department of Energy is preparing the report required by Section 40321 of the Infrastructure Investment and Jobs Act on utilizing small modular reactors and microreactors to enhance energy resilience and reduce carbon emissions. Once approved for release, the report will be provided to Congress.

Q5. Laser enrichment technology is an inherently modular and flexible process that could be ideal for producing the various quantities and enrichment levels needed for existing and future reactors.

Q5a. What is the Department doing to support the commercialization of laser enrichment technology?

A5a. Demonstrating uranium enrichment on a commercial scale using laser technology, to date, has not occurred. However, the Department, through its Office of Environmental Management, supported laser-enrichment technology development via a competitive award in 2016. The Office of Nuclear Energy (NE) continues to keep a close eye on the progress of the technology.

Q5b. The Department plans to pursue offtake agreements to spur commercialization of high-assay, low-enriched uranium enrichment. Is DOE also considering additional cost-share agreements beyond the current one with Centrus to demonstrate innovative enrichment technologies?

A5b. The Department, through NE, plans to pursue pay-for-production offtake agreements for HALEU. These are not intended to result in cost sharing agreements. However, NE will supplement this pay-for-production element of the HALEU Availability Program with Funding Opportunity Announcements using funding provided by the Inflation Reduction Act of 2022 to enhance the HALEU supply chain. These are anticipated to be competitively awarded, cost sharing agreements.

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QUESTIONS FROM SENATOR CATHERINE CORTEZ MASTO

Q1. In response to my question on nuclear waste reprocessing and recycling, you recognized that while the United States does not currently encourage nuclear waste reprocessing, the Department is continuing to carry out research and development in this space.

Q1a. Does the Department currently view the reprocessing of used nuclear fuel as economically viable? If not, what market conditions would be necessary for it to become viable?

A1a. Currently, there is no U.S. government policy that restricts commercial nuclear fuel recycling in the United States. As a matter of policy, the U.S. government discourages foreign partners from developing their reprocessing capabilities because of the proliferation and nuclear security risks such activities can pose. The Department is currently focusing on developing simplified technical processes that can reduce the cost of recycling used reactor fuel. The goal is to continue research and development into technologies that may support a commercial business case.

Q1b. Is used fuel from advanced reactor designs suitable for reprocessing (i.e. Do the new fuel types make it easier or harder to reprocess)?

A1b. Advanced reactors use a wider range of fuel forms than the current generation of light water reactors. Although different advanced fuel forms will present unique recycling technology challenges, none of the advanced reactor fuels are considered more suitable or unsuitable for recycling. The issue, at present, is related to the maturity levels for recycling technologies for the various fuel forms.

Q1c. What are the proliferation concerns with advanced reactor fuel?

A1c. Reactor fuels are subject to domestic and international nuclear materials security and safeguards measures. Existing, well-developed Material Control and Accounting (MC&A) procedures enable commercial Light Water Reactors to operate securely. The Department will continue evaluating the proliferation and security risks of advanced reactor fuels. Some advanced reactors envision new fuels with yet-to-be-developed MC&A approaches. The Department, for example, is working with nuclear fuel

researchers and developers as well as industry to ensure that MC&A technology is ready to meet U.S. regulatory requirements for these fuel fabrication processes. Without these approaches there will be proliferation concerns regarding the potential diversion and misuse of nuclear material. Our activities focus on integrating domestic safeguards in the early-stage engineering efforts utilizing a "by design" approach to maximize the effectiveness of controls and minimize associated costs to meet Nuclear Regulatory Commission (NRC) requirements. The Department's National Nuclear Security Administration (NNSA) is partnering with U.S. nuclear industry vendors to integrate "security and safeguards by design" in anticipation of international deployment, so that facilities proposed for export can readily meet foreign requirements and build confidence that the facilities and associated materials are used securely and exclusively for peaceful purposes. NNSA is also collaborating with the International Atomic Energy Agency (IAEA) to support development of safeguards and security approaches for new reactor and fuel types.

Q2. Your written testimony stated that: "The Department believes a consent-based siting process should be used for developing interim storage and disposal options to fulfill our obligations to safely and securely dispose of spent nuclear fuel and high-level radioactive waste…"

Q2a. Is the Department actively applying the framework and recommendations put forward by the 2012 U.S. Blue Ribbon Commission on America's Nuclear Future to implement such a consent-based approach?

A2a. DOE is committed to implementing a consent-based approach to siting nuclear waste facilities and a nuclear waste management system that enables broad participation and centers equity and environmental justice. DOE is actively applying, among other things, several of the recommendations put forward by the 2012 Blue Ribbon Commission on America's Nuclear Future Report to the Secretary of Energy and responses received in response to its Request for Information on Using a Consent-Based Siting Process to Identify Sites for a Federal Interim Storage Facility to implement a consent-based approach.

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Q2b. What are the Department's views on my legislation, S.404 – the Nuclear Waste Informed Consent Act?

A2b. DOE agrees that a consent-based approach to siting nuclear waste facilities that centers fairness and equity and seeks willing and informed hosts has the best chance of success. DOE is currently using a consent-based approach to identify a site for one or more federal interim storage facilities and expects to adapt that approach to site future permanent disposal solutions. Consent-based siting requires close collaboration with the public, interested groups, and governments at the Tribal, State, and local levels throughout all phases of the process. DOE has begun collaborating with all of these communities to understand what constitutes consent, how consent is to be determined, and the roles of communities, States, and Tribes in providing consent. One of the primary goals of DOE's recent funding opportunity announcement, "Consent-Based Siting for Interim Storage Program -- Community Engagement Opportunities" (DE-FOA-0002575) is to develop new and unique approaches aimed at maximizing and optimizing engagement to effectively collaborate with communities and relevant levels of local, Tribal and State governments in the consent-based siting process. DOE looks forward to continuing to work with Congress to fulfill our responsibility to safely and securely manage and dispose of our nation's spent nuclear fuel and high-level radioactive waste.

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QUESTIONS FROM SENATOR STEVE DAINES

Q1. Assistant Secretary Huff, nuclear energy and hydropower produce carbon-free, baseload, reliable power. Currently their combined production produces approximately ¼ of the electricity in the United States. Despite this, and reflected the President's FY2024 Budget, it appears that the Biden Administration is more focused on closing coal and natural gas plants and less focused on increasing clean baseload power like nuclear, hydropower, and carbon capture. What steps has the Department taken to increase the development, production, and permitting of new nuclear energy sites in the U.S.?

A1. Through the *Infrastructure Investment and Jobs Act*, the Department was provided approximately $2.5 billion to support the demonstration of two advanced reactor technologies, building on an initial $160 million investment. The construction of these advanced demonstration reactors supports the development of future demonstrations and deployments by addressing the licensing, construction and operational risks of first-of-their-kind advanced reactor designs that have the potential to significantly improve upon the operational and safety characteristics of the current generation of reactors. The *Inflation Reduction Act* also provides expanded loan guarantee authorities enabling the Loan Programs Office to support the deployment of advanced reactor technologies to meet our climate objectives. Furthermore, through the Carbon Free Power Project, the Department is providing cost-shared support for the commercial demonstration of the NuScale small modular reactor (SMR) technology. This effort is funded through the Advanced SMR Research, Development, and Demonstration (RD&D) program, which builds on the successful Small Modular Reactor Licensing Technical Support Program that supported NuScale's design certification and the Tennessee Valley Authority's Clinch River early site permit application.

Q2. Assistant Secretary Huff, do you believe that the Department and the Biden Administration as a whole, should be focusing more on promoting the development of additional baseload power like nuclear and hydropower?

A2. Both DOE and the Administration are focused on strengthening energy security through the addition of generation, including nuclear and hydropower, by modernizing and strengthening the grid, including through the addition of energy storage. To meet our ambitious carbon reduction goals and rebuild U.S. leadership globally, the Biden-Harris

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Administration is prioritizing activities that keep the existing fleet of nuclear power plants in operation and deploy advanced reactor technologies.

Q3. Assistant Secretary Huff, this committee has long promoted and supported efforts to expedite the commercial development of Small Modular Reactors. What recent actions has the Department taken to advance this priority and what obstacles are still in the way of broader SMR commercial adoption?

A3. Advanced nuclear technology is needed if the United States (U.S.) is going to achieve net-zero emissions, economy-wide, by no later than 2050. The Department of Energy (DOE) is working aggressively to accelerate the timeline for the domestic demonstration of small modular reactor (SMR) technologies and has three active SMR demonstration projects underway in partnership with Carbon Free Power Project (CFPP), TerraPower, and X-Energy. These demonstration projects are critically important to resolve regulatory uncertainty and to stimulate the necessary supply chains for widescale deployment. Additionally, DOE is funding five projects through the Advanced Reactor Development Program (ARDP) Risk Reduction pathway to help reduce the regulatory and technical risks for a diverse portfolio of advanced reactor designs, including SMRs. DOE is also speeding commercial deployment by continuing to support early-stage research and development activities at universities, national laboratories, and industrial partners needed to drive efficiencies and innovation. The Department appreciates Congress' support in pursuing these objectives.

However, even with the above efforts underway and driving progress, the Department is finding that more is needed if the U.S. industry is going to move forward with using nuclear power to meet their firm, clean energy needs within the coming decades. First-of-a-kind technical, financial, and licensing risks must be overcome to enable broad commercial deployment of advanced nuclear reactors, including small modular reactors. The nuclear industry is at a commercial stalemate between potential customers and investments in the nuclear industrial base needed for deployment, which could put decarbonization goals at risk.

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Utilities and other potential customers recognize the need for nuclear power, but perceived risks of uncontrolled cost overruns and project abandonment have limited committed orders for new reactors. Waiting until the mid-2030s to deploy nuclear at scale could lead to the U.S. missing decarbonization targets, to a significant supply chain overbuild if the U.S. tries to ramp up over a short period of time later, or to a reduced deployment potential of domestic technologies in international markets.

Q4. Assistant Secretary Huff, the United States does not currently recycle spent nuclear fuel despite the fact that other nations, like France, do. What steps can the Department take to remove barriers to recycling spent nuclear fuel?

A4. Currently, there is no U.S. government policy that restricts commercial nuclear fuel recycling in the United States. As a matter of policy, the U.S. government discourages foreign partners from developing their own domestic reprocessing capabilities because of the proliferation and nuclear security risks such activities can pose. The Department continues research and development on nuclear fuel recycle with the goals of long-term sustainability and efficient waste management.

Q5. Assistant Secretary Huff, if limitations on recycling fuel were lifted, would current reactors be able to begin using recycled nuclear fuel? If not, how long would it take for needed modifications?

A5. Recycled nuclear fuel is widely used (for partial core) in Europe and Japan to replace a portion of the standard uranium fuel. Thus, operationally, most existing U.S. light water reactors can be slightly modified and/or adapted slightly to accept recycled nuclear fuel.

However, using recycled nuclear fuel will require licensing from Nuclear Regulatory Commission. The timing for the needed adaptation or modifications for using recycled nuclear fuel will depend on reactor types, operations, and associated licensing requirements.

Q6. Assistant Secretary Huff, if Russian imports of uranium were to cease next month, how would you predict the enriched uranium market to react? How would these changes impact U.S. inventories and usage of nuclear fuel?

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A6. As with any commodity, a supply disruption can lead to scarcities and a corresponding increase in the cost of supplies and services. The impacts would not be uniform across the industry as some uranium consumers are better positioned to manage short term disruptions. Ultimately, the significant quantity of current Russian imports would need to be replaced by new domestic capacity or cooperation with allied suppliers. Some short-term remedies exist to partially mitigate the consequences of a supply disruption, such as the American Assured Fuel Supply. However, mitigation at the appropriate scale will require domestic investment in expanded conversion and enrichment capacity.

Q7. Assistant Secretary Huff, the Department of Energy has partnered with Centrus to create advanced centrifuges for an enrichment facility in Ohio. By the end of the three-year demonstration, what do you expect to be the most significant takeaway?

A7. The creation of the infrastructure to manufacture, assemble, and operate American enrichment technology is already a pivotal accomplishment. However, the most significant takeaways will be successful U.S. Nuclear Regulatory Commission Licensing and successful production of HALEU using this technology. This is a foundational step toward establishing a commercial U.S. HALEU production and supply chain capability for the long term.

Q8. Assistant Secretary Huff, how has the increase in price of uranium since the onset of the Russian invasion in Ukraine affected energy prices, U.S. energy security, and the further development of nuclear energy?

A8. The Russian Federation's unjustifiable invasion of Ukraine has demonstrated the grave threat to global energy security posed by dependence on Russian-supplied fuels. While the price of nuclear fuel has increased since the Russian invasion, the larger concern is that of security of supply. We must act swiftly to support domestic nuclear fuel supply and processing capabilities. Expanding our domestic nuclear fuel capabilities will require strategic investments coupled with import restrictions that protect those investments well into the future. Without expansion of domestic and international allies' and partners' fuel cycle capacity, the United States cannot reliably make sufficient low enriched uranium

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(LEU) or high-assay LEU (HALEU) to support the needs of today's reactor fleets, advanced reactors, research reactors, and medical isotope production.

Q9. Assistant Secretary Huff, do you agree that the United States should produce more domestic uranium and other fuels related to current and future nuclear energy?

A9. Yes. We must begin to reduce U.S. reliance on Russia for nuclear fuel. This will require strategic investments to expand our domestic fuel capacity.

Q10. Assistant Secretary Huff, has the Department taken any recent efforts to streamline, promote, or prioritize the responsible domestic mining of materials necessary for nuclear fuel?

A10. The Department has taken recent efforts to promote and prioritize the responsible domestic mining of materials necessary for nuclear fuel. In December 2022, NNSA awarded contracts to U.S. mining and conversion companies to acquire natural uranium and convert this uranium into uranium hexafluoride. Unless the material is requested for other Departmental uses, NNSA plans to store the uranium to support future mission needs. The Department is working with the private sector to establish a commercial U.S. HALEU production and supply chain capability.

HALEU production includes considerations for supporting domestic supply chains and fuel cycle capabilities including mining and conversion. To support this goal, the Department established a HALEU Consortium in March 2023.

Q11. Assistant Secretary Huff, do you believe that it would weaken national security to prohibit the development of uranium mining on certain public lands?

A11. The U.S. should produce uranium from licensed and permitted mines and mills, consistent with Congressional direction in the Energy Act of 2020.

Q12. Assistant Secretary Huff, has the Department worked with the U.S. Geological Survey to identify locations in Montana or other states where uranium deposits could be mined in an economically and environmentally responsible manner?

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A12. No. The U.S. Geological Survey has the federal responsibility to assess the location and characteristics of domestic uranium deposits. The Department of Energy does not have authority over mining siting or operations.

Q13. Assistant Secretary Huff, can you describe how the Department handles cyber threats to nuclear reactors?

A13. Several federal agencies contribute to the cybersecurity of nuclear power plants, including the Nuclear Regulatory Commission and the Department of Homeland Security. The Department's contribution to the cybersecurity of commercial nuclear plants is through R&D. The Office of Nuclear Energy's Nuclear Cybersecurity R&D Program supports existing and future plants in strengthening cybersecurity controls and improving their cost-effectiveness, as well as removing cybersecurity-related barriers to deployment of advanced digital technologies. Examples of recent and current research topics include security by design, wireless technologies, zero trust architectures, remote and/or autonomous operations, and supply chain security. This scope is coordinated with other cybersecurity R&D organizations to ensure that the work is unique to the needs of nuclear plants and not duplicative of broader programs. For instance, a key area this year is to demonstrate the application of consequence-driven, cyber-informed engineering techniques developed by the Department's Office of Cybersecurity, Energy Security and Emergency Response to the design of microreactors, using the Microreactor Applications Research Validation and Evaluation (MARVEL) microreactor as a case study.

Q14. Assistant Secretary Huff, has the Department received any interest from the private sector for opening SMRs in Montana?

A14. The Office of Nuclear Energy has not received any specific interest from the private sector about deploying SMRs in Montana.

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QUESTIONS FROM SENATOR JOHN HOEVEN

Q1. What steps are being taken by the Department to help reduce our dependence on foreign sources of uranium, including from Russia?

A1. To reduce our dependence on foreign sources of uranium, including from Russia, we must act swiftly to support domestic nuclear fuel supply and processing capabilities. Expanding our domestic nuclear fuel capabilities will require strategic investments coupled with import restrictions that protect those investments well into the future. Without expansion of domestic and international allies' and partners' fuel cycle capacity, the United States cannot reliably meet the low enriched uranium (LEU) needs of today's reactor fleet as well as the high-assay LEU (HALEU) needs of advanced reactors, research reactors, and medical isotope production.

Q2. Would a statutory policy to phase-out or ban imports of Russian uranium help strengthen our domestic nuclear fuel capabilities?

A2. Expanding our domestic nuclear fuel supply capabilities will require strategic investments coupled with import restrictions that protect those investments well into the future.

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QUESTIONS FROM SENATOR JOSH HAWLEY

Q1. During your testimony on March 9, 2023, I asked you about the Chinese government's espionage efforts against the American nuclear energy industry. What steps is the Department of Energy taking to protect American nuclear power producers and related organizations from Chinese intelligence collection?

A1. The U.S. Department of Energy's Office of Intelligence and Counterintelligence is part of the nation's intelligence community. They are tasked with informing policymakers of threats and protecting the DOE enterprise through counterintelligence activities. They frequently partner with federal law enforcement, such as the FBI, and work directly with U.S. energy companies to improve threat awareness and provide actionable intelligence to counter potential surveillance activities from adversarial nations, such as China.

Q2. Are Chinese state-owned enterprises stealing U.S. intellectual property and repurposing it in ways that hurt our global standing?"

A2. The U.S. Government has indicted China's major nuclear company, China General Nuclear Power Company, for violations of U.S. export control regulations. It is also on the U.S. Department of Commerce's Entity List, and is presumptively denied from receiving civil nuclear exports from U.S. companies. The Executive Branch encourages our foreign partners to consider taking similar actions and imposing similar restrictions. We continue to press this messaging abroad so that there is broad global understanding that "Chinese" developed technology may be based on stolen – and often incorrectly used – U.S. technology, making any country that relies on that technology a potential risk for a major nuclear incident.

Q3. On February 24, 2022, the Department of Energy released a report on America's nuclear energy supply chain titled, "Supply Chain Deep Dive Assessment." This report states that "New reactor designs that rely on TRi-structural ISOtropic (TRISO) fuels need structural graphite in the core. Natural graphite is currently not produced in the United States" with most of America's graphite imports coming from China. What steps is the Department of Energy taking to ensure that the United States nuclear energy industry is not reliant on Chinese-produced graphite?

A3. DOE recognizes the importance of supporting the establishment of a domestic

graphite supply chain. Through the TRISO Fuel and Graphite Qualification Program, DOE funds research to qualify nuclear grades of graphite by identifying graphite performance requirements. Graphite qualification is among the steps necessary to establish a domestic supply chain. DOE has initiated engagement with industry to develop a series of additional recommendations to facilitate closing this supply chain gap. DOE plans to work very closely with the nuclear energy industry to implement the recommendations to enable the demonstration and deployment of high temperature reactors to meet the energy needs of the future.

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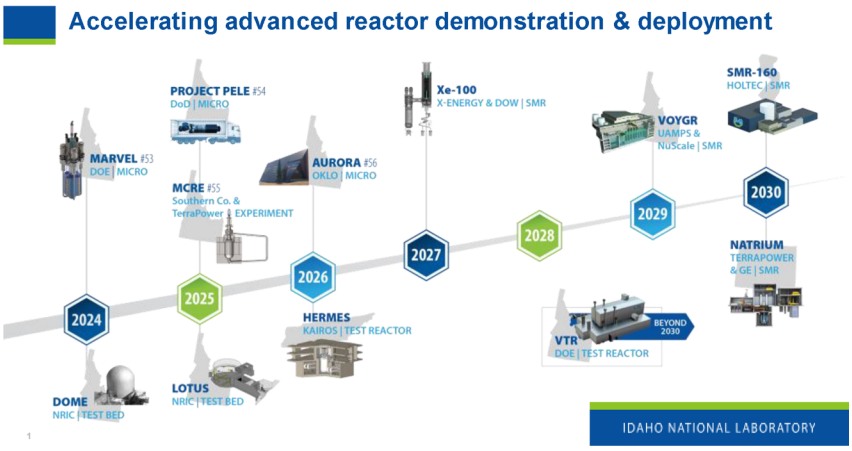
Questions for the Record Submitted to Dr. John Wagner

Questions from Ranking Member John Barrasso

Question 1: During the hearing you referenced a timeline for advanced reactor demonstrations. Will you please provide that for the record?

Please see the INL reactor timeline below. Note that the anticipated advanced reactor timeline is current as of the date of this response and is subject to change. This timeline does not reflect the entire ecosystem of advanced reactor development, either in the United States or globally. Inclusion on the timeline is based on a set of criteria balancing the firmness of funding, siting, regulatory engagement, and technical maturity. Timeline dates reflect the publicly available dates provided by the reactor developers. At this time, only reactors planned for deployment in the United States are included, and space reactor projects and the Eielson Air Force Base micro-reactor project are not currently included, though they are under consideration for the future.



Question 2: Section 40321 of the Infrastructure Investment and Jobs Act (IIJA) (42 U.S.C. 18751) defines micro-reactors and small modular reactors. Section 327 of the John S. McCain National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2019 (P.L. 115-232) and section 320 of the James M. Inhofe NDAA for FY 2023 (P.L. 117-263) also define these reactors, albeit slightly differently, with the FY 2023 NDAA definition for micro-reactors tailored to transportable micro-reactors. These definitions are not necessarily consistent with what various nuclear organizations use.

a. Why aren't consistent definitions used across the nuclear sector?

Initially, factors other than power generation were considered more relevant to defining micro-reactors and small modular reactors (SMRs). In the early conceptual development of microreactors the key attributes identified were: 1) complete factory fabrication, 2) transportable by truck, rail, or ship, and 3) installation without significant on-site preparation. These attributes were chosen to enable rapid development, production, and deployment for distributed and remote energy needs. However, for comparison purposes it became useful to define the reactor class in terms of power output, similar to how Small Modular Reactors (SMRs) have been defined to have a rated capacity of less than 300 electrical megawatts (MWe). As such, there have been differing top-level values assigned, typically 20 MW or 50 MW, which reflect the power production limits of a reactor with the three micro-reactor attributes.

b. Do you agree it would make sense for the nuclear community to coalesce around the definitions found in the IIJA? If not, why not?

I agree that there is a need to apply a common definition for microreactors that can be used to clearly articulate provisions in legislation, regulations, and fuels. Section 40321 of the Infrastructure Investment and Jobs Act (IIJA) (42 U.S.C. 18751) defines micro-reactors as "... an advanced nuclear reactor that has an electric power production capacity that is not greater than 50 megawatts." I believe that 50 MWe certainly provides an upper limit to achieving those attributes outlined in my response in part a. A question remains about how this definition would be used for reactors that do not produce electricity, for example reactors producing heat for industrial applications. Therefore, I would recommend either a clarification of existing definitions or a new definition based on the thermal energy generation, which can either be directly applied or converted to electricity.

Question 3: Does the scientific analysis developed over several decades show that nuclear waste can be safely and securely disposed of in Yucca Mountain?

The final answer as to whether waste can be safely and securely disposed of in the proposed repository at Yucca Mountain would be determined by the Nuclear Regulatory Commission's (NRC) licensing process, which primarily consists of 1) a technical review by NRC staff of the Department of Energy's (DOE) license application and Environmental Impact Statement (EIS), followed by 2) licensing adjudication before the NRC Atomic Safety and Licensing Board. By design, the adjudication would rely in large part upon the NRC's Safety Evaluation Report (SER) referred to below, but the adjudication has not occurred due to termination of the Yucca Mountain program funding.

From 2014 through 2016, NRC resumed some aspects of the licensing process, such as completing its technical review and report on DOE's Yucca Mountain application, but not the adjudication. Under NRC's plan for reviewing the license application, the staff issued its views on DOE's regulatory compliance in a five-volume SER. The 781-page SER document (available here: https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1949/index.html) concluded that the site 100 miles northwest of Las Vegas "with reasonable expectation" could satisfy licensing rules. Under NRC regulations, this report was required to be available to support the next step – licensing adjudication.

While the final determination of safety ultimately rests with the NRC decision on whether to issue a license to construct a repository at Yucca Mountain, the scientific analyses developed over several decades served as the technical basis of the DOE license application submitted to the NRC in 2008. The technical evidence therein suggests the answer is a qualified yes, recognizing that the final determination hinges on completing the adjudication of the DOE license application.

Question 4: Advanced reactors may generate less nuclear waste. Some may even run on previously-used nuclear fuel. But there still will be nuclear waste. How does recycling nuclear fuel contribute to solving our nuclear waste problem?

The process of recycling nuclear fuel involves recovery and utilization of remaining energy content in discharged nuclear fuel (commonly referred to as "used" or "spent" nuclear fuel) to improve fissile material utilization and reduce the amount of long-lived radioactive materials that require permanent disposal. The benefits of recycling nuclear fuel include: 1) reducing requirements for uranium fuel supply, such as mining and enrichment, and 2) reducing requirements for permanent disposal, such as the volume and radioactive characteristics of the materials requiring permanent disposal. While recycling does reduce the overall volume of material, it does not eliminate the need for a geological repository. Another important point is that advanced reactors use higher enrichment fuel, referred to as High-Assay Low Enriched Uranium (HALEU) that, generally speaking, will correspond to more favorable economics for nuclear fuel recycling.

Question 5: What is the current status of the Department's research and development programs to develop nuclear fuel recycling options and associated transmutation fuels?

Since INL is a Management & Operating (M&O) contractor for the Department of Energy (DOE), we would defer to DOE on the details of the complex wide research & development (R&D) portfolio. Specific to INL, we have a long history of developing innovative approaches to the fuel cycle. INL demonstrated 1) recycling of uranium and other valuable fission products using aqueous processing technologies at the Idaho Chemical Processing Plant (ICPP), 2) closing of the fuel cycle using pyroprocessing at the Fuel Cycle Facility (FCF) located at the Materials and Fuels Complex (MFC), and 3) management and storage of more than 250 types of spent nuclear fuel (SNF).

INL advances integrated fuel cycle solutions by conducting research at the fundamental level to gain process understanding, followed by small scale testing, and demonstration of an integrated system at the engineering scale. As new reactors are being developed, INL's fuel cycle science

and technology portfolio is expanding to ensure that new nuclear energy systems can be deployed with confidence, providing solutions that reduce proliferation risk and responsibly manage waste.

Questions from Senator Martin Heinrich

Question 1: Issues have been raised with the recertification of approximately 40,000 previously-certified, aging drums to meet the advanced Acceptable Knowledge (AK) process and Basis of Knowledge requirements in place since the 2014 WIPP event. What sort of challenges are you experiencing with building the AK process for these drums?

In 2021, the Idaho Environmental Coalition, LLC (IEC) was selected by the DOE to manage cleanup operations at the INL Site. The scope for the Idaho Cleanup Project (ICP) includes the packaging and certification of transuranic (TRU) waste for the INL. The general challenge in meeting the new enhanced AK requirements (implemented after the WIPP event in July 2016) is that the process is lengthy and requires significant time for review and validation of data on packaged waste. Additionally, AK data is not well known for much of the waste retrieved at the site. Regardless, ICP has the task of certifying or recertifying all waste to the advanced AK process prior to shipping and placement of the waste containers at the WIPP. While shipments were delayed during WIPP recovery, subsequent changes were made by WIPP for certification via enhanced AK requirements. Consequently, the Idaho drums continued to age and could represent an increased risk for shipping due to that age.

In such cases, these containers are under enhanced inspection protocols for shipment, and many will require overpacking using either a Standard Waste Box, Ten Drum Overpack, or alternative method, to reduce the risk for container failures during transport and ensure containers received at WIPP are ready for emplacement. Regardless of the overpack method used, cost impacts to the program are a certainty, although some methods are more costly than others. Overpacking creates inefficiencies at WIPP for emplaced volumes over time and increases the number of shipments required for the overpacked waste. Subsequently, ICP is evaluating all options to balance overpacking for the safety against being as efficient as possible for WIPP emplacement.

Question 2: Supply chain issues have been noticed within the DOE complex for packaging materials when assembling drums to be shipped to WIPP. Are any of these issues affecting packaging and shipping at Idaho National Lab?

Like most DOE laboratories, supply chain issues have become increasingly common as it relates to essentially all nuclear-related activities. However, our packaging and shipping activities continue to meet all safety and regulatory requirements as outlined in PDD-2500, "INL Transportation Safety Document (TSD)". INL, like other waste generators, continues to prioritize the safe packaging and transportation of our waste and ensure appropriate compliance to all regulations and requirements.

For the ICP, impacts are being experienced for overpack containers with extended delivery times and increased costs. This has not had an impact on meeting shipment schedules provided by WIPP as of yet and is not anticipated through the end of this calendar year. For containers that do not require overpack, the containers are closely inspected to assure they remain of high quality and

meet the required safety requirements for assembly of payloads, shipment, and placement in the repository.

Questions from Senator James E. Risch

Question 1: The work that INL is doing to down-blend the spent EBR II fuel into HALEU is not only important for demonstrating advanced nuclear reactors but also for establishing independence from Russian controlled fuel supply. Outside of EBR II fuel, what other spent HEU fuel is available for reprocessing throughout the entire Department of Energy complex to produce HALEU? How would utilizing those resources help us achieve self-sufficiency for HALEU?

Since INL is an M&O contractor for DOE, we would defer to the Department on the details of the complex wide Highly Enriched Uranium (HEU) inventory. However, we can say that DOE has a limited quantity of HEU material, including spent HEU fuel, that could be processed to generate High-Assay Low Enriched Uranium (HALEU). Though limited in amounts, this material is incredibly valuable for both research purposes as well as to "bridge the HALEU gap" until commercial scale HALEU is available.

DOE's ongoing efforts that will yield HALEU in the near term (1 to 5 yrs.) include[1]:

- Material derived from Experimental Breeder Reactor II (EBR-II) used fuel at Idaho National Laboratory (~10 MT). Advanced reactor vendors have expressed strong interest in polished uranium HALEU.
- Non-proliferation stocks (~2.4 MT)
- Potential repatriation from a partner country (~1.7 MT)
- Material derived from used fuel at Savannah River Site (~2.4 MT)
- Scrap recovery at Y-12 and BWXT (~2.2 MT)

Although not currently funded, other sources of spent HEU fuel that could potentially be reprocessed to produce HALEU in the next 5 to 10 years include:

- Fuel discharged from Advanced Test Reactor (ATR) and High-Flux Isotope Reactor (HFIR). Processing Advanced Test Reactor spent fuel could provide approximately 20 MT of HALEU.
- Fuel housed at the Savannah River Site from the Fuel Take-back Program (~19 MT of HALEU).

In the long-term, to support the deployment of advanced reactors a domestic HALEU supply chain is required. To start, it would be beneficial for DOE to execute its plans for offtake contracts for HALEU production at a rate that could be used to stock a DOE-owned HALEU bank. Offtake contracts will incentivize the expansion of domestic mining and conversion and HALEU enrichment capacity from the current DOE American Centrifuge Plant demonstration that will

[1] Jeff Chamberlain, (March 28-29, 2023), MIT Center for Advanced Nuclear Systems (CANES) Symposium. "Nuclear Everywhere?" How new technologies, regulations, and policies may finally make the use of nuclear energy mainstream and ubiquitous. NNSA.

produce 900 kgs of HALEU per year to full-scale commercial-scale HALEU production in the U.S.

In addition to large metric ton quantities of HALEU, there is an immediate need to supply R&D quantities of HALEU to support fuel qualification. INL supplies small quantities of HALEU from other HEU unirradiated stocks. This effort could be expanded by increasing glove box processing and packaging capability.

Questions from Senator John Hoeven

Question 1: Could you expand upon the importance of having a supply of next generation fuel to power advanced nuclear reactors?

The existing fleet of nuclear reactors use Low-Enriched Uranium (LEU) fuel, which is uranium fuel in which the uranium composition has been enriched up to 5 percent in uranium-235. On the other hand, most U.S. advanced reactors have been designed to use High-Assay Low Enriched Uranium (HALEU), which is enriched between 5 and 20 percent in uranium-235. HALEU is required by most U.S. advanced reactors to achieve smaller designs, longer operating cycles, and increased efficiencies over current technologies.

Although small quantities of HALEU are being made available by the Department of Energy through its national laboratories, HALEU is not available on a commercial scale from domestic suppliers. In fact, Russia is currently the world's only viable commercial supplier. The lack of HALEU supply, if not addressed timely, will significantly impact the development, demonstration, and deployment of U.S. advanced reactors, ceding the market to other countries, such as Russia and China. Advancing domestic capability to produce HALEU will help reestablish American global leadership in nuclear energy, helping us meet our climate, clean energy, national security, and economic goals. A robust domestic HALEU fuel cycle is also important for the United States government to fulfil its commitments to supply HALEU for research and test reactors as part of the Highly Enriched Uranium (HEU) to HALEU National Nuclear Security Administration conversion program. This includes HALEU fuel for domestic and international reactors and medical isotope conversion.

Question 2: How can we increase the availability of HA-LEU to help scale-up the deployment of advanced reactors?

The United States once maintained a robust domestic fuel cycle capability, from mining to conversion, to enrichment, to fuel fabrication. That is no longer the case. In the United States, uranium mining has decreased 92% since 1980. The only U.S. conversion facility was idled in 2017. Only one enrichment facility currently operates domestically, with the capacity to support about one third of the current reactor fleet.

The two sources of HALEU include: 1) downblending existing or recovered fuels, which are available only in limited quantities, and 2) building new enrichment capabilities key to long-term HALEU supply. To ensure future fuel supply, and meet national energy security goals, additional

domestic mining, conversion, enrichment, deconversion, and fuel fabrication capabilities are needed. Developing the complete HALEU fuel cycle represents an opportunity to reinvigorate the domestic frontend of the fuel cycle in the U.S. and is key to fueling our nuclear future.

In the near-term downblending existing or recovered fuels seems to be the fastest approach to enable the demonstration of a subset of advanced reactors. DOE's ongoing efforts that will yield HALEU in the near term (1 to 5 yrs.) include[2]:

- Material derived from Experimental Breeder Reactor II (EBR-II) used fuel at Idaho National Laboratory (~10 MT). Advanced reactor vendors have expressed strong interest in polished uranium HALEU.
- Non-proliferation stocks (~2.4 MT)
- Potential repatriation from a partner country (~1.7 MT)
- Material derived from used fuel at Savannah River Site (~2.4 MT)
- Scrap recovery at Y-12 and BWXT (~2.2 MT)

Although not currently funded, other efforts could be increased by adding other sources of spent HEU fuel, including:

- Fuel discharged from Advanced Test Reactor and High-Flux Isotope Reactor. Processing Advanced Test Reactor spent fuel could provide approximately 20 MT of HALEU.
- Fuel housed at the Savannah River Site from the Fuel Take-back Program could provide approximately 19 MT of HALEU.

In the longer-term, developing a 100% domestic HALEU fuel cycle, which would include mining, conversion, enrichment, and deconversion capabilities, would address both 1) HALEU needs for advanced reactors and 2) LEU needs for existing reactors. The Department of Energy has a plan to execute offtake contracts for HALEU production at a rate that could be used to stock a DOE-owned HALEU bank. Offtake contracts would incentivize the expansion of domestic mining and conversion and HALEU enrichment capacity from the current DOE American Centrifuge Plant demonstration that will produce 900 kgs of HALEU per year to full-scale commercial-scale HALEU production in the U.S.

Question 3: Does the lack of a nuclear waste management plan have impacts on the development and expansion of new nuclear technologies?

Yes. The lack of a nuclear waste management plan negatively impacts public perceptions and support for development and deployment of new nuclear technologies, which are critically important. Further, the lack of an effective nuclear waste management policy and plan results in significant uncertainty that stifles investments by private sector companies and investors

[2] Jeff Chamberlain, (March 28-29, 2023), MIT Center for Advanced Nuclear Systems (CANES) Symposium. "Nuclear Everywhere?" How new technologies, regulations, and policies may finally make the use of nuclear energy mainstream and ubiquitous. NNSA.

contemplating investments in nuclear energy – many of them drawn to the clean, reliable, firm-power attributes.

Certainty in the fuel cycle, by developing a 100% domestic HALEU supply, and actions to develop a workable nuclear waste policy would inspire investments in microreactor technologies, small modular reactors, and other advanced nuclear technologies our nation needs.

In addition to the impacts on the development and expansion of new nuclear technologies, there are significant impacts to the U.S. taxpayer associated with the management of existing spent nuclear fuel at the generation sites. The details on Department of Energy settlement estimates and assumptions including total liabilities are included in the Department of Energy Annual Financial Report (DOE/CF-0191, page 119).

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Questions for the Record Submitted to Mr. Joseph Dominguez

Questions from Ranking Member John Barrasso

Question 1: You specifically highlighted laser enrichment technology in your written and oral testimony. Why is laser enrichment appealing to Constellation?

GLE is appealing to Constellation for the following reasons:

- Laser enrichment is the next generation enrichment technology that will add additional capacity and diversity of suppliers to the enrichment market:
  - Constellation has high confidence in the technology due to years of prior due diligence of the project
  - Laser enrichment is more efficient that centrifuge technology
  - Laser enrichment is flexible; it can be tuned to HALEU, LEU or enrich tails material to equivalent UF6
- The GLE design is modular and can be expanded incrementally based on market demand
- Constellation believes GLE could be the fastest new entrant to market, thereby providing diversity of suppliers, and among the fastest to bring new capacity online with minimal support from DOE
- GLE is uniquely positioned to advance clean-up of DOE facilities and bring depleted UF6 from storage yards to nuclear power plants where they can be used to generate carbon free nuclear power.
- GLE is jointly-owned by Cameco and Silex. The partners are supportive of the management team and the possible acceleration of capacity deployment and have invested over $500 million in GLE to-date. The parents are looking forward to working with DOE to commercialize the technology.
- GLE has a proven management team with significant nuclear industry experience. It is the correct team to complete the R&D activities and commercialize this new technology.

Question 2: The Department of Energy (DOE) currently plans to pursue offtake agreements to spur expansion of the domestic nuclear fuel supply chain for existing and advanced reactors. You testified in favor of a public-private cost-share program to spur expansion of the domestic nuclear fuel supply chain.

a. There is general consensus that offtake agreements are the preferred option for ensuring availability of high-assay, low-enriched (HALEU) for advanced reactors. Strategic cost-share arrangements could beneficially supplement this approach as necessary. Do you agree offtake agreements, supplemented, as necessary, with strategic cost-share agreements is the appropriate approach for ensuring the commercial availability of HALEU for advanced reactors? If not, why not?

   Constellation agrees that offtake agreements make sense for ensuring the availability of HALEU. The HALEU market is different than the LEU market. HALEU demand is not

yet clearly established and long-term offtake agreements with DOE are necessary to support the suppliers who will risk capital investment to bring HALEU to market.

b. During the hearing, I asked Dr. Huff what the Department plans to do to ensure it is not competing against utilities for limited quantities of low-enriched uranium (LEU) for existing reactors. She responded that DOE will purchase LEU and then resell it to utilities. This seems to create an unnecessary and potentially problematic middleman.

   i. Is there any benefit to having DOE serve as a broker of LEU for existing reactors?

      Constellation does not believe that DOE should serve as a broker of LEU for several reasons.

      - The nuclear fuel markets (uranium, conversion and enrichment) are not liquid markets. Should DOE enter the market we believe the spot market and possibly the term market price will increase sharply, harming both the nuclear operators and the taxpayer. Conversely, when DOE enters the market to resell, they will likely depress the market, hurting the suppliers and the taxpayers. Introducing additional volatility into the market is not conducive to stabilizing the enrichment and conversion markets. Constellation does not believe that DOE can enter the market and both buy and resell in a market-neutral manner.

      - In addition, on the buy side, utilities are already contracting with suppliers for long-term enrichment supply. New capacity will be coming online in 2028 at the earliest. There is also significant momentum to discontinue reliance on Russian enrichment when new western capacity is available. If DOE enters the market as that new capacity is available they will be competing with nuclear operators for limited Western enrichment supply presumably as access to Russian nuclear fuel is further limited.

      - Similarly on the resell side, when DOE enters the market to resell the LEU, they will be competing with the suppliers and pushing the market down.

      - DOE has not proven itself to be efficient at issuing requests for proposals or standing up new programs in a timely manner (e.g. by the recent one million pound purchase, and the still not issued RFP for HALEU). Most nuclear operators transact conversion and enrichment under long-term contracts. Constellation believes it unlikely that a nuclear operator will rely on periodic DOE RFP process to ensure its security of supply. By inserting themselves

into the existing and well understood conversion and enrichment markets, they are further stressing already stressed markets.

- Approximately 40% of the value of LEU is contained in the uranium component. Therefore, if DOE buys LEU, only 60% of the designated funding will be available to support them mission of bringing new new conversion and enrichment capacity to market. In addition, programs to purchase uranium are already in place.

ii. Is cost-share a preferred approach for ensuring availability of LEU for existing reactors? If so, why is this approach preferred by utilities?

- Instead of establishing a new government-administered program, utilities recommend alternatives, such as public-private partnerships/cost-shares with enrichers/converters or partially reimbursing utilities for purchasing new capacity at higher price points. These methods of U.S. government investment in the industry avoid the risks of DOE entering the market as a buyer and competing against private companies.
- Taxpayer investments could be protected by making milestone payments as part of the partnership, requiring converters and enrichers to meet major milestones (license application, license approval, construction progress, production, etc.) before receiving the next round of funding under a cost-share partnership.
- Cost-share also provides both a signal to suppliers that DOE is committed to establishing domestic capacity and much needed capital necessary to deploy costly new facilities that take years to come online.