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Hearing to Consider Pending Legislation

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Thank you, Chairman Manchin, Ranking Member Barrasso, and members of the Committee, for allowing me to be here today. My name is Jeff Navin and I am the Director of External Affairs for TerraPower, the advanced nuclear company that will be developing the Natrium™ project in Kemmerer, Wyoming in partnership with the United States Department of Energy and PacifiCorp/Rocky Mountain Power, near a coal plant slated to be retired.

Previously, I served in the Department of Energy as the Acting Chief of Staff and Deputy Chief of Staff, as well as in positions in the House of Representatives and the United States Senate. I have followed this Committee's work for many years, and I appreciate that it continues to work in a bipartisan manner to address the important energy issues facing our country.

Advanced nuclear is one of those issues that is broadly supported by both Democrats and Republicans. The Natrium project in Wyoming is a public-private partnership made possible by the Advanced Reactor Demonstration Program (ARDP), created by Congress in 2019. We are grateful for the work the Committee has done in creating and continuing to support the ARDP.

To date, TerraPower has met our key milestones in developing the Natrium reactor. But the success of our project, and our ability to build subsequent plants here and across the globe, is threatened by a lack of fuel needed for advanced reactors. A critical disruption in our supply chain caused by the Russian invasion of Ukraine has highlighted the importance of building out domestic enrichment capabilities to power this next generation of carbon-free energy. We are grateful the Committee is working to address this issue.

TerraPower: Who We Are

TerraPower was created in 2008, two years after our company's founders - Bill Gates and Nathan Myhrvold – began looking for a technological solution to the dual challenges of the growing global demand for energy and the need to reduce emissions. A key tool, they discovered, is advanced nuclear technology.

The mission of advanced nuclear energy companies like TerraPower is to improve nuclear energy technology on several fronts, using the capabilities offered by 21st century advancements and digital modeling unavailable to previous generations of engineers and scientists. Advanced nuclear technologies move well beyond our country's 20th Century fleet of light water reactors, including safety improvements, reductions in the risk of weapons proliferation, minimization of waste production, more efficient use of uranium supplies, and lower costs.

Natrium and the Advanced Reactor Demonstration Program

When TerraPower initially began its work, the United States did not have a program supporting the demonstration of advanced nuclear reactors. That changed when Congress, with leadership provided by this committee, created the Advanced Reactor Demonstration Program, which cleared a path to demonstrate this important technology here in the United States.

In 2020, TerraPower competed for, and was selected for an award through the ARDP to demonstrate our Natrium technology, which we developed with GE-Hitachi. Under this program, we will develop our reactor in a public-private partnership with the US Department of Energy. Under the terms created by Congress, DOE is funding up to 50% of the cost of the project. TerraPower is responsible for privately funding the remaining 50% and managing the project. Once the plant is built, our utility partner – PacifiCorp/Rocky Mountain Power – will own and operate the plant as part of its energy generation fleet. The language enacted by Congress requires our ARDP reactor to be operational by 2028.

As the committee knows, the existing conventional fleet has provided carbon-free, safe, and reliable electricity in the United States for decades. Conventional reactors are large – often more than 1,000MW in capacity. They generate electricity by creating heat from nuclear fission and use that heat to make steam and spin a turbine to generate electricity. Because the heat generated by fission can stress fuel rods and the reactor core itself, reactors require coolants to remove the heat from the reactor. Natrium's technology provides step change improvements over conventional designs and differs from existing reactors in three important ways.

First, is the way Natrium's reactor core is cooled. Today, every nuclear reactor producing electricity in the United States is cooled by water. While water has several properties that make it useful as a coolant, it has a relatively low boiling point, and steps must be taken to ensure that the water does not boil off, exposing the core and leading to a meltdown. Those steps can include pressurizing the water to raise its boiling point and using pumps to circulate cool water over the core and remove heat. If those pumps stop operating, as was the case in Fukushima, the coolant will boil off and the fuel rods within the reactor core will melt, damaging the reactor core and leading to a release in radiation. Preventing the fuel from boiling off of the reactor core is the primary safety mission of today's conventional reactors. That's why the existing fleet has multiple redundant safety systems to ensure that the pumps never stop pumping water over the core.

The Natrium reactor, on the other hand, uses sodium as a coolant. Sodium is a metal and a solid at room temperature. When heated, it becomes a liquid, and sodium's boiling point is 882 degrees Celsius – far above the temperature at which our reactor operates. As a result, our reactor's coolant will not boil off. Our fuel rods sit in a pool of molten sodium, and our reactor uses natural convection and air circulation to remove heat from the reactor core. Natrium's reactor operates at atmospheric pressure and does not require auxiliary pumps and backup power in the event of an unplanned incident. Our system is designed to be inherently safe though the use of physics and natural convection, which allows Natrium's design to be less complex and less expensive, with higher levels of safety, than conventional designs.

Secondly, the Natrium reactor is much smaller than conventional reactors. Our reactor's baseload capacity is 345MWe, roughly a third of the size of a conventional plant. This means that the price for a utility to deploy our reactor is far less than the price of deploying a large, water-cooled reactor. Due to its smaller size and enhanced safety profile, the Natrium plant uses far less land than conventional reactors and can easily be placed – like our first plant – at the site of coal plants that are retiring. This allows us to utilize the workforce at those plants, as well as their transmission and water infrastructure, and replace the generation lost when those plants retire.

And finally, the Natrium plant is unique in how it produces power and stores energy. As previously noted, every commercial nuclear reactor in the United States uses the heat generated from the reactor core to generate steam and spin a turbine. Our design is different, as the Natrium plant uses the heat from our reactor to power a molten salt storage system that allows us to store 500MWe of power for five and a half hours – gigawatt scale energy storage – much larger than any lithium-ion battery storage system currently operating in the world, and a game changer for grids with high penetrations of wind and solar. The Natrium plant uses the same technology for molten salt energy storage currently used by concentrated solar plants, allowing us to use off-theshelf technology to store massive amounts of clean energy that can be dispatched when needed.

This makes Natrium valuable to utilities that are looking to increase reliability as more weather dependent renewable energy is brought onto the grid. Natrium can provide carbon-free electricity twenty-four hours a day, seven days a week, but can also ramp up and down to fill the gap when renewables, like wind and solar, are not available. Natrium will provide our customers with an emissions free, firm, and flexible generation option – a critical tool for utilities and countries looking to decarbonize their electricity systems.

Natrium and Advanced Reactor Fuel

TerraPower is confident that our Natrium technology will fill a critical need for utilities in the United States and abroad. As our project in Wyoming is moving forward, we've seen interest from utilities across the country and around the world who want to learn more about our technology. We're seeing states like West Virginia repeal bans on new nuclear plants, as they look for ways to create jobs and generate reliable, clean energy. And as countries in central and eastern Europe look for alternatives to Russian natural gas, Natrium's technology is well positioned to provide reliable, always-on, carbon free power to our allies.

But no nuclear reactor can operate without fuel, and most of the advanced reactor designs, including the two reactors being demonstrated by the Advanced Reactor Demonstration Program, require a special kind of fuel called High Assay Low Enriched Uranium or HALEU.

All nuclear reactors run on uranium enriched to certain levels. Low Enriched Uranium, or LEU, is the most common nuclear fuel, and it is enriched to a level of 3%-5% of Uranium-235. HALEU is uranium enriched up to 20%. HALEU allows for advanced reactors to operate more efficiently, and allows the reactors to burn up more fuel, resulting in smaller volumes of spent fuel. But while there are dozens of advanced reactor designs being pursued in the United States that require HALEU, the United States does not currently have the capacity to produce HALEU.

As a result, today, the only source of commercially available HALEU is a Russian state-owned enrichment company, TENEX. When TerraPower applied for the ARDP in 2020, our plan was to use HALEU from this source for our initial core load while Congress and the DOE established the Advanced Nuclear Fuel Availability Program to make commercial HALEU available in the United States. This plan was blessed by the Department of Energy, as the best path to get our projects launched on the timeframe mandated by Congress, while the Department worked separately to launch the program created by the Committee to develop HALEU enrichment capability in the United States. But with the Russian invasion of Ukraine, TerraPower has made clear that it will not use Russian HALEU to power its reactor. That leaves our project, and many other advanced reactors, without a source of fuel.

While we are not the only company in the energy sector with a supply chain disrupted by the Russian invasion of Ukraine, we are one of the few with no other options for such a critical item. Without HALEU we cannot power our reactor, and without confidence that fuel will be available for future reactors, we cannot sell additional plants. Every other advanced nuclear developer in the United States that relies on HALEU faces the same issue.

The Committee recognized this problem long before Vladimir Putin's tanks crossed into Ukraine. The Advanced Nuclear Fuel Availability Program was created by the Committee, and enacted into law in the

Energy Act of 2020, nearly two years ago. The Energy Act of 2020 requires the Secretary of Energy to establish a program to support the availability of HALEU for projects like ours. As the Committee knows, DOE is moving forward with this program. The Department requested information from stakeholders in December, but we have not yet seen the program launch. It is imperative that Congress and the Executive Branch work together to get the Advanced Nuclear Fuel Availability Program up and running. The invasion of Ukraine has made the problem identified by the Committee in 2020 even more urgent, and multi-billion-dollar projects supported with federal funds are vulnerable because of this gap in the supply chain.

This is a big program, with significant interest from Congress and other governmental stakeholders, but it should be able to be launched quickly. The Advanced Reactor Demonstration Program was signed into law on December 20, 2019. The Department released the Funding Opportunity Announcement for the program on May 14, 2020 and made the awards on October 13, 2020 – less than ten months after the program was signed into law. Today is the eighteen-month anniversary of the Energy Act of 2020, which contains the Advanced Nuclear Fuel Availability Act, becoming law. The United States is supporting the rapid deployment of two advanced reactor designs, and the invasion of Ukraine has made this need even more urgent.

But even if a fuel availability program were launched today, it will be years before HALEU is produced in the United States at commercial scale. Once the awards are made, contracts will need to be negotiated, financing secured, and only then will construction begin on the centrifuges and facilities needed to produce HALEU. The ARDP award winners will require the first deliveries of HALEU for our initial cores long before these new enrichment facilities are operating.

TerraPower's schedule requires the first delivery of HALEU to its fuel fabrication facility in late 2025, which is why our original plan was to use HALEU from Russia for our first core load. With that option understandably off the table, the only viable path to remain on schedule is to use HALEU downblended from the Department of Energy's inventory of excess Highly Enriched Uranium, or HEU. HEU is used by the Department of Energy's National Nuclear Security Administration for research reactors, naval propulsion, and for weapons. A kilogram of HEU can be downblended into 3-4 kgs of HALEU.

Secretary Granholm and Assistant Secretary Huff have been working with their NNSA colleagues to determine how much of the excess inventory at the Department of Energy can be made available to keep the two ARDP projects on track. We've spoken with NNSA officials who are, we believe, earnestly looking for material that can be downblended into HALEU. While they report that they have identified some material that can be used, the volumes they've identified to date are below what is needed to fuel the two ARDP projects' initial cores.

The amount of excess HEU available for downblending is classified, but in March 2016 the Obama Administration declassified the HEU inventory as of September 2013. In that report, the Department of Energy reported a total HEU inventory of 585.6 metric tons, with 41.6 metric tons available for downblending. We believe 5-6 metric tons of HEU could be downblended into enough HALEU for the two ARDP demonstration project initial cores.

While we do not know the current amount of HEU available for downblending, we understand that some of that material remains in weapons that need to be disassembled, and that there are further constraints on the NNSA facilities used to perform downblending. But without this material, there is no path for the Advanced Reactor

Demonstration Program to meet the timeline prescribed by Congress. I am encouraged that the legislative efforts contemplated by the Committee today provide the resources and direction necessary to allow the ARDP initial cores to fueled with HALEU downblended from HEU in a way that does not threaten America's national security.

To be clear, downblending of HEU is a temporary solution to the HALEU problem. We will need both the fuel provided from downblending for our initial core, as well as a fully functional, fully funded, Advanced Fuel Availability Program for subsequent cores and to meet the growing demand for advanced nuclear technologies in the United States and around the world.

Comments on the Bills Being Considered Today

As such, we are encouraged that the Committee is discussing these bills, which seek to strengthen the nuclear fuel supply chain, and move towards a solution on the back end of the fuel cycle.

First, S. 4066, the Fueling Our Nuclear Future Act of 2022, recognizes the critical and urgent need for domestic HALEU enrichment capabilities and properly directs the Department to accelerate efforts to establish domestic, commercial enrichment capabilities. It also notes that even if that process started today, those capabilities would not be in place to provide for the initial core loads of the ARDP reactors on the schedule put forth by Congress. As such, it looks to downblending of HEU from the DOE stockpile to meet the initial need. The Fueling Our Nuclear Fuel Act recognizes that we must do both, and we must move quickly, given the advanced reactor fuel implications of the Russian invasion of Ukraine.

Secondly, on S. 3856, a bill to prohibit the importation of uranium from the Russian Federation, TerraPower has made clear after the invasion of Ukraine that we would not be using Russian HALEU in our reactor. We believe that America and the west need reliable, stable supply chains for advanced nuclear, and Russia is not a reliable, stable partner. As I noted in my testimony, however, Russia is the only commercial enricher of HALEU, the fuel needed for America's advanced nuclear reactors. As such, it's appropriate that the Committee is considering both S. 3856 and S. 4066 together. Ending the importation of Russian HALEU will require the establishment of domestic capabilities to produce HALEU, as well as ensuring that our operating fleet has the fuel it needs to continue to provide carbon-free, reliable electricity at plants across the country.

Ensuring that advanced reactor developers and operators have access to a reliable supply of advanced nuclear fuels is an important national priority, and we appreciate the Committee's work on this issue.

Conclusion

Finally, let me again express my sincere appreciation for all that this Committee has done over the past number of years to support advanced nuclear power. The Advanced Reactor Demonstration Program is a direct result of the Committee's work, as is the Advanced Nuclear Fuel Availability program. Those bills built on the Nuclear Energy Innovation Capabilities Act of 2017, and the bills being considered today will continue to build on that legacy.

Both Chairman Manchin and Ranking Member Barrasso, and many other members of the Committee, have been leaders on advanced nuclear and we are confident you will begin to see the commercial reactors made possible by your work soon.

Thank you again for the invitation to testify today, and I look forward to taking your questions.