Testimony of
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Energy Innovation: Letting Technology Lead

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<u>Written Testimony</u>

Chairman Smith, Ranking Member Johnson, and distinguished members of this Committee, I want to thank you for holding this hearing and for giving me the opportunity to testify. I am honored to be here today, and I am eager to share my experience commercializing advanced reactor technologies that build upon a rich legacy of research and development with the national laboratory system and the Department of Energy.

I am the Co-Founder and CEO of Oklo, a Silicon Valley based company developing and building a very small advanced reactor that produces 2 MW of electric power. We sometimes refer to it as a micro-reactor that is designed to bring distributed, clean, affordable, and reliable nuclear power in small packages to the market. These reactors fit into a containerized system that can power a wide variety of markets both domestically and internationally, which do not have access to affordable and reliable power, and in some cases, do not have access to power at all.

Our reactor operates purely on natural forces, with very few moving parts in the entire system, and it is designed to operate for more than 10 years before refueling. It will produce reliable, affordable, safe, emission-free power wherever needed. The reactor is sized appropriately to open up new opportunities for clean and safe nuclear power in remote and rural communities, as well as industrial and military sites in areas that are too small for larger reactors. The Oklo reactor has the potential to reduce some of these customer's energy bills by up to 90 percent.

Furthermore, our reactor can use fuel nearly 300 times more efficiently than current reactors, producing less waste, and can actually consume the used fuel from today's reactors as well as the depleted uranium stockpiles around the nation. In fact, fast reactors like ours could power the world for over 500 years with the global inventory of used fuel and depleted uranium. Our reactors can also assist with plutonium disposition by consuming excess cold war era materials and turning them into clean, peaceful energy.

We started Oklo because we believe advanced reactors will play a significant role in the energy mix of the future, and we want to make that future a reality as quickly as we can.

Advanced Reactors

Advanced reactors are next generation nuclear technologies that can provide affordable, reliable, and clean power that can be deployed on a global scale. They offer the potential to realize the energy future envisioned by the intellectual giants upon whose shoulders we all stand: Fermi, Weinberg, Wigner, Seaborg, and others who saw the potential that next-generation reactors have. Some of the key attributes include:

- Competitive economics due to reduced capital costs and shortened construction times
- Multiple energy product streams ranging from electricity to process heat
- Improved fuel efficiency and the ability to consume used nuclear fuel
- Flexible operations such as load following and grid stabilization to couple with solar and wind
- Flexible siting, independent of access to cooling water

Advanced reactor technologies are varied and diverse in terms of the coolants, materials, fuels, and neutron spectrum they use, and fast reactors represent over half of the active advanced reactor commercialization efforts ongoing in the United States today. Fast reactors are well suited to achieving the benefits offered by advanced reactors, and they build upon a rich legacy of proven and demonstrated technologies, including the groundbreaking success of the EBR-II reactor.

Metal Fuels

One of the key technologies to the success of fast reactor research and development in the United States has been the development of metal fuels. Metal fuels are alloys of uranium or other actinides that combine incredible durability, flexibility, and resilience to achieve phenomenal fuel utilization, manufacturability, and safety behavior. Metal fuel was used in several early experimental reactors operated in the 1950s and 1960s, and showed great promise, but were sidelined until several key engineering discoveries were made through research and development campaigns sponsored by the Atomic Energy Commission (AEC) and then the Department of Energy (DOE) that enabled the fuels to realize their potential. These advances were highlighted by several successful demonstrations at the EBR-II reactor in Idaho which operated from 1964 to 1994:

- Demonstrated fuel recycling by using over 39,000 recycled fuel elements.
- Demonstrated high fuel utilization with less waste, achieving burnups four times higher than the current industry standard.

- Demonstrated groundbreaking safety behavior with the Shutdown Heat Removal Tests in 1986.

The benefits and capabilities of metal fuels make them a key enabling technology for advanced reactor developers, and over half of the fast reactor developers in the United States are building upon this rich research and development legacy. This is a striking example of a successful government investment in research and development that matured a promising early stage technology to the point of commercial readiness.

There are also opportunities to expand upon these successes. Lessons learned in the development of metal fuels have identified avenues to expand its capabilities and applicability to new designs and new performance features, such as advanced fabrication methods, liners and coatings, dopants, new claddings, new geometries, and tailored engineered properties at the atomistic level. These branches on the metal fuel tree may lead to higher temperature operations, longer fuel lifetimes, and overall better performance that further enhance the performance of fast reactors.

These technologies present research and development opportunities that can follow similar pathways, and are ripe for further investment as they mature to commercial readiness. In fact, industry is already partnering with the national laboratories to pursue some of these technologies. This illustrates the continuum of innovation that occurs when one discovery leads to many more that can further advance the state of the art.

Oklo is working to commercialize a reactor that builds on the successful legacy of metal fuel. We pursue a business model of following market needs and demands, in other words, we strive to make reactors people want. It can be tempting to push an exciting new technology to market, but miss what the market needs for the sake of the technology, so talking to users to understand what the market wants requires discipline. In our early days, we found the capabilities offered by metal fuel reactor designs fit customer needs, and have continued to find market fit and traction thanks in part to the research and development efforts in metal fuel.

Research Infrastructure

The research and development infrastructure at the national labs has played, and will continue to play a key role in commercializing advanced reactors. This infrastructure includes world-leading experimental facilities, research reactors, and expertise. These resources are also helpful to industry as we work with the national laboratories to tap into their capabilities.

We have partnered with several national labs to date, including Argonne National Laboratory, Idaho National Laboratory, and Sandia National Laboratories to support our commercialization efforts. A significant amount of this work has focused on commercializing our metal fuel design. For example, ongoing work with Argonne and Idaho supported by the Gateway for Accelerating

Innovation in Nuclear (GAIN) program has assembled fuel performance data that we used in formal pre-application meetings with the Nuclear Regulatory Commission (NRC) to support our licensing efforts, and has enabled us to fabricate three prototypic fuel elements demonstrating key manufacturability characteristics. We are currently expanding our work with the national labs because many of the capabilities we need are uniquely found in the national lab complex, providing us with an international advantage. Similar stories are found throughout the national lab system and are an example of how valuable the national lab system is.

Furthermore, I was fortunate to grow up near Sandia, and my experiences with the lab in my community were instrumental in my growth. Laboratory tours, staff visits to my schools, and internships I had at the lab were significant influences in my decisions to pursue technical work. The labs play a crucial role in their communities and the national innovation ecosystem.

Research and Development Challenges and Opportunities

The legacy of research and development by the DOE and its predecessors in the last 70 years has been tremendously helpful to advanced reactor developers today. We are all building on that work. More recently, DOE has supported programs to help accelerate advanced reactor commercialization by improving how industry can work with the national labs, but there is still more we can do. The GAIN program is a great example of recent efforts to enhance how industry can work with the national labs and DOE. In the past year, significant progress has been made through the GAIN program to advance these efforts, and these will continue to expand.

The work by DOE and the national labs to characterize and qualify advanced reactor fuels has been and will continue to be quite valuable to advanced reactor commercialization efforts. The facilities and resources used for this work are good examples of just some of the capabilities within the national laboratory complex from which we and other advanced reactor developers can benefit. GAIN provides an avenue for streamlined access to DOE facilities and expertise, and continued initiatives within the GAIN program will help propel advanced reactor efforts. Additionally, DOE sites could be ideal proving grounds for first-of-a-kind reactors. NuScale and INL are paving the way here, as NuScale plans to build their first plant in Idaho.

Unfortunately, some of these capabilities are also deteriorating, or have been shut down. For example, the premature closures of the FFTF and EBR-II reactors ended access to domestic fast neutron sources. This has slowed advanced reactor commercialization efforts, and has slowed the continuum of innovation that will lead to even better materials, fuels, and other technologies which will enhance advanced reactor capabilities in the future. These national assets and capabilities must be maintained.

New capabilities also need to be developed. I specifically want to highlight the efforts to build a fast test reactor that this Committee has so earnestly supported. It is a tragedy that we terminated our fast neutron irradiation capabilities in the 1990s, and are now forced to go overseas for irradiation testing. The lack of these domestic capabilities must be addressed, and the construction and operation of a domestic fast test reactor will pay substantial dividends to American energy competitiveness and leadership. This facility be a national asset that will not only accelerate ongoing advanced reactor commercialization efforts, but will also be the catalyst for new innovations and new technologies.

In addition to experimental facilities, DOE and the national labs are developing world leading modeling and simulation tools that support advanced reactor design and analysis. Advances in software and computing have helped fuel the recent growth of the advanced reactor industry. It has never been cheaper to design and analyze new technologies. These capabilities provide a significant advantage to U.S. advanced reactor developers, and we should invest in further research and development to enhance these capabilities and create new ones. However, it can be prohibitively difficult, costly, and time consuming for industry to access and use some of these publicly-funded capabilities. This can drive industry users away from these tools, limiting opportunities for commercialization and diminishing the value of the investments made to develop them. The challenges to accessing these tools are a result of a variety of factors, but one of which is the lack of minimal support to maintain these tools. Without maintenance, these tools will remain difficult to access and atrophy away. Fortunately, there has been demonstrable progress to improve these processes in the last year, but there is still more to do.

Other DOE resources and capabilities that are often underappreciated include their inventory of nuclear fuel materials, and their capability to provide these materials to support advanced reactor demonstrations. Demonstration, prototype, and first-of-a-kind advanced reactors will require a variety of fuels, and we will all benefit from being able to use some of the fuel that DOE manages. This is particularly relevant to low enriched uranium fuels that are enriched above the 5% enrichment that current light water reactor (LWR) fuels use. DOE should anticipate these opportunities, and manage their fuel resources accordingly to maintain fuels in usable forms and compositions. This will also reduce DOE's fuel management burdens.

DOE should also work with the relevant federal agencies to modernize nuclear export control rules. Unfortunately, recent changes to nuclear technology export controls are hindering innovation, and will handicap our global leadership. This is particularly important now so that the growing advanced reactor industry can flourish.

Finally, I must encourage federal agencies to be cautious with development or demonstration investments to avoid ones that are out of touch with the market. Unfortunately, these investments can follow "pet project" preferences or projects with strong lobby support, instead of following the market, which could severely damage the rising advanced reactor movement by sending false and incorrect market signals. We all have a vector on getting to market and achieving cost competitiveness, while producing emission-free power at a global scale. Getting there will be hard, but this is one of the most promising times for nuclear since the birth of the industry.

Regulatory Challenges and Opportunities

In general, the regulatory challenges to advanced reactor commercialization efforts have been overstated. While there are challenges, I must emphasize that the widely-held view that advanced reactors cannot be licensed today is mistaken. We are formally engaged in pre-application activities with the NRC and we have found clear licensing pathways for our technology. However, there is room for improvement and modernization.

Recent progress made by the NRC to support advanced reactor licensing is yielding value. The DOE's work to develop advanced reactor design criteria and other issues will have a substantial effect on advanced reactor licensing. Furthermore, recent NRC initiatives to use a core team review approach and safety focused reviews will improve cost and schedule predictability.

I also encourage updating security and staffing requirements so they are "right-sized" to reactor size and type. Furthermore, future regulatory reforms should yield requirements and cost burdens that reflect reactor size and safety performance. I would also like to acknowledge the work NuScale has done to address many of the challenges that advanced reactor developers face. The work they have done has helped pave the way on many issues, and we hope to build on this trend and pave the way forward for advanced reactor commercialization.

Closing Thoughts

Advanced reactor development has grown significantly in the past decade, particularly in the last five years, and these efforts are better equipped than ever to bring these technologies to market. Advances in computational modeling and simulation, along with an injection of talented, creative, and hungry young engineers into the nuclear industry have fueled much of this growth. Federal efforts to attract students into nuclear engineering programs over the last decade are paying dividends, and there is more to come. Furthermore, advanced reactor research and development activities sponsored by the DOE and the national laboratories over the past few decades have demonstrated some of the core technologies that many of these startups and larger companies are working to commercialize.

Innovation in nuclear is proceeding at a pace reminiscent of the early days of nuclear power, with dozens of startups and over $1 billion in private capital at work developing the future of energy technologies. The United States is still the global leader in nuclear technology, and we have taken steps to cultivate this growing movement, but there is still more to be done to remove outdated obstacles, and overcome hurdles that slow the growth of this industry. Furthermore, we must be mindful of international competition. China and Russia are investing heavily to develop advanced nuclear technologies, and we cannot afford to fall behind. Our national capacity to innovate, combined with our national capabilities to research and develop give us tremendous advantages. We have a unique opportunity in front of us. If we seize it, we can lead the world in a clean energy transition powered by advanced reactors that can mitigate the effects of climate change, bring affordable, reliable, emission-free energy to the billions without it, and support the growth of an entirely new technology and manufacturing workforce. Furthermore, these technologies can fuel mankind's ambitions of navigating the stars. We need energy to explore the heavens, and nuclear energy will power future trips to our neighboring planets and beyond. I thank you for this opportunity to testify, and would be pleased to respond to any questions you might have today or in the future.