Written Testimony of Dr. Troy A. Carter
Director, Fusion Energy Division, Oak Ridge National Laboratory

Before the
Committee on Science, Space, and Technology
Subcommittee on Energy
U.S. House of Representatives

Hearing on *Igniting America's Energy Future: The Promise and Progress of Fusion Power*

September 18, 2025

Chairman Weber, Ranking Member Ross, and Members of the Committee, thank you for the opportunity to testify today on the promise of fusion energy. My name is Troy Carter, and I am Director of the Fusion Energy Division at Oak Ridge National Laboratory. Prior to joining ORNL, I was a Professor of Physics at UCLA, where I directed both the Basic Plasma Science Facility and the Plasma Science and Technology Institute. The last time I appeared before this Committee was in 2021, after chairing the Fusion Energy Sciences Advisory Committee (FESAC) long-range planning subcommittee, which produced the consensus report *Powering the Future: Fusion and Plasmas*.

Federal investment has led to significant scientific and technological progress

Long-term federal support for fusion energy research, thanks to the support of this Committee and Congress, has delivered extraordinary returns. We have advanced our fundamental understanding of the behavior of plasmas, the superheated gases that are at the heart of fusion devices, so we can create and control fusion fuel in conditions required for future power plants. DOE Fusion Energy Sciences investments in major user facilities, current and past--including the DIII-D tokamak at General Atomics; TFTR, NSTX, and NSTX-U at Princeton Plasma Physics Laboratory; and Alcator C-Mod at MIT—have been essential in enabling this progress. Facilities supported by the National Nuclear Security Administration, such as the National Ignition Facility at Lawrence Livermore National Laboratory and the Z-Machine at Sandia, while built for stockpile stewardship, have also generated breakthroughs with direct implications for fusion energy. International collaboration has been equally vital. For example, U.S. researchers have played central roles in recent record-setting results on the Joint European Torus in the UK and on the Wendelstein 7-X stellarator in Germany, and partnership in ITER is yielding experience in delivering industrial-scale fusion systems while building the U.S. fusion supply chain and workforce. These federal investments have also seeded important spin-off technologies – among them, plasma processing techniques that underpin the semiconductor industry, extremeultraviolet lithography for microelectronics, and the development of high-temperature superconducting magnets now being leveraged in fusion device design. Investment in fusion research has also led to progress in artificial intelligence – in developing the tools to analyze and control fusion plasmas, our community has helped drive innovations in artificial intelligence and machine learning methods that are now broadly used across fields like manufacturing, robotics, and even drug discovery.

Opportunity: Public–Private Partnerships to enable a US fusion industry

The opportunity before us is to significantly amplify this return on investment by fostering a robust and competitive U.S. fusion industry. Owing to the progress made in the fundamental science and technology relevant to fusion, around 30 U.S.-based fusion start-ups—most spun out by university and national laboratory researchers—are now pursuing electricity-producing fusion pilot plants on aggressive timelines. Their ambition reflects both the urgency of energy needs and confidence in the scientific foundation built through federal investment.

There are significant common technical challenges that need solutions for these efforts to succeed. Without strong public–private partnerships, these companies will bear unsustainable risks, and the U.S. risks ceding leadership in a sector it arguably founded. By coupling the innovative drive and risk tolerance of U.S. industry with the stability, depth of technical expertise, and specialized tools in the U.S. national lab–university system, we can de-risk the path to economical fusion power and ensure the United States fully captures the benefits of this emerging industry.

To succeed, we must also improve and streamline mechanisms for public and private partners to engage. Improving the process for and timeline to approval of Cooperative Research and Development Agreements (CRADAs) and Strategic Partnership Projects (SPPs), as well as exploring more flexible mechanisms for collaboration, would accelerate progress. These improvements would not only benefit fusion energy but are essential to strengthen U.S. competitiveness in other critical fields, such as artificial intelligence.

How to get there: Expert consensus path to fusion energy in the US

We are not starting from scratch. The technical challenges and strategic pathway for the U.S., targeting the goal of an electricity-producing fusion pilot plant, are clearly enumerated in consensus reports:

- The FESAC Long Range Plan, *Powering the Future: Fusion and Plasmas* (2021)
- The National Academies' *A Strategic Plan for U.S. Burning Plasma Research* (2019)

- The National Academies' *Bringing Fusion to the U.S. Grid* (2021)

Congress, and especially this Committee, has acted on recommendations from these reports through authorizing legislation and appropriations. DOE Fusion Energy Sciences is recently responding through the creation of new programs. This includes the Fusion Milestone program, which is supporting the private sector to develop technology roadmaps and preliminary designs for fusion pilot plants, as well as the popular and successful INFUSE program. INFUSE provides support for the private sector to access expertise and facilities at national labs and universities to make progress on their technology development. It also includes the recently announced Fusion Innovation Research Engine (FIRE) Collaboratives, which will unite labs, universities, and industry to tackle critical common challenges such as closing the fusion fuel cycle, identifying and qualifying robust materials for the extreme environment of a fusion system, and mitigating plasma instabilities that limit fusion performance.

New experimental facilities have been identified that are essential to de-risking the path to fusion pilot plants. The reports mentioned previously, along with a report released last year from the Fusion Energy Sciences Advisory Committee that recommended new facilities for public investment that "best serve fusion", identified priority facilities including:

- **ITER**: U.S. participation ensures access to a flexible and well-diagnosed platform for studies and optimization of the burning plasma that will be at the heart of a fusion reactor. It also provides valuable experience in designing, fabricating and assembling a fusion device at industrial scale. Investment in ITER has also benefited the private sector through developing a fusion technology supply chain.

- **Fusion Prototypic Neutron Source (FPNS)**: Will advance the science of materials under energetic fusion neutron bombardment and develop and qualify materials that can withstand the extreme neutron environment of a fusion reactor.

- **Materials Plasma Exposure eXperiment (MPEX)**: Now under construction at ORNL, this device will subject materials to intense heat and particle flows to enable the study of plasma–material interactions and the development of materials and components solutions for fusion exhaust systems.

- **Blanket and fuel-cycle test facilities**: Will demonstrate tritium breeding from fusion neutrons and tritium handling, demonstrating closing of the fusion fuel cycle—a critical hurdle for achieving economy and efficiency for commercialization.

The expert consensus view is that access to these facilities for U.S. public researchers and private sector developers is critically important to close science and technology gaps toward fusion pilot plants. I note that other countries, particularly China, are heavily investing in a number of similar fusion facilities that are under construction as we speak.

The importance of public sector innovation in the long-term success of the US fusion industry

Alongside increased efforts to partner with and enable the success of the private sector, we must also sustain and grow foundational fusion science and technology research programs at National Labs and Universities. Innovations from this research–and their translation to industry–will shape not just the first pilot plants, but the generations of fusion systems needed for a sustainable industry. This research ecosystem—spanning plasma physics, materials science and technology, and fusion enabling technology—has been the bedrock of U.S. progress.

Public sector programs will remain central to our long-term success by filling knowledge and technology gaps and serving as a rapid-response resource as technical challenges arise during demonstration and deployment of novel fusion systems. Foundational research and development at universities and national labs is also critical to sustain and grow the workforce needed for a successful fusion energy enterprise in the U.S.

A fusion workforce strategy should be developed for the U.S. and should include engagements across K-12 education, trade schools, community colleges, and higher education – with partnerships from national labs and industry providing, for example, internships and apprenticeships. I am very glad to see the Fusion Workforce Bill introduced by Representatives Lofgren and Obernolte – the provisions of this bill will set us on the right path to establishing the needed fusion workforce.

Closing: Now is the time to act

In short, Congress's consistent investment in fusion research has paid off in science, technology, and economic opportunity. But the decisive moment is upon us. Other nations are moving aggressively to invest in fusion energy development. With deliberate action now—by supporting new facilities, public–private partnerships, and sustained innovation—we can ensure that the U.S. leads in bringing fusion energy from scientific promise to commercial reality.

Thank you for your leadership and support. I look forward to your questions.

References

1. U.S. Department of Energy, Fusion Energy Sciences Advisory Committee, *Powering the Future: Fusion and Plasmas* (2021). https://usfusionandplasmas.org

2. National Academies of Sciences, Engineering, and Medicine. *A Strategic Plan for U.S. Burning Plasma Research* (2019). Washington, DC: The National Academies Press. https://doi.org/10.17226/25331

3. National Academies of Sciences, Engineering, and Medicine. *Bringing Fusion to the U.S. Grid* (2021). Washington, DC: The National Academies Press. https://doi.org/10.17226/25991