Written Testimony to the House Committee on Science, Space, and Technology

Research and Development to Advance a Clean Hydrogen Future

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Introduction

Chairwoman Johnson, Ranking Member Lucas, Energy Subcommittee Chairman Bowman, Energy Subcommittee Ranking Member Weber, and other Members of the Committee, thank you for the opportunity to testify today. I am Tomás Díaz de la Rubia, Vice President for Research and Partnerships at the University of Oklahoma. Prior to my current position, I spent the first part of my career at Lawrence Livermore National Laboratory—one of the Department of Energy's (DOE) 17 national laboratories—serving in various roles, including Deputy Director for Science and Technology and Chief Research Officer, and then spent some time in the private sector, before returning to academia. These experiences have given me important insights on public-private partnerships, innovation, and workforce development that are relevant to today's topic—the future of hydrogen to advance clean energy and climate goals.

A Fundamental Research Program for Carbon-Neutral Hydrogen

On June 7, 2021, DOE announced an ambitious goal through its Hydrogen Earthshot to reduce the cost of clean hydrogen by 80 percent to $1 per kilogram in just 10 years. Cost remains a major obstacle for advancing economically viable clean hydrogen. At present, clean hydrogen produced using renewables costs five times the DOE goal. The bipartisan American Investment and Jobs Act passed by Congress in November 2021 made a significant investment in hydrogen. Specifically, the legislation provided DOE with $8 billion to launch Hydrogen Hubs to demonstrate clean hydrogen technologies and help build out infrastructure for a hydrogen economy as well as $1.5 billion for research and development in electrolysis and clean hydrogen manufacturing and recycling. These investments are critical and essential. However, they alone are not sufficient to meet DOE's cost goals and overcome significant barriers to clean hydrogen development and deployment. Scientific breakthroughs are still needed to advance hydrogen technologies that do not emit carbon dioxide and are carbon neutral. These are primarily supported by DOE's Office of Science in coordination with the Offices of Energy Efficiency and Renewable Energy, Fossil Energy and Carbon Management, and Nuclear Energy and will need to include the new Office of Clean Energy Demonstrations.

To fully realize the potential of hydrogen, fundamental research is still needed to overcome significant technical hurdles and lower the cost of all three stages of a hydrogen economy—production, storage, and utilization. Massive amounts of hydrogen are produced globally each year and used in oil refining, transportation fuels, steel manufacturing, and chemical production, especially for ammonia. Hydrogen is produced using a variety of techniques, such as water splitting, catalytic or thermal cracking of methane, and catalytic processes using biomass, and it is transported by pipelines. Hydrogen also has energy storage properties as a clean way to store energy for future use and as a chemical feedstock. However, none of this is carbon neutral today. This is why a fundamental research program focused on all three aspects—production, storage, and utilization—is essential. This is the foundation to provide solutions to known and emerging challenges over the next five to ten years.

A focused and dedicated DOE Office of Science-supported fundamental research program would accelerate innovation and directly support planned DOE demonstration and deployment activities. DOE has already laid out a roadmap for fundamental research investments in its *Foundational Science for Carbon-Neutral Hydrogen Technologies* roundtable report, which incorporated input from academia, national labs, and industry. This includes investments in the discovery of stable and efficient chemical and materials systems to produce and safely store and transport hydrogen; the development of new experimental techniques and tools and analytical data science methods; and improved predictive theory and modeling.

A Hydrogen and Fuel Cell Innovation Center

While a dedicated, fundamental research program would help address scientific challenges, there also needs to be a bridge between new discoveries and practical applications and between use-inspired research and clean hydrogen demonstration and commercialization programs. This is a gap that must be filled. I recommend the creation of a Hydrogen and Fuel Cell Innovation Center. This Center would be modeled after other successful Energy Innovation Hubs in energy storage, solar fuels, desalination, and nuclear modeling. A number of key attributes include tackling a specific energy grand challenge over five to ten years; clear, measurable metrics; assembling multi-disciplinary, multi-institutional teams from DOE national labs, research universities, and the private sector; and addressing science, engineering, and technology challenges simultaneously, including assembly and testing of new devices and tools. The most recent DOE National Quantum Information Science Research Centers are also a helpful model for bringing industry to the table at the very beginning to define a research agenda and help overcome specific challenges as well as negotiate intellectual property use agreements to expedite deployment and commercialization of new technologies.

A Hydrogen and Fuel Cell Innovation Center would also be responsible for coordinating activities across the innovation ecosystem. Discoveries from single Principal Investigators or small research groups at DOE national laboratories and research universities as well as from Energy Frontier Research Centers would feed into the Center. The Center would also then be fully integrated with future DOE Hydrogen Hubs and other hydrogen-relevant activities supported by DOE applied energy programs. As the Hydrogen Hubs start to build infrastructure and focus on the production, transport and use of hydrogen, the Hubs can call on the Center to resolve specific fundamental research problems.

Another critical aspect is workforce development. The Center would support hands on training and learning for students and early-career researchers that will provide the future talent and workforce needed to advance a clean hydrogen economy. A highly skilled, creative, and innovative workforce is an essential component. This is also a unique opportunity to bring in diverse talent including participation from underrepresented groups in STEM as well as build the research capacity of Established Program to Stimulate Competitive Research (EPSCoR) states. These educational efforts will ensure that the U.S. continues to be a world leader in the development and deployment of clean hydrogen.

Regional Innovation and Public-Private Partnerships

Regional diversity and strong public-private partnerships are essential for the successful and sustained deployment of clean hydrogen technologies. While fundamental research activities and innovation centers can help solve a broad set of challenges, taking in to account the unique resources and geographic diversity of each region, such as energy infrastructure, sources of energy, and key industrial sectors, will be critical. Another key element is strong public-private partnerships between state and local governments, Tribal Nations, industry, academia, national labs, and federal agencies such as DOE. Institutions of higher education, such as the University of Oklahoma, play a critical role in fostering both regional innovation and forming public-private partnerships.

The state of Oklahoma has embraced its regional leadership potential in the transition to a low-carbon hydrogen economy. In early 2021, Governor Stitt and the State Legislature created the Hydrogen Production, Transportation, and Infrastructure Task Force. I had the privilege of serving as Co-Chair of the Subcommittee on Hydrogen Production and helped deliver a comprehensive report to the Governor that was published in December 2021. The purpose of the report was to make recommendations on ways in which the state can be a national leader in driving forward a new hydrogen economy. We sought feedback from a diverse set of stakeholders, including academia, industry, non-profits, and other state and local government representatives, to identify the opportunities and challenges for the large-scale production, use, and export of hydrogen in Oklahoma.

The report found that Oklahoma has inherent advantages that position it as a future regional leader in hydrogen production, transport, storage, and use. Oklahoma ranks fifth in the nation in natural gas production and is the nation's third largest producer of renewable electricity from wind. In particular, Oklahoma has extensive natural gas pipeline infrastructure; a highly-skilled oil, gas, and renewable energy workforce; low-cost electricity with substantial renewable energy production (nearly 40% and growing) making it the 3rd largest renewable energy producing state; access to abundant clean and alternative (e.g. produced) water sources for electrolytic production and steam methane reforming; abundant CO_2 and H_2-ready geologic pore space; the inland-most seaport in the U.S. via Tulsa's Port of Catoosa; and many companies already engaged in the hydrogen economy supply chain (e.g. production, storage, transport, and end use).

To take advantage of these report findings and recommendations will require strong public private partnerships. In Oklahoma, the state's research universities are working closely with the private sector and state offices to coordinate efforts to innovate on topics as important as carbon capture and sequestration, efficient approaches to hydrogen production, hydrogen storage, pipeline integrity, and hydrogen fuel blends. At the University of Oklahoma, for example, we're partnered closely with some of the state's tribal nations as well as with Oak Ridge National Laboratory on the development of advanced materials and production technologies to advance the hydrogen economy in support of the nation's drive toward net-zero emissions.

Importantly, our report highlighted Oklahoma's capacity and capability to support fundamental research and technological innovation that's needed for the H_2 transition. Coordinated by the Office of the Secretary of Energy and Environment, a consortium of university-based researchers is now working collaboratively to leverage strengths across the university system to innovate and optimize key aspects of the production, transport, and use of hydrogen.

An area of strength, led by the University of Oklahoma, is focused on optimizing the efficiency and minimizing the carbon emissions in the use of natural gas as a feedstock to produce hydrogen. For instance, in the multi-state Department of Energy funded project, "Carbon Utilization and Storage Partnership" (CUSP), which involves PNNL, LANL, and Sandia National Labs, we are addressing key infrastructure, technical, and data challenges in regional CCUS to ensure we can safely and profitably lower the carbon emissions for steam methane reforming through geologic storage of CO2. In related research that leverages our petroleum engineering and below-ground science strengths we are advancing a research program, in collaboration with teams at ORNL and LLNL, on hydrogen geologic storage potential. The team is investigating geochemical processes that could impact the longevity and reversibility of geologic storage; and developing sensor technologies to monitor and mitigate potential risks. At OU we are also advancing experimental and theoretical research in catalytic processes that convert methane—or even waste plastics and biomass—directly into H2 along with solid carbon byproducts in the form of nanomaterials which may have end-uses ranging from cement reinforcement, environmental remediation, to batteries.

A key to reaching our carbon neutrality goals is an accurate accounting of carbon emissions from cities and from petroleum and natural gas facilities, including abandoned wells. The University of Oklahoma is a world-leading innovator in atmospheric monitoring and modeling of natural gases from the well head to the regional scales. At the forefront of this innovation is the OU-designed and led NASA Geostationary Carbon Observatory (GeoCarb) satellite, launching in 2024, which will collect 10 million daily observations of the concentrations of carbon dioxide, methane, carbon monoxide and solar-induced fluorescence (SIF) at the highest spatial resolution to date –a remarkable 5 to 10 kilometers.

Conclusion

States like Oklahoma and our regional partners are well positioned to advance a clean hydrogen economy. I want to thank the Members of this Committee for advancing new federal opportunities in hydrogen in the American Infrastructure and Jobs Act, such as the Hydrogen Hubs and related research and development activities. This is already having the intended effect of bringing together a broad coalition of stakeholders from state and local governments, academia, national laboratories, Tribal Nations, non-profits, and local communities. As the Committee looks for additional opportunities to help advance a hydrogen economy, I recommend legislation that establishes a dedicated fundamental research program for carbon-neutral hydrogen and a Hydrogen and Fuel Cell Innovation Center that would tackle the hardest science and technology challenges and coordinate activities across the innovation spectrum.

Thank you for your strong support and interest in this critical energy topic.