INNOVATION THROUGH COLLABORATION: THE DEPARTMENT OF ENERGY'S ROLE IN THE U.S. RESEARCH ECOSYSTEM

HEARING

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

OF THE

HOUSE OF REPRESENTATIVES

ONE HUNDRED EIGHTEENTH CONGRESS

FIRST SESSION

MARCH 8, 2023

Serial No. 118–2

Printed for the use of the Committee on Science, Space, and Technology

Available via the World Wide Web: http://science.house.gov

U.S. GOVERNMENT PUBLISHING OFFICE

51–313PDF WASHINGTON : 2024

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HON. FRANK LUCAS, Oklahoma, *Chairman*

BILL POSEY, Florida
RANDY WEBER, Texas
BRIAN BABIN, Texas
JIM BAIRD, Indiana
DANIEL WEBSTER, Florida
MIKE GARCIA, California
STEPHANIE BICE, Oklahoma
JAY OBERNOLTE, California
CHUCK FLEISCHMANN, Tennessee
DARRELL ISSA, California
RICK CRAWFORD, Arkansas
CLAUDIA TENNEY, New York
RYAN ZINKE, Montana
SCOTT FRANKLIN, Florida
DALE STRONG, Alabama
MAX MILLER, Ohio
RICH MCCORMICK, Georgia
MIKE COLLINS, Georgia
BRANDON WILLIAMS, New York
TOM KEAN, New Jersey
VACANCY

ZOE LOFGREN, California, *Ranking Member*
SUZANNE BONAMICI, Oregon
HALEY STEVENS, Michigan
JAMAAL BOWMAN, New York
DEBORAH ROSS, North Carolina
ERIC SORENSEN, Illinois
ANDREA SALINAS, Oregon
VALERIE FOUSHEE, North Carolina
KEVIN MULLIN, California
JEFF JACKSON, North Carolina
EMILIA SYKES, Ohio
MAXWELL FROST, Florida
YADIRA CARAVEO, Colorado
SUMMER LEE, Pennsylvania
JENNIFER MCCLELLAN, Virginia
TED LIEU, California
SEAN CASTEN, Illinois
PAUL TONKO, New York

C O N T E N T S

March 8, 2023

INNOVATION THROUGH COLLABORATION: THE DEPARTMENT OF ENERGY'S ROLE IN THE U.S. RESEARCH ECOSYSTEM

WEDNESDAY, MARCH 8, 2023

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Committee met, pursuant to notice, at 10:03 a.m., in room 2318, Rayburn House Office Building, Hon. Frank Lucas [Chairman of the Committee] presiding.

Memorandum

TO: Committee on Science, Space, and Technology

FROM: Majority Staff, Committee on Science, Space, and Technology

DATE: March 8, 2023

SUBJECT: Full Committee Hearing: "Innovation Through Collaboration: The Department of Energy's Role in the U.S. Research Ecosystem"

The Committee on Science, Space, and Technology will hold a hearing titled *Innovation Through Collaboration: The Department of Energy's Role in the U.S. Research Ecosystem* on March 8, 2023, at 10:00 a.m. in Room 2318 of the Rayburn House Office Building.

Hearing Purpose

The purpose of this hearing is to examine the role of the U.S. Department of Energy (DOE) in the federal research enterprise by exploring longstanding interagency research partnerships between DOE and the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Agriculture (USDA), and the National Science Foundation (NSF), among others. This hearing will serve as a legislative hearing for a series of bills that would strengthen these partnerships and codify them in law as appropriate.

Witness List

- **Dr. Harriet Kung**, Deputy Director for Science Programs in the Office of Science, the U.S. Department of Energy
- **Mr. James L. Reuter**, Associate Administrator for the Space Technology Mission Directorate, the National Aeronautics and Space Administration
- **Dr. Michael C. Morgan**, Assistant Secretary of Commerce for Environmental Observation and Prediction, the National Oceanic and Atmospheric Administration
- **Dr. Sean L. Jones**, Assistant Director for the Directorate of Mathematical and Physical Sciences, the National Science Foundation

Overarching Questions

- What specific role does or should DOE play in addressing national research challenges?
- What types of federal interagency research partnerships are the most useful in bolstering U.S. competitiveness in science and technology? How can Congress best facilitate these types of partnerships and protect them from Administration turnover?
- What research infrastructure investments are necessary to ensure the DOE and its interagency research partners can compete on a national stage? In a restricted budget environment, what research facilities or investments should be prioritized?
- Are there specific areas of DOE's research portfolio where additional coordination or consultation with relevant federal agencies is needed?

DOE's Research Capabilities and Role in the U.S. Research Ecosystem

DOE's mission is to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions. As a leader in energy technology innovation and as the largest federal sponsor of basic research in the physical sciences, DOE plays a central role in the U.S. research ecosystem. DOE employs over 14,000 federal employees and oversees 95,000 contractors.[1] It operates 17 world-leading national laboratories which steward cutting-edge research in high priority focus areas such as materials science, advanced scientific computing, high energy physics, fusion energy sciences, and diverse next generation clean energy technologies.[2]

Through its Office of Science, DOE maintains and operates 28 scientific user facilities, which serve as essential resources for the research and development community. These facilities include advanced supercomputers, large-scale analytical and experimental tools like particle accelerators, x-ray light sources, and neutron scattering sources, as well as dedicated facilities for nanoscience and genomics. Together, this network of user facilities supports tens of thousands of researchers each year and provides a foundation for U.S. competitiveness in science and technology.[3]

Since the 1950s, DOE has applied its unparalleled expertise and resources to national science and technology challenges - work that has led to major scientific discoveries and technology innovations. Just a few of DOE's accomplishments include jump-starting the shale gas revolution by pointing the way to key technologies and methodologies for cost efficient extraction; pioneering optical digital recording technology; partnering with other federal agencies to identify and map all of the genes of the human genome; building the radioisotope thermoelectric generators that fuel NASA missions; and developing some of the fastest supercomputers currently in operation, including two exascale computers.[4]

---

[1] Department of Energy Overview. Performance.gov. (n.d.). Retrieved March 2, 2023, from https://trumpadministration.archives.performance.gov/energy
[2] "National Laboratories." *Energy.Gov*, www.energy.gov/national-laboratories. Accessed 2 Mar. 2023.
[3] "Office of Science User Facilities." *Energy.Gov*, www.energy.gov/science/office-science-user-facilities. Accessed 2 Mar. 2023.
[4] "75 Breakthroughs by America's National Laboratories." *Energy.Gov*, 14 Feb. 2018, www.energy.gov/articles/75-breakthroughs-americas-national-laboratories-0. Accessed 2 Mar. 2023.

In carrying out this work, DOE has developed longstanding partnerships with various federal research agencies. As international competition grows and new opportunities for government-wide coordination and collaboration emerge, there is a need to examine these partnerships and determine the appropriate steps for strengthening them.

DOE and NASA

Fueled by the Department's expertise in nuclear propulsion, DOE and NASA have held a formal research partnership since 1960. DOE's national laboratories were instrumental in developing the Radioisotope Thermoelectric Generator (RTG), which powered several successful missions such as the Apollo program and the Voyager and Cassini spacecraft.[5]

Over the last sixty years, this relationship has expanded to new areas; DOE's Office of Science has provided NASA with their expertise in variety of subjects such as astronomy, astrophysics, biology, materials science, plasma science, space weather, solar energy, microgrids, low dose radiation, and high energy science. In the early 2000s, both offices worked together to build the Large-Area Telescope, which is the primary instrument for the Fermi Gamma-ray Space Telescope. This device detects gamma rays emitted by phenomena and highly energized objects across the universe, which has greatly improved our understanding of black holes, supernovas, and the universe itself.[6] In addition, NASA has employed the DOE's Frontier system at Oak Ridge National Laboratory, an exascale supercomputer, for weather simulations as well as to model a potential Mars landing. The latter simulation required nearly 400 terabytes of data for the six different flight scenarios.[7]

The most recent Memorandum of Understanding between NASA and DOE was signed in 2020.[8] This agreement continued collaboration in these areas of research and established three working groups: infrastructure on the lunar surface, nuclear power and propulsion in space, and space safety and planetary defense. One main goal for this renewed partnership was to return humans to the Moon by 2024 and develop a sustainable crewed space exploration program.[9] In 2021, NASA and DOE's Idaho National Laboratory awarded funding to nuclear thermal propulsion system designs, which could aid crew and cargo missions to Mars as well as science missions to the outer solar systems.[10] In 2022, these two groups then granted funding to fission surface power system designs that could support long-duration missions on the Moon and Mars.[11]

---

[5] "Radioisotope Thermoelectric Generators (RTGs)." *NASA.Gov*, 25 Sept. 2018, solarsystem.nasa.gov/missions/cassini/radioisotope-thermoelectric-generator/. Accessed 2 Mar. 2023.
[6] "Fermi Gamma-ray Space Telescope." *NASA.Gov*, 31 Jan. 2023, solarsystem.nasa.gov/missions/cassini/radioisotope-thermoelectric-generator/. Accessed 2 Mar. 2023.
[7] McDowell, Rachel. "NASA Team Releases Mars Landing Simulation Data to Encourage New Research into Spacecraft Descent Technologies." *Oak Ridge National Laboratory*, 23 Sept. 2020, www.olcf.ornl.gov/2020/09/23/nasa-team-releases-mars-landing-simulation-data-to-encourage-new-research-into-spacecraft-descent-technologies/. Accessed 2 Mar. 2023.
[8] "Department of Energy and NASA Sign Memorandum of Understanding." *Energy.Gov*, 20 Oct. 2020, www.energy.gov/articles/department-energy-and-nasa-sign-memorandum-understanding. Accessed 2 Mar. 2023.
[9] "Department of Energy and NASA Sign Memorandum of Understanding." *Energy.Gov*, 20 Oct. 2020, www.energy.gov/articles/department-energy-and-nasa-sign-memorandum-understanding. Accessed 2 Mar. 2023.
[10] Potter, Sean. "NASA Announces Nuclear Thermal Propulsion Reactor Concept Awards." NASA, July 13, 2021. https://www.nasa.gov/press-release/nasa-announces-nuclear-thermal-propulsion-reactor-concept-awards.
[11] Dodson, Gerelle. "NASA Announces Artemis Concept Awards for Nuclear Power on Moon." NASA, June 22, 2022. https://www.nasa.gov/press-release/nasa-announces-artemis-concept-awards-for-nuclear-power-on-moon.

DOE and NOAA

DOE and NOAA collaborate on a range of weather and climate focused research activities. These agencies also work together through the National Climate-Computing Research Center (NCRC). Located at DOE's Oak Ridge National Laboratory, the NCRC provides NOAA with the ability to utilize high performance computing systems to develop, test, and apply complex Earth system models and computer simulations to all aspects of the climate and environment.[12]

Since the partnership agreement was established in 2009, the NCRC has contributed to the accelerated development and deployment of NOAA's four major modeling configurations: weather and subseasonal-to-seasonal forecasting (SHiELD), seasonal-to-multidecadal forecasting (SPEAR), high-resolution-ocean-based climate modeling (CM4), and Earth system modeling (ESM4). This work has been conducted on a computing system named Gaea that is operated by personnel from the National Center for Computational Sciences and capable of 5.29 petaflops.[13]

In January of 2021, DOE and NOAA formally agreed to renew their strategic partnership. This new agreement extends the partnership for another five years, funds a new series of technical and scientific projects, and installs a new HPC system that will increase Gaea's performance capability to around ten petaflops.[14]

DOE and the USDA

DOE and USDA have an established history of partnering to address multidisciplinary research challenges, and many of these collaborations have been formalized through various laws, agreements, and Memoranda of Understanding. A few focus areas include earth and environmental systems science, biomass and genomics-based research[15], sustainable aviation fuels[16], integrated water and natural resources[17], and methods for improving energy development in rural America.[18]

[12] "Climate Research Accelerated." *NCRC.Gov*, www.ncrc.gov/. Accessed 2 Mar. 2023.
[13] "GAEA." *NOAA.Gov*, 27 Feb. 2023, www.noaa.gov/organization/information-technology/gaea. Accessed 2 Mar. 2023.
[14] Turczyn, Coury. "DOE and NOAA Extend Strategic Partnership." *ORNL.Gov*, 12 Jan. 2021, olcf.ornl.gov/2021/01/12/doe-and-noaa-extend-strategic-partnership/. Accessed 2 Mar. 2023.
[15] 7 U.S.C. §8108.
[16] *Memorandum of Understanding Sustainable Aviation Fuel Grand Challenge*, 8 Sept. 2021. https://www.energy.gov/sites/default/files/2021-09/S1-Signed-SAF-MOU-9-08-21_0.pdf. Accessed 2 Mar. 2023.
[17] *Collaboration to Support Integrated Water Resources Science, Information, and Services*, 14 Jan. 2021. https://water.usgs.gov/osw/iwrss/ws00000587-final-iwrss-mou-signed.pdf. Accessed 2 Mar. 2023.
[18] *Relative to Cooperation and Coordination on Improving Energy Development in Rural America*, 25 Apr. 2017. Accessed 2 Mar. 2023.

For example, coordinating on fundamental genomics and early-stage biomass research helps the USDA and DOE overcome the challenges inherent in developing low-cost, high-efficiency biofuels. Through its Agricultural Research Service (ARS), and its National Institute of Food and Agriculture (NIFA), USDA has a history of coordinating with DOE and its Regional Feedstock Partnerships and Bioenergy Research Centers to develop science-based strategies to accelerate the production of regionalized biofuels feedstocks, renewable chemical feedstocks, and conversion systems that can support clean energy technologies and rural economic growth.[19,20]

Working together on future challenges, these agencies can improve crop science, maximize carbon storage, enhance precision agriculture technologies, and identify ways to combat invasive species, among many other areas.

DOE and the NSF

DOE and NSF have an active and extensive history of collaboration. These agencies collaborate on a wide range of research topics such as physics, quantum information sciences, biotechnology, artificial intelligence, advanced manufacturing, clean energy technologies, and advanced manufacturing.

Over the years, these agencies have developed several highly successful joint initiatives, such as the Basic Plasma Science and Engineering partnership. Since 1997, this program has expanded our understanding of plasma, its applications, and trained a new generation of scientists and engineers.[21] In addition, this partnership led to the development other initiatives such as the Algorithms for Modern Power Systems program which supports research projects to develop advanced mathematical and statistical algorithms that can improve the security, reliability, and efficiency of the power grid.[22]

DOE and NSF have also partnered to support the development of international scientific resources. The Vera C. Rubin Observatory, a world-leading tool for scientific discovery in astronomy, is a joint DOE-NSF project located in Chile. The Rubin Observatory is an 8.4-meter-wide field optical telescope designed to carry out a deep survey of our solar system and galaxy.[23] DOE and NSF have also provided funds for upgrades to the Large Hadron Collider at CERN (the European Organization for Nuclear Research), a project that has improved our global understanding of the fundamental nature of the universe.[24]

---

[19] "Special Projects and Partnerships." *USDA.Gov*, www.wctsservices.usda.gov/Energy/SpecialProjects. Accessed 2 Mar. 2023.
[20] Office of Science (2019) *Plant Feedstock Genomics for Bioenergy Joint Awards 2006-2018*. Available at: https://genomicscience.energy.gov/wp-content/uploads/2021/09/usda-doe-Awards_flyer_2018.pdf (Accessed: March 2, 2023).
[21] Zweibel, E., Brown, M., Mauel, M., Milchberg, H., Rocca, J., & Thomas, E. J. (2017, March 31). The NSF/DOE partnership in Basic Plasma Science & Engineering at 20: Report on the Anniversary Workshop. AUrora Home. Retrieved March 2, 2023, from https://aurora.auburn.edu/handle/11200/49635.
[22] *Algorithms for Modern Power Systems (AMPS)* NSF. Available at: https://www.nsf.gov/pubs/2022/nsf22569/nsf22569.htm (Accessed: March 2, 2023).
[23] *National Science Foundation - Where Discoveries Begin* NSF. Available at: https://www.nsf.gov/about/budget/fy2022/ (Accessed: March 2, 2023).
[24] "NSF Awards $153 Million for High Luminosity Upgrades to Particle Detectors at Large Hadron Collider." *NSF.Gov*, 31 Mar. 2020, www.nsf.gov/news/special_reports/announcements/033120.jsp. Accessed 2 Mar. 2023.

DOE and other Federal Research Agencies

DOE also partners with additional federal agencies like the National Institute for Standards and Technology (NIST) and the Department of Homeland Security (DHS). NIST and DOE have worked closely over the past few years to improve critical infrastructure cybersecurity through NIST's updated cybersecurity framework.[25] Both agencies also are active participants in the National Quantum Initiative along with NSF. DOE and DHS signed an MOU in 2020 to partner on a new Energy Sector Pathfinder initiative.[26] The goals of this initiative are to advance information sharing, improve training and education to understand systemic risks, and develop joint operational preparedness and response activities to cybersecurity threats. The two agencies also collaborate at DHS's National Urban Security Technology Laboratory (NUSTL) in New York to help first responders prepare, protect, and respond to homeland security threats.[27]

Relevant Legislation

This hearing will serve as a legislative hearing for three Science Committee Majority bills that would codify in law the existing research partnerships between DOE and NASA, DOE and NOAA, and DOE and the USDA. This hearing will also be used to inform the development of future legislation in this area.

Last Congress, in August 2022, the DOE Office of Science was authorized in P.L. 117-167, the bipartisan CHIPS and Science Act. This legislation includes detailed program direction and targeted funding for DOE fundamental research programs and for critical research infrastructure, including upgrades and construction for scientific user facilities, at the DOE National Laboratories. It advances cutting-edge science with a responsible, scalable funding increase and provides a long-term strategic roadmap for DOE's R&D activities. CHIPS and Science also includes investments in NSF, NIST, and NASA, as well as provisions to protect these investments from theft and interference by adversaries. Oversight of CHIPS and Science implementation is a key priority for the Science Committee this Congress.

---

[25] Department of Energy Order 205.1C, May 15, 2019. https://www.directives.doe.gov/directives-documents/200-series/0205.1-BOrder-c-chg1-ltdchg/@@images/file
[26] "U.S. Department of Energy, U.S. Department of Homeland Security, and U.S. Department of Defense Announce Pathfinder Initiative to Protect U.S. Energy Critical Infrastructure." *Energy.Gov*, 3 Feb. 2020, www.energy.gov/articles/us-department-energy-us-department-homeland-security-and-us-department-defense-announce. Accessed 2 Mar. 2023.
[27] "National Urban Security Technology Laboratory." *Dhs.Gov*, 14 Feb. 2023, www.dhs.gov/science-and-technology/national-urban-security-technology-laboratory. Accessed 2 Mar. 2023.

Chairman LUCAS. The Committee will come to order. Without objection, the Chair is authorized to declare recesses of the Committee at any time.

Welcome today's hearing entitled "Innovation Through Collaboration: The Department of Energy's (DOE's) Role in the U.S. Research Ecosystem." I recognize myself for five minutes for an opening statement.

Good morning. Today, the Science Committee will examine the Department of Energy's role in the Federal research enterprise. DOE is the Nation's largest Federal sponsor of basic research in the physical sciences and is a world leader in energy technology development and innovation. As such, it is uniquely able to partner with other Federal research agencies to address our most critical national science and technology challenges.

This hearing will serve as a legislative hearing for three bills we plan to introduce soon that would authorize a number of DOE's existing interagency research partnerships. We'll also use the information from today's discussions to inform the development of future legislation in this area.

DOE has a wide range of assets at its disposal that can be leveraged for research partnerships. It operates 17 world-leading national laboratories, which—with steward cutting-edge research in high-priority areas and maintains and operates 28 scientific user facilities which serve as an essential resource for the research and development (R&D) community. Together, this network of facility supports tens of thousands of researchers each year and provides a foundation for U.S. competitiveness in emerging technologies.

We're here today to discuss how we can leverage DOE's tremendous expertise and resources to help other Federal research agencies address cross-cutting scientific challenges. I hope to examine how these partnerships are already benefiting Americans and how we can craft legislation to ensure that agencies can continue collaborating on strategic research to enhance U.S. competitiveness for the next generation.

For example, partnering on genomics-based research helps DOE and the U.S. Department of Agriculture (USDA) overcome the challenges inherent in developing low-cost, high-efficiency biofuels. Working together, the agencies can improve crop science, maximize carbon storage, enhance precision agriculture technologies, and identify ways to combat invasive species, among many other areas.

DOE and NOAA (National Oceanic and Atmospheric Administration) partner to improve climate modeling, weather prediction, and other activities that require analysis of large—extremely large and complex data sets. Leveraging DOE's high-performance computing (HPC) capacities can improve NOAA's forecasting and advance DOE's machine-learning abilities.

DOE and NASA (National Aeronautics and Space Administration) have a long history of collaboration on fundamental science research and particularly on nuclear propulsion and power for spacecraft. The Voyager spacecrafts launched more than 40 years ago continue to operate with DOE's power system. DOE and NASA can work together on critical challenges of building a lunar surface infrastructure and efficiently powering a crewed journey to Mars.

Similarly, DOE and NSF (National Science Foundation) have an active and extensive history of collaboration. These agencies collaborate on a wide range of research topics such as physics, quantum information sciences, artificial intelligence (AI), and advanced manufacturing. By combining their resources, DOE and the NSF support large-scale discovery science and the development of international scientific resources like the Vera C. Rubin Observatory.

I'm looking forward to hearing more from our witnesses about the potential for future collaboration to enhance U.S. competitiveness. As the United States faces growing competition from the Chinese Communist Party, it's never been more important to maximize our Federal R&D resources. One aspect of that is examining how we can best utilize interagency partnerships to strengthen American science and technology.

Last summer, Congress passed the *CHIPS and Science Act,* which included detailed program direction and substantial funding for DOE research programs and critical research infrastructure. *CHIPS and Science* also includes investments in NSF, NIST (National Institute of Standards and Technology), and NASA, as well as provisions to protect these investments from theft and interference by adversaries. Overseeing the implementation of *CHIPS and Science* will be a priority issue for our Committee this year, and I expect many—that we'll have many hearings that will touch on this subject.

Prioritizing support for our Federal science research agencies like DOE and its Office of Science is one pillar of our oversight plans this Congress, to build on these investments, protect them from administration overrun—or should I say turnover—and maximize return on investment of taxpayer dollars.

There's a need for legislation to secure our essential interagency research. Setting the seal on DOE's partnerships with agencies like NASA, NOAA, NSF, and the USDA means we're making the best use of our resources when we tackle challenges like furthering space exploration, improving weather forecasting, and advancing production agriculture.

I'm looking forward to speaking with experts about how we in Congress can capitalize on this opportunity. I want to thank our witnesses for their testimony today, and I look forward to a very productive discussion.

[The prepared statement of Chairman Lucas follows:]

Good morning. Today, the Science Committee will examine the Department of Energy's role in the federal research enterprise.

DOE is the nation's largest federal sponsor of basic research in the physical sciences and is a world leader in energy technology development and innovation. As such, it is uniquely able to partner with other federal research agencies to address our most critical national science and technology challenges.

This hearing will serve as a legislative hearing for three bills we plan to introduce soon that would authorize a number of DOE's existing interagency research partnerships. We'll also use the information from today's discussions to inform the development of future legislation in this area.

DOE has a wide range of assets at its disposal that can be leveraged for research partnerships. It operates 17 world-leading national laboratories which steward cutting-edge research in high priority areas and maintains and operates 28 scientific user facilities, which serve as essential resources for the research and development community.

Together, this network of facilities supports tens of thousands of researchers each year and provides a foundation for U.S. competitiveness in emerging technologies.

We're here today to discuss how we can leverage DOE's tremendous expertise and resources to help other federal research agencies address cross-cutting scientific challenges. I hope to examine how these partnerships are already benefitting Americans and how we can craft legislation to ensure agencies can continue collaborating on strategic research to enhance U.S. competitiveness for the next generation.

For example, partnering on genomics-based research helps DOE and the U.S. Department of Agriculture overcome the challenges inherent in developing low-cost, high-efficiency biofuels.

Working together, the agencies can improve crop science, maximize carbon storage, enhance precision agriculture technologies, and identify ways to combat invasive species, among many other areas.

DOE and NOAA partner to improve climate modeling, weather prediction, and other activities that require analysis of extremely large and complex data sets. Leveraging DOE's high-performance computing capabilities can improve NOAA's forecasting and advance DOE's machine learning abilities.

DOE and NASA have a long history of collaboration, on fundamental science research and particularly on nuclear propulsion and power for spacecraft. The Voyager spacecrafts-launched more than 40 years ago-continue to operate with DOE's power system. DOE and NASA can work together on the critical challenges of building a lunar surface infrastructure and efficiently powering a crewed journey to Mars.

Similarly, DOE and NSF have an active and extensive history of collaboration. These agencies collaborate on a wide range of research topics such as physics, quantum information sciences, artificial intelligence, and advanced manufacturing.

By combining their resources, DOE and NSF support large-scale discovery science and the development of international scientific resources like the Vera C. Rubin Observatory.

I'm looking forward to hearing more from our witnesses about the potential for future collaboration to enhance U.S. competitiveness.

As the United States faces growing competition from the Chinese Communist Party, it's never been more important to maximize our federal R&D resources. One aspect of that is examining how we can best utilize interagency partnerships to strengthen American science and technology.

Last summer, Congress passed the *CHIPS and Science Act,* which includes detailed program direction and substantial funding for DOE research programs and critical research infrastructure.

CHIPS and Science also includes investments in NSF, NIST, and NASA, as well as provisions to protect these investments from theft and interference by adversaries.

Overseeing the implementation of *CHIPS and Science* will be a priority issue for our Committee this year, and I expect that many hearings will touch on this topic. Prioritizing support for our federal science research agencies like DOE and its Office of Science is one pillar of our oversight plans this Congress.

To build on these investments, protect them from administration turnover, and maximize return on investment of taxpayer dollars, there is a need for legislation to secure our essential interagency research. Setting the seal on DOE's partnerships with agencies like NASA, NOAA, the NSF, and the USDA means we're making the best use of our resources when we tackle challenges like furthering space exploration, improving weather forecasting, and advancing production agriculture.

I'm looking forward to speaking with experts about how we in Congress can capitalize on this opportunity.

I want to thank our witnesses for their testimony today, I look forward to a productive discussion.

Chairman LUCAS. Now, I'd like to recognize the Ranking Member, the gentlewoman from California, for an opening statement.

Ms. LOFGREN. Well, thank you. Thank you, Mr. Chairman, and thank you for today's hearing. And I want to thank our distinguished panel as well. It's not every day that we're able to speak to senior officials from four of our Nation's major science agencies, and in the same panel no less, so we look forward to working with each of you in this Congress.

The Members of the Science Committee take the responsibility of overseeing America's scientific research enterprise quite seriously, and it's a duty that will consume this Committee as we move forward in this Congress. We have to remain focused on making sure that we're enabling all the tools and technologies we'll need to aggressively confront the climate crisis. And as the economic and national security implications of losing our global leadership in science and technology are stark, I hope that everyone in the room can agree that robust Federal science and technology programs are essential to ensuring the prosperity and well-being of all Americans.

We had a hearing last week on the importance of Federal coordination on a National Science and Technology Strategy. And today, we'll take a closer look at the role of the DOE and the interagency partnerships that enable us to reap the benefits of the research that the Department stewards. So many questions of science are interdisciplinary and, as such, often require close collaborations among relevant agencies to properly address them. Fields such as quantum, artificial intelligence, climate science really demand a whole-of-government approach to advance the science.

And the agriculture sector is a great example where these Federal science partnerships shine. Our Nation can only fully address the climate crisis by deploying methods and tools to decarbonize the ag sector, which represents 11 percent of U.S. greenhouse gas emissions. My district is one of the most productive agricultural regions in California, and I'm encouraged to see that DOE national labs are leading impressive research to balance farming productivity with conservation.

For example, DOE's Lawrence Berkeley and Idaho National Labs are leveraging their scientific resources and facilities to support technological innovation that's going to help develop this emerging field of agriculture with notable contributions like the crop artificial intelligence quotient. This computational tool will provide farmers with accurate up-to-date yield maps capable of analyzing variables like crop yield and moisture to help growers apply precision treatments only where needed, which will save time and money, while simultaneously benefiting the environment.

This DOE project uses datas—data from USDA satellites, which demonstrates the interconnection that we need between our research agencies. And this is just one example of these important interagency partnerships that we have to preserve and build upon.

I also think that we would benefit greatly if we start thinking about cross-cutting research opportunities for newly emerging technologies. As we develop next-generation technologies like fusion energy, we need to be thinking now about the cross-cutting benefits and research that will be needed to enable full benefits of that technology for our society that could involve NASA collaborations for off-Earth applications. It could involve DOD (Department of Defense) collaborations for applications from remote locations to power a future nuclear Navy.

But if we aren't beginning to think of those cross-cutting opportunities now, then we will ultimately be depriving ourselves of the tremendous potential and promise of fusion, a game-changing technology. It won't be enough to simply develop fusion energy technologies. If we want America to be a world leader in this space, we need to utilize the full breadth of opportunity in the Federal research enterprise to help create a fusion research ecosystem to advance this technology.

We have an interesting discussion ahead of us this morning and an incredible opportunity in front of us, and we must make the most of it by ensuring our Federal research enterprise is working as collaboratively as possible.

And I want to thank you again, Mr. Chairman. It's been wonderful to work with you.

[The prepared statement of Ms. Lofgren follows:]

Thank you, Chairman Lucas, for holding today's hearing. And I want to thank our distinguished panel of witnesses for joining us. It is not every day that we are able to speak to senior officials from four of our nation's major science agencies, and in the same panel no less. I look forward to working with each of you this Congress.

As Members of the Science Committee, we have the responsibility of overseeing America's scientific research enterprise. This is a duty we do not take lightly, especially in a time when numerous existential threats face our nation. We must remain focused on making sure that we are enabling all of the tools and technologies we will need to aggressively confront the climate crisis. And the economic and national security implications of losing our global leadership in science and technology are stark. I hope that everyone in the room can agree that robust federal science and technology programs are essential to ensuring the prosperity and well-being of all Americans.

We had a hearing just last week on the importance of federal coordination on a national science and technology strategy. Today, we will take a closer look at the role of the Department of Energy, and the interagency partnerships that enable us to best reap the benefits of the research that the Department stewards. So many questions of science are interdisciplinary, and as such, often require close collaborations among relevant agencies to properly address them. Fields such as quantum, artificial intelligence, and climate science really demand a whole-of-government approach to advance the science.

The agriculture sector is a great example where these federal science partnerships shine. Our nation can only fully address the climate crisis by deploying methods and tools to decarbonize the agriculture sector, which represents 11 percent of U.S. greenhouse gas emissions. My district is one of the most productive agricultural regions in California, and I am encouraged to see that DOE national laboratories are leading impressive research in precision agriculture, which offers the opportunity to balance farming productivity with conservation. For example, DOE's Lawrence Berkeley and Idaho National Laboratories are leveraging their scientific resources and facilities to support technological innovation that will help develop this emerging field of agriculture, with notable contributions like the Crop Artificial Intelligence Quotient. This computational tool will provide farmers with accurate, up-todate yield maps capable of analyzing variables like crop yield and moisture to help growers apply precision treatments only where needed, saving time and money while simultaneously benefitting the environment. This DOE project uses data from USDA satellites, which demonstrates the interconnection that we need between our research agencies. And this is just one example of these important interagency partnerships that we must preserve and build upon.

I also think that we would benefit greatly if we start thinking about crosscutting research opportunities for newly emerging technologies. As we develop next generation technologies like fusion energy, we need to be thinking now about the crosscutting research that will be needed to enable the full benefits of that technology for our society. That might involve NASA collaborations for off-earth applications. That might involve DOD collaborations for applications in remote locations or to power our future nuclear navy. But if we aren't beginning to think of those crosscutting opportunities now, then we will ultimately be depriving ourselves of the tremendous promise of this game-changing technology. It won't be enough to simply develop fusion energy technologies if we want America to be the world leader in this space. We need to utilize the full breadth of opportunity in the federal research enterprise to help create a fusion research ecosystem to advance this technology.

We have an interesting discussion ahead of us this morning. We have an incredible opportunity in front of us and we must make the most of it by ensuring our federal research enterprise is working as collaboratively as possible.

Thank you, and I yield back my time.

Chairman LUCAS. Thank you, Ranking Member, and I appreciate those opening comments.

Let me introduce our witnesses today for the panel. Our first witness today is Dr. Harriet Kung, the Deputy Director for Science Programs at the Office of Science at the U.S. Department of Energy, where she's responsible for direction and oversight of Office of Science programs in advanced scientific computing, computing research, fusion energy sciences, basic energy sciences, high-energy physics, biological environmental research, and nuclear physics. That's quite an agenda.

Our second witness is Mr. James Reuter, the Associate Administrator for NASA's Space Technology Mission Directorate (STMD), where he manages and oversees investments in cross-cutting technologies that support NASA's current and future missions.

Our third witness is Dr. Michael Morgan, the Assistant Secretary of Commerce for Environment, Observation, and Prediction at NOAA. In this role, Dr. Morgan provides the Administration with direction and expertise regarding weather, climate, ocean observations, and water.

And our fourth witness is Dr. Sean Jones, who is the Assistant Director for the Directorate of Mechanical—or Mathematical, I should say, and Physical Sciences at the National Science Foundation. In his capacity, he oversees the astronomy, chemistry, mathematics, material, and physics divisions.

Thank you all, witnesses, for being here today and sharing your expertise with our Committee.

And with that, Dr. Kung, I turn to you for five minutes for your opening comments, please.

TESTIMONY OF DR. HARRIET KUNG, DEPUTY DIRECTOR FOR SCIENCE PROGRAMS IN THE OFFICE OF SCIENCE, THE U.S. DEPARTMENT OF ENERGY

Dr. KUNG. Thank you, Chairman Lucas, Ranking Member Lofgren, and Members of the Committee. It is a great honor and pleasure for me to join you today representing the Department of Energy to discuss the critical role of interagency partnerships in delivering DOE's mission while supporting the Nation's broader innovation ecosystem.

My name is Harriet Kung. As the Chairman just mentioned, I'm the Deputy Director for Science Program in DOE's Office of Science where our core mission is to deliver scientific discoveries and major scientific tools that will transform our understanding of nature, while advancing our Nation's energy, economic, and national security goals.

I want to start by noting that DOE shares the Committee's view of the critical importance of this topic, especially in our current environment. As we all know, America is in increasingly intense global competitions. It's a competition for leadership in science. It's a competition in technology and innovation. It will take all of us working together in the executive branch, Congress, across the whole Nation in order to meet this challenge, but also to build a more prosperous, innovative, and inclusive America for decades to come.

In my testimony today, I would like to focus on three key points on how DOE delivers impact to our interagency collaborations. First, DOE's interagency partnerships span from fundamental research to demonstration and deployment. Whether it's unlocking the mysteries of the universe with NSF or driving innovation in ocean observation with NOAA, DOE is contributing our unique expertise and capabilities to interagency partnerships to address the most challenging cross-cutting science and technology problems.

Second, DOE engages in partnership where we advance our own missions, while bringing complementary technologies capabilities to our partners. Our 17 national laboratories, and the Office of Science 28 user facilities represent unmatched national resources, especially in the physical sciences and high-performance computing areas. Thirdly, our shared efforts have already delivered enormous outcomes going back many decades. For example, DOE, along with our NIH (National Institutes of Health) partner and private sector were instrumental to unlocking the human genome, and in turn, revolutionize modern biology and medicine. Working with NSF and others, we have peered into the heart of atoms and deliver exciting new insights on the fundamental building blocks of the universe and making our Nation the global intellectual leader in discovery science. And similarly, working with NASA, we leverage our expertise in nuclear seismic technology to deliver radio isotopes and power technologies that are driving Mars landers and satellite probes traversing the whole solar system.

Looking to the future, we see a landscape where strengthening U.S. leadership in science innovation will require even greater collaboration. And as we work together to implement the *CHIPS and Science Act,* these collaborations will be needed to realize a future where the U.S. meets an increasingly competitive global landscape. And for that matter, our user facilities and national laboratories need to be upgraded and fully resourced to meet the increasing demands from both the DOE and also interagency-funded research. Fully leveraging these existing centers of excellence, while building capacity among historically minoritized communities, will be critical to delivering on the promise Congress laid out in the *CHIPS and Science Act.* We're already leaning in with a new cross-cutting partnership with NSF and in collaboration with NASA to deliver a one-of-a-kind instrument called LuSEE-Night (Lunar Surface Electromagnetic Experiment-Night) to explore the far side of the Moon. Similarly, we're looking to expand our partnerships further with NOAA and USDA.

In closing, thank you for opportunity to address the Committee, and I'm looking forward to talking with you about DOE's collaborations and answering your questions. Thank you.

[The prepared statement of Dr. Kung follows:]

Testimony of Dr. Harriet Kung

Deputy Director for Science Programs, Office of Science

U.S. Department of Energy

Before the

Committee on Science, Space, and Technology

U.S. House of Representative

March 8, 2023

Introduction

Thank you, Chairman Lucas, Ranking Member Lofgren, and Members of the Committee. It is with great pleasure that I join you today to represent the Department of Energy (DOE) at this hearing to discuss the critical role of interagency partnerships in delivering on our missions at DOE and supporting the broader U.S. innovation ecosystem.

My name is Harriet Kung, and I am the Deputy Director for Science Programs in the DOE Office of Science, where I oversee the majority of scientific research programs within our office, from Advanced Scientific Computing Research to Nuclear Physics and beyond. As this committee is well aware, the Office of Science's core mission is to deliver the scientific discoveries and major scientific tools that will transform our understanding of nature and advance the energy, economic, and national security goals of the United States. Over the decades, the investments and accomplishments in basic research and enabling research capabilities made by the Office of Science and its predecessor agencies have provided the foundations for countless new technologies, businesses large and small, and entirely new industries. These investments have contributed immensely to our nation's economy, to our national security, and to our quality of life.

In my testimony today, I'd like to focus on three key points:

First, DOE's interagency engagements span fundamental and applied research, development, demonstration, and deployment, involving offices across the entire Department. While my testimony today will largely focus on those partnerships that we steward in the Office of Science, the Department welcomes continued discussions on the broader suite of partnerships across the agency.

Second, DOE engages in interagency partnerships only where such partnerships are aligned with our mission space and where the Department can provide complementary capabilities and expertise to deliver on shared outcomes. We leverage our unique and world class research infrastructure at the DOE National Laboratories and across the Office of Science's 28 user facilities, to provide access to capabilities, many of which can be found nowhere else in the world. We bring our mission-driven focus on energy, economic, and national security to these partnerships.

Finally, I want to take this opportunity to highlight some of the incredible outcomes we have delivered in partnership with our sister agencies, both here and across the broader U.S. research and development enterprise. Together, we have unlocked the human genome, accelerated diagnostics and treatments for COVID, and delivered new insights on the fundamental building blocks of our universe. These advancements represent just a few of the many groundbreaking discoveries taking place in the U.S. R&D enterprise.

The sections below provide representative examples of some of the important work DOE's Office of Science has conducted in partnership with the National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and U.S. Department of Agriculture (USDA). I will also touch on our long history of partnership with the National Institutes of Health (NIH) and the recent multi-agency collaborations launched in response to the COVID-19 crisis.

Before going any further, I want to take the opportunity to thank this Committee for your collaborative, bipartisan efforts on the CHIPS and Science Act. We know the hard work that went into crafting that legislation and appreciate the inclusive approach this Committee took to engage the Department and other agencies here today in that process. Your hard work on the CHIPS and Science Act positions DOE and the Office of Science to not only rise to meet today's most pressing scientific and technical challenges, but to expand our capabilities to support the interagency partnerships we are here to discuss.

Along these lines, I also want to take the opportunity, on behalf of DOE, to thank you for the opportunity to provide technical assistance on the discussion drafts you have prepared on interagency partnerships. We appreciate the Committee's support for DOE establishing and sustaining mutually beneficial collaborations on topics of national importance, while also maintaining the Department's flexibility to develop collaborations from the bottom up and in response to new frontiers of scientific discovery and innovation. Many of our most successful partnerships have been driven from the bottom up by our scientific and technical subject matter experts.

Interagency Partnership for Science, Energy, and Security

The Office of Science has a long and fruitful history of coordination and collaboration with R&D funding agencies across the Federal Government. These partnerships allow us to leverage DOE's unique expertise and capabilities to address the most challenging science and technology problems with mutual benefit to the American public and in alignment with the missions of DOE and our partners. We are continuously looking for new opportunities for collaboration to ensure maximum utilization of government-funded science and technology and to minimize duplication. These impactful engagements have all contributed to the Office of Science's ability to meet DOE's missions in science, energy, and national security.

The Office of Science primarily engages with other agencies through White House-led working groups and activities, bilateral and multilateral collaborations, and coordination of laboratory projects funded directly by other agencies. The Office of Science plays a leading role in numerous ongoing efforts, led by our colleagues at the White House, to develop and implement coordinated, government-wide strategies for the advancement of the most impactful science and technology priorities, including Artificial Intelligence (AI), Quantum Information Science (QIS), microelectronics, fusion science, and climate change where staying at the S&T forefront is vital for national security and competitiveness. Due to the breadth of our research portfolio and expertise, the Office of Science plays a critical role in almost every major interagency group focused on science and technology. We sit on approximately 120 active committees, subcommittees, and working groups, and serve as chair of close to 20. Our technical experts have also been instrumental in the development of policies that promote the sharing and use of research products derived from Federal R&D investments, while protecting the U.S. from misappropriation.

We are also committed to bilateral and multilateral interagency collaboration on foundational research activities, including with the NSF, NASA, NOAA, USDA, and NIH. Such collaborations have led to transformative advances in areas such as particle physics, climate science, and biomedicine. Partnership mechanisms range from informal to formal and include signed agreements, such as Memoranda of Understanding (MOU), joint facility construction projects, co-sponsorship of federal advisory committees, coordinated funding opportunity announcements, joint workshops, shared peer review, and more. We enter into multiple new partnerships each year and maintain dozens more.

The Office of Science possesses unique computational and experimental facilities, expertise in science at scale, and oversees an unparalleled National laboratory complex, which are utilized by other agency personnel and researchers. Many of the transformative scientific discoveries made by the research community are enabled by our stewardship of 28 scientific user facilities, which are available to all researchers based on the scientific merit of their proposed research. These tools include the world's most powerful computers, brightest X-ray light sources, most intense neutron sources, fastest information network, and specialized capabilities, such as nanofabrication and multiple modes of imaging, within centers for nanoscience and bio-characterization.

National Laboratory projects funded by other agencies play an important role in strengthening core capabilities at the laboratories that, in turn, enable the laboratories to better serve the Department and the Nation. Examples of this include life sciences research funded by the NIH, emergency response work funded by the Department of Homeland Security, and computational research and capacity at Office of Science laboratories funded by many other Federal agency sponsors. The expertise of the laboratory staff, and the research capabilities they help develop and employ, are invaluable assets that serve to advance the frontiers of fundamental scientific discovery, train the scientific and technical workforce in the U.S., and develop the tools and advanced instrumentation that keep our Nation at the forefront of innovation.

Furthermore, The DOE National Laboratories are essential resources that the Nation turns to in emergencies. In response to COVID-19 and other crises, the Office of Science and the 17 DOE Laboratories worked closely with agency partners to ensure our expertise, capabilities, and unique facilities could be leveraged to support the U.S. response.

Interagency Partnerships: The National Science Foundation

The partnership between NSF and the Office of Science spans all research programs within the two agencies and encompasses a wide range of activities from formal interagency agreements, co-funding research and user facilities, and co-directing federal advisory committees. There are numerous examples to choose from, a select few that are mentioned below.

Our partnership in Basic Plasma Science and Engineering, which began in 1996, is one of the longest-running interagency joint programs in the federal government. Under the partnership, the Fusion Energy Sciences (FES) program within the Office of Science and NSF sponsor a funding opportunity announcement for fundamental plasma science and experts from the two agencies jointly decide which proposals NSF will fund and which proposals FES will fund.

In the field of particle physics, the Office of Science partners with the NSF Physics Division to support two flagship experiments at the Large Hadron Collider (LHC), the CMS and ATLAS collaborations, which continue to provide deep insights into properties of the Higgs boson. The SC-NSF Joint Oversight Group (JOG) for the LHC jointly review the US-supported LHC program on a regular basis to provide oversight on operations. In addition, the Office of Science supports the Tier 1 computing capabilities for the CMS and ATLAS collaborations, while NSF supports the bulk of the Tier 2 computing.

Building on the Memorandum of Agreement between DOE and NSF on Quantum Information Science (QIS), the two agencies coordinate on the investment strategy and build bridges between DOE's Quantum Information Science Research Centers and NSF's Quantum Leap Challenge Institutes. DOE and NSF, along with the National Institute of Standards and Technology (NIST), also plan to enhance cooperation in QIS workforce development with an emphasis on broadening participation from underrepresented and underserved communities.

The Office of Science and NSF solidified their commitment to partner through an overarching MOU that was signed on January 4, 2023. In addition to existing areas of collaboration, possible topics for new or increased cooperation include, but are not limited to, biotechnology, QIS and quantum engineering, AI and machine learning, advanced manufacturing, microelectronics, climate science, and clean energy. Both agencies also have an interest in coordinating their development of a capable STEM workforce through research, education, and training initiatives that foster diversity, equity, and inclusion.

Interagency Partnerships: The National Aeronautics and Space Administration

For decades, the Office of Science has supported numerous activities that contribute to a broad range of space science interests. This includes fundamental research in science areas of interest to NASA and collaborative research efforts between the Office of Science and NASA. The MOU between DOE and NASA that was established in 2020 created new mechanisms to explore additional partnerships in science and technology development between the Office of Science and NASA's Science Mission Directorate. Compelling opportunities for future coordination and collaboration have been identified in areas such as space-based quantum sensors and quantum communication, space weather, high-throughput robotics for research in the space environment, and joint analysis of data from terrestrial and space-based telescopes.

Among the longest and most scientifically fruitful collaborations between the Office of Science and NASA is the Alpha Magnetic Spectrometer (AMS). Located on the International Space Station since 2011, the AMS project is searching for evidence of dark matter and the cosmic domains of anti-matter and characterizing the types of cosmic nuclei as a function of location in Earth's atmosphere. Since the end of FY 2022, the AMS detector has observed more than 210 billion cosmic ray events. Thanks to the close partnership between NASA, DOE, and the international AMS Collaboration, the potential lifetime of this unique experiment has been extended at least 5 years. The Office of Science and NASA are currently discussing the future of this scientific experiment, including a potential upgrade to the detector to allow for its continued operation throughout the lifetime of the ISS.

The future of the Office of Science's partnership with NASA is bright. For example, the High Energy Physics program and NASA jointly support a novel pathfinding science mission to the far side of the moon as part of NASA's Commercial Lunar Payload Services Program. The success of this experiment can enhance our understanding of the early stages of the universe, after the first atoms formed before the formation of stars and galaxies.

Interagency Partnerships: The National Oceanic and Atmospheric Administration

DOE, through the Office of Science, and NOAA advance our understanding of the complex Earth system, including modeling and simulation of the changing climate and coastal research. Each agency tackles scientific challenges in this domain through the lens of their mission—basic science, energy, and security for DOE; applied science for climate, weather, oceans, and coasts, and conservation of coastal and marine ecosystems and resources for NOAA. These efforts, as evidenced by the breadth of engagement between our two agencies, are complimentary and leveraged for mutual benefit and the benefit of the U.S.

The execution of NOAA's mission has meant developing earth system models, and DOE has maintained a long-standing partnership to support their efforts. Now in its twelfth year, NOAA and DOE's earth system modeling partnership is facilitated by Oak Ridge National Laboratory (ORNL), which provides multiple supercomputers, referred to as *Gaea*, to support sub-seasonal to decadal earth systems forecasts using NOAA's Finite-Volume Cubed-Sphere Dynamical Core. ORNL also conducts research in the area of seasonal to subseasonal prediction and analysis, working with multiple Earth system models. NOAA has long-term objectives to extend *Gaea* and other systems so that they can leverage graphics processing units, commonly known as GPUs, which are foundational to DOE's current exascale computers. Doing so would enable higher fidelity solutions and the inclusion of computationally expensive physics elements in NOAA's models.

For more than 30 years, the U.S. Global Change Research Program (USGCRP) has effectively coordinated research activities among agencies, including both DOE and NOAA, with interagency working groups established to cover climate modeling, coastal research, and observations. Through collaboration, the participating agencies are more effective in leveraging each agency's assets to achieve a greater scientific return on investment. Additional interagency coordination between DOE and NOAA in advanced computing is enabled through groups on

Networking and Information Technology Research and Development and the Future Advanced Computing Ecosystem Subcommittee. These and similar engagements ensure DOE is positioned to provide awareness of DOE's development of next-generation computers and avenues for targeted collaboration with other agencies in leveraging these assets in service of their missions.

Interagency Partnerships: The U.S. Department of Agriculture

DOE and the USDA have a long history of partnership in both science and applied R&D. This has included basic science in support of food, agriculture, and bioenergy, and applied R&D in sustainable transportation fuels, energy-water-agriculture nexus, and water data infrastructure. Currently, DOE's Office of Energy Efficiency and Renewable Energy is partnering with USDA and other agencies on a sustainable aviation fuel grand challenge.

The Office of Science's Biological and Environmental Research (BER) program and the National Institute of Food and Agriculture (NIFA) at USDA share many interests and complementary responsibilities for the support of research and outreach. A relatively recent example of this partnership was the DOE-USDA Plant Feedstocks program (2006-2018) that was a highly successful research collaboration on bioenergy crops. This effort and other shared interests were outlined in an MOU from 2015. BER supports four Bioenergy Research Centers that provide a portfolio of diverse and complementary scientific strategies to address the challenges to cost-effective production of biofuels and bioproducts from plant biomass. USDA Agricultural Research Service units located in both Louisiana and Illinois are current partners in BER's Center for Advanced Bioenergy and Bioproducts Innovation, which has a multidisciplinary, integrative approach to increasing the value of energy crops and uses a "plants-as-factories" approach to the research for the production of high-value fuels and products. USDA researchers are also active partners on several projects stemming from BER funding opportunities for research related to bioenergy and a broader bioeconomy. Also, DOE and USDA representatives serve together on the Biomass Research and Development (BR&D) board to help align mutual research interests. Both agencies are currently cooperating on reports called for under the Biotechnology and Biomanufacturing Executive Order (Sept 2022). In applied bioenergy R&D, the Bioenergy Technologies Office (BETO) at DOE together with the USDA has supported the Integrated Biorefinery Optimization program to strengthen the U.S. bioenergy industry for efficiently converting biomass feedstocks into commercially viable biofuels and bioproducts.

Interagency Partnerships: The National Institutes of Health

The partnership between DOE and the NIH is a representative example of the mutual benefit that comes from collaboration between agencies having unique but complementary missions. The history of coordination and collaboration between DOE and the NIH spans decades and includes early efforts to pioneer ion beam therapy of cancer and map the human genome and joint funding for the SPEAR3 upgrade at the Stanford Synchrotron Radiation Lightsource.

The Office of Science has continued this tradition by supporting a robust portfolio of collaborative efforts across multiple NIH Institutes and Centers. With the National Nuclear

Security Administration (NNSA), the partnership with the National Cancer Institute (NCI)—now in its 7th year—continues to develop new computing tools that integrate novel AI and Uncertainty Quantification technology and that take advantage of the Department's advances in computing—including Frontier, the Nation's first exascale computer—to accelerate discovery in cancer research. The Office of Science continues to support the long-standing partnerships with NCI to advance specific areas of cancer research and technology development, including large-scale simulations of proteins that play an important role in cancer development and progression, deep learning-enabled drug response predictions, and near real-time cancer surveillance through automated extraction of clinical information. We are pleased to share that two projects under the collaboration are among the first research teams using Frontier to advance the goals of the Cancer Moonshot SM and DOE grand challenges in exascale AI. Finally, the Office of Science continues to coordinate with the National Institute of General Medical Sciences and National Institute of Biomedical Imaging and Bioengineering on the development of and support for bioimaging capabilities that utilize the unique capabilities of SC's X-ray light sources.

We are also establishing entirely new, multi-disciplinary partnerships. Recently established collaborations with NIH in both AI and computational neuroscience can contribute to advancing both of these fields. Over the past year, we have been exploring with the NIH Brain Research Through Advancing Innovative Neurotechnologies® (BRAIN) Initiative the opportunity for DOE to bring its expertise in imaging, computing, and data science to bear on the transformational challenge of comprehensively mapping the neural structures in complex brains. The technical innovations required to meet this challenge, as well as the scientific discoveries that would arise from developing wiring diagrams in complex brains, can be similarly impactful to advancing the Office of Science mission, including in the development of novel AI technologies and neuro-inspired computing architectures.

Multi-agency Partnerships to Address National Priorities: The National Virtual Biotechnology Laboratory and the COVID-19 Global Pandemic

During the COVID-19 crisis, DOE stood up the National Virtual Biotechnology Laboratory (NVBL), bringing together the expertise and capabilities of DOE's 17 national laboratories in the nation's fight against COVID. As this effort was initiated, we consulted with other agencies to define the most critical challenges that would take advantage of DOE's unique strengths in the physical sciences. For example, our expertise in trace detection and characterization were used to support the Food and Drug Administration (FDA), Centers for Disease Control (CDC), and Department of Defense (DOD), to establish national guidelines used in millions of clinical tests. NVBL assessed the quality of commercial test kits coming into the U.S. market and kept kits off the market that would yield erroneous results due to contamination. NVBL researchers also evaluated sample pooling approaches that reduced test costs by a factor of ten. DOE's world-leading scientific user facilities were used to determine X-ray structures of SARS-CoV-2 virus to support vaccine and anti-viral approvals by FDA. These resources, along with DOE's high-performance computers, also supported NIH in the rapid evaluation of purported anti-virals that flooded the news. These powerful computers were also used to support decision makers at agencies like CDC, FEMA, and the U.S. Bureau of Economic Analysis by building a data platform to forecast disease transmission, stress on public health infrastructure, and economic outlook for the nation, providing in-depth understanding of COVID-19 impacts.

Building on the success of NVBL, we have established a new initiative—the Biopreparedness Research Virtual Environment, or BRaVE—that will support basic research that leverages DOE's experimental and computational capabilities to develop next generation epidemiological models, accelerate drug discovery and development, advance disease diagnostics and surveillance, and develop new materials to reduce disease transmission. As with NVBL, interagency partnerships are critical to the success of this initiative, and our researchers are encouraged in the funding opportunity to collaborate with their colleagues at NIH, CDC, or other agencies. Thanks to the support for DOE's work on biopreparedness that is provided through the CHIPS and Science Act, we are well positioned to build on the success of NVBL and contribute to a whole-of-government effort to be prepared to face future biological threats.

Conclusion

As demonstrated by the select examples provided, conducted in partnership with NSF, NASA, NOAA, USDA, NIH, and the recent multi-agency collaboration during COVID-19, the Office of Science has a long and fruitful history of coordination and collaboration with R&D funding agencies across the U.S Government. The Office of Science primarily engages with other agencies through White House-led working groups and activities, bilateral and multilateral collaborations, and coordination of national laboratory projects funded directly by other agencies, and the Office of Science User Facilities also play host to researchers supported by a wide range of Federal Agencies. These partnerships allow us to leverage DOE's unique expertise and capabilities to address the most challenging science and technology problems for mutual benefit to the American public. As such, we are continuously looking for new opportunities for collaboration to ensure maximum utilization of government-funded science and technology and to minimize duplication of effort. With the passage of the CHIPS and Science Act, DOE and the Office of Science are poised to not only grow to meet today's most pressing scientific and technical challenges, but also to pursue additional partnerships with other agencies.

Dr. Harriet Kung
Deputy Director for Science Programs
Office of Science
U.S. Department of Energy

Dr. Harriet Kung is the Deputy Director for Science Programs in the Office of Science at the U.S. Department of Energy. As Deputy Director for Science Programs, Dr. Kung is the senior career official providing scientific and management direction and oversight for the Office of Science research programs, including Advanced Scientific Computing Research, Basic Energy Sciences, Biological and Environmental Research, Fusion Energy Sciences, High Energy Physics, and Nuclear Physics, as well as other supporting functions and offices. Prior to serving in this position, Dr. Kung served in various leadership roles in Basic Energy Sciences, the largest program in Office of Science, from 2002 - 2020. Before joining DOE in 2002, Dr. Kung was a technical staff member and a project leader at Los Alamos National Laboratory. Her research focused primarily on nanoscale materials and high temperature superconductivity.

With over 20 years of service in the Department of Energy, Dr. Kung led and cultivated one of the Nation's premier research programs in the physical sciences. During her tenure, she developed a new basic research paradigm, fostering a team-science approach to advance DOE's science and energy missions by spearheading a decade-long strategic planning initiative to assure timely, science-based solutions. She also positioned the Office of Science as a National Quantum Initiative leader by establishing strategies to capitalize on strong synergies between disciplines, such as physics, biology, materials, computation, and engineering, as well as its world-leading scientific user facilities. She has chaired and co-chaired high-level interagency working groups to develop and implement national science priorities.

Dr. Kung received her M.S. and Ph.D. degrees from Cornell University. She is the recipient of numerous awards including the Presidential Meritorious Executive Rank Award in 2009 and the Distinguished Executive Rank Award in 2022.

Chairman LUCAS. Thank you, Doctor.
Mr. Reuter, you're recognized for five minutes.

TESTIMONY OF MR. JAMES L. REUTER, ASSOCIATE ADMINISTRATOR FOR THE SPACE TECHNOLOGY MISSION DIRECTORATE, THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. REUTER. Yes, thank you, Chairman Lucas, Ranking Member Lofgren, and your entire Committee. It's really a pleasure for me to be here, and I'm excited to do so. My name is Jim Reuter, the Associate Administrator for NASA's Space Technology Mission Directorate. STMD develops transformative technologies, enabling future missions to the Moon, to Mars, and beyond while driving the space economy through strategic investments.

NASA and DOE have worked together for over 50 years. Currently, we have more than 20 active partnership agreements and more in development. Our collaboration has allowed for many successful missions and projects. We wouldn't be here and—without them with DOE providing crucial expertise in support of NASA's Human Spaceflight, Science, Technology, and Aeronautics Mission Directorates. Today, one of our most critical collaborations is space nuclear power and propulsion because it's nuclear systems that are essential to NASA's Artemis program and Moon-to-Mars exploration objectives. Maturing space nuclear technologies is also beneficial to advancing small modular reactor technology on Earth.

DOE provides NASA with nuclear regulatory and safety support, with indemnification, subject matter expertise, test facility capabilities. Integrated teams are maturing low-enriched uranium reactor designs, advanced manufacturing methods, digital modeling, and test capabilities for space systems. Fission power systems offer a reliable way to power operations in other worlds, such as providing electricity for habitats, resource extraction, and processing plants.

In 2018, the agencies conducted a joint ground test of a kilowatt reactor prototype that helped develop preliminary reactor design concepts. In 2022 then, the agencies extended that development through three industry-led design efforts for 40 kilowatt systems as part of our NASA's Moon-to-Mars campaign.

Space nuclear propulsion is an enabling technology for human missions to Mars. DOE's contributions to this technology are key to reducing the size of our reactors by advancing higher-temperature fission fuels and reactor designs. NASA and DOE continue working with industry to develop thermal propulsion engines, and in 2021, this work led to the award of three contracts for design efforts.

DOE and NASA also work closely on radioisotope power systems (RPS), which harness heat from the natural decay of plutonium-238 radioisotope, producing electric power and heat for spacecraft systems and science instruments. This technology has allowed 30 NASA missions to visit the solar system's most remote and otherwise unreachable locations. Five of these RPS-powered science missions are operating today, including two Voyager spacecraft that launched in 1977 and are still functioning in interstellar space. RPS powers the Mars Perseverance rover, which is currently exploring and collecting samples on the surface of Mars, and will also power NASA's Dragonfly mission, an upcoming mission that will be a rotorcraft destined for Saturn's largest moon Titan.

Through constant rate production, DOE has established the domestic capability to produce plutonium-238 with production aligned to NASA's mission needs. We're also investing in new technology for more efficient and higher-performing RPS to be considered for infusion in the next decade.

Our coordination and scientific research is increasing our knowledge of the universe. DOE is the primary government sponsor of the Alpha Magnetic Spectrometer (AMS). It's a particle physics detector attached to the external exterior of the International Space Station and has been operating for 12 years. It has helped us understand the formation of the universe and search for evidence of dark matter. AMS is just one example of DOE's Office of High-Energy Physics carrying out successful joint projects with NASA.

In the coming years, an experiment called LuSEE-Night will be delivered by NASA's commercial lunar payload services to the far side of the Moon. It will test the feasibility of low-frequency radio astronomy from the lunar far side and make radio observations of the very early universe.

Our partnership also benefits us at home. NASA and DOE both participate in the U.S. Global Climate Research Program. We coordinate models used to understand climate change on timescales ranging from months to centuries and keeping our Nation a leader in understanding the Earth system.

And finally, NASA Aeronautics works closely with DOE's Advanced Research Projects Agency to develop lighter electrical systems and more reliable circuits. We are applying that research to our national aviation challenges.

We look forward to continued collaboration with DOE and welcome opportunities to expand our partnerships and leverage our resources in order to advance technology, science, and exploration in meaningful ways for the American people. Thank you.

[The prepared statement of Mr. Reuter follows:]

National Aeronautics and
Space Administration

Hold for Release Until
Presented by Witnesses

March 8, 2023

**Committee on Science, Space,
and Technology**

United States House of Representatives

Statement by:

Mr. Jim Reuter, Associate Administrator, Space Technology Mission Directorate
National Aeronautics and Space Administration

HOLD FOR RELEASE
UNTIL PRESENTED
BY WITNESSES
March. 8, 2023

Statement of

Mr. Jim Reuter, Associate Administrator
Space Technology Mission Directorate

National Aeronautics and Space Administration

before the
Committee on Science, Space, and Technology
U.S. House of Representatives

Good morning and thank you for inviting me here today. My name is Jim Reuter and I am the Associate Administrator for NASA's Space Technology Mission Directorate (STMD). STMD develops transformative technologies enabling future missions to the Moon, Mars, and beyond, while driving the space economy through strategic investments.

NASA and the Department of Energy (DOE) have worked together for over 50 years. Our collaboration has allowed for many successful missions and projects – from plutonium-powered Mars rovers to a unique physics experiment on the International Space Station to a nuclear fission system ground demonstration that could be used on other worlds.

DOE expertise provides crucial support to NASA's human spaceflight, science, technology, and aeronautics mission directorates. We currently have more than 20 active partnership agreements, with more in development.

Today, one of our most critical collaborations is space nuclear power and propulsion because fission surface power is essential to living and working on the Moon and nuclear propulsion systems may help power future crewed missions to Mars.

DOE provides NASA with nuclear regulatory and safety support, indemnification, subject matter expertise, and test facility access. Integrated teams are maturing low-enriched uranium reactor designs and materials, advanced manufacturing methods, design data, digital modeling, and test capabilities for space systems. Advancing space nuclear technologies may also benefit small modular reactors on Earth.

Fission power systems offer a reliable way to support operations on other worlds by providing electricity for habitats, resource extraction and processing plants. DOE assists our maturation efforts for reactor designs and materials. In 2018, the agencies conducted a joint ground test of a kilowatt reactor concept that helped develop preliminary reactor design concepts. In 2022, the agencies extended that development through three industry-led design efforts for 40-kilowatt systems as part of NASA's Moon to Mars campaign.

DOE contributions to space nuclear propulsion – a technology that may be used for human missions to Mars – are key to reducing the mass and size of reactors through advanced reactor fuels and materials. NASA and DOE are working with industry to advance higher-temperature fission fuels and reactor designs as part of a nuclear thermal propulsion engine. Three contracts for design efforts were awarded in 2021. The technology maturations gained through these efforts provided the groundwork for NASA's partnership with DARPA, which plans to accelerate the technology readiness of a nuclear thermal rocket.

DOE is also a major partner in nuclear facility and irradiation testing. Currently, we are coordinating enhancements at the Idaho National Laboratory Transient Reactor Facility to bolster capabilities for nuclear propulsion fuel element testing. We are also coordinating facility assessments and strategies for a nuclear propulsion ground demonstration test site and concept development.

DOE and NASA also collaborate on Radioisotope Power Systems (RPS) which harness heat from the natural decay of a radioisotope, plutonium-238, to produce electric power and heat for spacecraft systems and science instruments. This technology has allowed 30 NASA missions to visit some of the solar system's most remote and otherwise unreachable locations.

Five nuclear-powered science missions are operating today, including two Voyager spacecraft that launched in 1977 and are still operating in interstellar space. RPS powers the Mars Perseverance Rover, which is currently exploring and collecting samples on the surface of Mars, and will also power NASA's Dragonfly mission, a rotorcraft destined for Saturn's largest moon Titan.

Through Constant Rate Production, DOE has reestablished the domestic capability to produce plutonium-238, with production aligned to NASA mission needs. We are also investing in new technology for more efficient, higher-performing RPS to be considered for infusion in the next decade.

Our coordination in scientific research is increasing our knowledge of the universe. DOE is the primary government sponsor of the Alpha Magnetic Spectrometer (AMS), a particle physics detector attached to the exterior of the International Space Station. It has helped us understand the formation of the universe and search for evidence of dark matter.

AMS is just one example of DOE's Office of High Energy Physics and NASA carrying out successful joint projects. In the coming years, an experiment called LuSEE-Night (one of two landers in the Lunar Surface Electromagnetics Experiment) will be delivered by NASA's Commercial Lunar Payload Services to the far side of the Moon. It will test the feasibility of low-frequency radio astronomy from the lunar far side and make radio observations of the early universe.

Our partnership also benefits us closer to home. NASA and DOE both participate in the U.S. Global Climate Research Program, coordinating models used to understand climate change on timescales ranging from months to centuries and keeping our nation a leader in understanding the Earth system.

NASA Aeronautics has been working closely with the DOE's Advanced Research Projects Agency-Energy to develop lighter electrical systems and more reliable circuits and is applying that research to our national aviation challenges.

We look forward to continued collaboration with DOE and welcome opportunities to expand our partnerships and leverage our resources. Together, we will advance technology, science, and exploration in meaningful ways.

James L. Reuter, Associate Administrator

James L. Reuter was named NASA's associate administrator for the Space Technology Mission Directorate (STMD) at NASA Headquarters in June 2019, a position in which he served in an acting capacity since February 2018. In this role, he provides executive leadership and management of the technology programs within STMD, with an annual investment value of more than $1 billion.

Reuter was the deputy associate administrator of STMD from February 2017-February 2018. Prior to this role, Reuter served as the senior executive for technical integration in the Center Director's Office at NASA's Marshall Space Flight Center in Huntsville, Alabama, from 2009-2015, providing strategic leadership on critical technology and integration activities. Additionally, Reuter served as the Exploration Systems Division (ESD) standing review board chair, responsible for overseeing development activities of the Space Launch System, Orion Multi-Purpose Crew Vehicle, Ground Systems Development and Operations Programs, and the ESD integration activities.

Previously, Reuter served in many managerial roles at Marshall including Ares vehicle integration manager in the Constellation program, the deputy manager of Space Shuttle Propulsion Office, and the deputy manager of Space Shuttle External Tank Project Office during the shuttle return-to-flight activities. In 2002, he was assigned to a detail at NASA Headquarters as the deputy associate director in the Space Transportation Technology Division in the Office of Aerospace Technology. From 1994 to 2001, he was the Environmental Control and Life Support System manager for the International Space Station at NASA's Johnson Space Center. Reuter began his NASA career in 1983 as an aerospace engineer in the Structures and Propulsion Laboratory in Marshall's Science and Engineering Directorate.

Reuter has a bachelor's degree in mechanical engineering from the University of Minnesota in Minneapolis. He has received numerous NASA awards and honors, including a 2019 Distinguished Service Medal, 2016 Outstanding Leadership Medal, 2013 NASA Exceptional Achievement Medal, a 2008 NASA Outstanding Leadership Medal, a 2002 NASA Exceptional Service Medal, a 1998 Silver Snoopy Award and a 1993 Space Station Award of Merit.

Chairman LUCAS. Thank you, Mr. Reuter.

Dr. Morgan, you're recognized for five minutes.

TESTIMONY OF DR. MICHAEL C. MORGAN, ASSISTANT SECRETARY OF COMMERCE FOR ENVIRONMENTAL OBSERVATION AND PREDICTION, THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Dr. MORGAN. Thank you. Chairman Lucas, Ranking Member Lofgren, and Members of the Committee, thank you for the opportunity to testify today regarding NOAA's work with the Department of Energy on high-performance computing and our Earth system modeling enterprise. I appreciate the Committee's interest in supporting successful interagency research collaborations with the Department of Energy, and I'm excited about the benefits that deeper ties with the DOE will bring to NOAA and the Nation.

NOAA's mission is to provide weather, water, and climate research and products which protect life and property, as well as enhancing the national economy. As the Nation grows more vulnerable to climate- and weather-related disasters, we will need improvements in these products to meet NOAA's mission.

A core component of NOAA's efforts to meet this challenge is the creation of more comprehensive Earth system models. These models represent our understanding of how the multifaceted connections between different components of the Earth's system such as the atmosphere, oceans, land, and sea ice, as well as hydrology, interact across short and long timescales. Research conducted using these models allows us to develop a deeper understanding of the climate—of climate change and to provide more accurate weather forecasts.

These models require significant high-performance computing capabilities. NOAA maintains a strong relationship with the DOE to secure access to these critical computing resources. Most notably, NOAA and DOE work together to run Gaea, NOAA's largest research and development supercomputer hosted by DOE's Oak Ridge National Laboratory. Gaea allows NOAA researchers to develop and refine advanced climate models, enhance scientific understanding of climate variability and change, and improve the accuracy of global and regional climate model projections. Gaea also powers research into the relationship between climate variations and extreme weather such as hurricanes.

Gaea provides additional value to NOAA researchers and the Nation by enabling seasonal real-time experimental predictions from the Seamless System for Prediction and Earth System Research, or SPEAR. These predictions are performed every month on the Gaea supercomputer fed into the North American Multi-Model Ensemble climate predictions, and made freely available to the public for use in regional and tailored forecast.

Gaea also supports the development of operational numerical weather prediction systems based on the Unified Forecast System, or UFS, a community-based coupled comprehensive Earth modeling system. UFS applications span local to global prediction on timescales from sub-hourly analyses to seasonal predictions. The system is designed to be a source system for NOAA's operational numerical weather predictions.

Finally, the Earth system model 4, the culmination of NOAA's 4th-generation climate model development effort, was developed and run primarily on Gaea. It unifies advances from past development efforts and focuses on chemistry, carbon, and ecosystem comprehensiveness. Analyses of simulations from this model will serve as the basis for future research, helping to improve our understanding of coupled carbon chemistry climate interactions and to reduce uncertainty and projections of future climate change and its impacts.

These advances have been made possible by NOAA's interagency agreement with DOE's Oak Ridge National Laboratory. Codifying and expanding this agreement, as proposed by the Committee, would benefit NOAA, the Department of Energy, and the Nation. Potential advances made possible includes simulations with large ensembles, more realistic representation of Earth's system processes and interactions, and high spatial resolution predictions of extremes and abrupt changes. Increasing resolution allows the capture of small-scale—smaller-scale processes and features which can lead to better representation of severe weather, more timely warnings, improved prediction of extreme events and their duration, and higher-confidence climate projections.

NOAA–DOE collaboration could enable also the application of artificial intelligence and machine-learning methodologies to the Earth system modeling. Similarly, using DOE's computing resources and expertise could lead to improvements in atmospheric data simulation.

Collaboration between NOAA and DOE not only reduces duplication of efforts, it is a cost-effective approach to generate an additional computational capability for both agencies. Moreover, such collaborations could result not only in computational advances, but also in better decisionmaking on issues of national importance, such as future energy use and technology options.

For over two decades, NOAA scientists have defined the leading edge of climate and Earth system modeling. Interagency agreements like those with DOE and other partnerships with academia and industry provide critical opportunities for NOAA to advance Earth system modeling in order to save lives and property and support the national economy, strengthening the exchange of information and scientific capabilities with partners will enable NOAA to continue to meet our core mission. Thank you.

[The prepared statement of Dr. Morgan follows:]

WRITTEN STATEMENT OF
DR. MICHAEL MORGAN
ASSISTANT SECRETARY OF COMMERCE
FOR ENVIRONMENTAL OBSERVATION AND PREDICTION

ON THE
DEPARTMENT OF ENERGY'S ROLE IN THE FEDERAL RESEARCH ENTERPRISE

BEFORE THE
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

1. INTRODUCTION

Chairman Lucas, Ranking Member Lofgren, and Members of the Committee, thank you for the opportunity to testify today regarding NOAA's work with the Department of Energy (DOE) on high performance computing (HPC) and Earth system modeling. My name is Dr. Michael Morgan and I am the Assistant Secretary of Commerce for Environmental Observation and Prediction. I appreciate the committee's interest in exploring successful interagency research collaborations with the Department of Energy (DOE).

NOAA is mandated to provide environmental intelligence on weather, water, and climate through data, forecasts, warnings, and impact-based decision support services for the protection of life and property and enhancement of the national economy. Communities around the country are struggling with the effects of high-impact and extreme events like hurricanes, heat waves, floods, droughts, wildfires, and fisheries collapse. The U.S. has sustained 341 weather and climate disasters from 1980 to 2022, where overall damages for each disaster reached or exceeded costs of $1 billion (including Consumer Price Index adjustment to 2022). The cumulative cost of these 341 events exceeds $2.475 trillion.[1] Due to increasing vulnerabilities and increasing demand for NOAA's environmental intelligence, there is a need for further improvements in weather and climate information and predictions.

In FY 2023, NOAA is leveraging significant investments from the Inflation Reduction Act of 2022 (P.L. 117-169) to accelerate advances and improvements in modeling and forecasting related to weather, coasts, oceans, and climate, as well as the procurement of additional HPC, data processing capacity, data management, and storage assets. Developing and delivering the next generation modeling systems for weather and climate prediction will be supported by crucial investments to maintain and expand high performance computing for research and development.

[1] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2023). https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73

2. NOAA'S APPROACH TO EARTH SYSTEM MODELING AND HIGH PERFORMANCE COMPUTING

For the past several years, NOAA has been developing and improving comprehensive climate and Earth system models (ESMs) to advance our understanding of how the Earth's biogeochemical, physical, and dynamical cycles, including human actions, interact with the climate system. The Earth system approach [2,3,4,5] includes multifaceted connections between different components of the Earth system such as the atmosphere, oceans, land and sea ice, and hydrology across short and long time scales. ESMs also incorporate interactive biogeochemistry, including the carbon cycle. Building the ESMs has been a large collaborative effort involving scientists from multiple NOAA laboratories, academic and private sector partners, and other federal agencies to study climate and ecosystem interactions and their potential changes, from both natural and anthropogenic causes. Substantial improvements in Earth system modeling will require the incorporation of these processes and interactions that are not already present in current models.

Complex environmental prediction models provide foundational tools for providing accurate and reliable guidance on various spatial and temporal scales to meet NOAA's core mission requirements. Adequate HPC capabilities are central to developing state-of-the-art and next generation numerical models to conduct research, validate, and transition to operations. In order for NOAA to meet current and future requirements for computing capability and services, there must be continual enhancement and investment in NOAA's core enterprise, including post-processing, product generation, real-time dissemination, and data storage. Optimization, modernization, and exploitation of emerging HPC technologies, as well as prioritization of available computing resources, are critical for the development of the next generation of models as well as highly reliable operational models.

NOAA's HPC strategy embraces the need to adopt the latest HPC technologies and plan for emerging uses of HPC. NOAA maintains strong relationships with interagency partners, including DOE and NSF, and participates in coordination activities with the National Science and Technology Council. Coordination occurs across initiatives, such as the Future Advanced Computing Ecosystem, Networking and Information Technology Research and Development,

---

[2] Shapiro et al. (2010): An Earth-system prediction initiative for the twenty-first century, Bulletin of the American Meteorological Society, 91, 1377-1388.

[3] IPCC, 2021: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, In press, doi:10.1017/9781009157896.

[4] NOAA Science Advisory Board, 2021: A Report on Priorities for Weather Research. NOAA Science Advisory Board Report, 119 pp. https://sab.noaa.gov/wp-content/uploads/2021/12/PWR-Report_Final_12-9-21.pdf

[5] NOAA Science Advisory Board, 2021: Advancing Earth System Prediction. NOAA Science Advisory White Paper, 22 pp. https://sab.noaa.gov/wp-content/uploads/2021/08/SAB_Report_Advancing-ESP_02April2021_Final.pdf

and Interagency Council on Advancing Meteorological Services, which are essential to advancing Earth system modeling as a whole by ensuring that NOAA's requirements are represented within national computing strategies.

NOAA's HPC approach provides opportunities for innovation using cutting-edge technology that leverages other computing resources such as DOE's Innovative and Novel Computational Impact on Theory and Experiment program and the National Science Foundation's Advanced Cyberinfrastructure Coordination Ecosystem Services and Support Program. NOAA's HPC environment enables NOAA scientists to apply and obtain grant hours on DOE and National Science Foundation systems by providing appropriate connectivity and support for use of these systems. These opportunities enable NOAA to gain competence and experience in the novel architectures provided by DOE and fosters interagency collaboration while allowing NOAA's traditional computing assets to carry out NOAA's research and operational mission.

3. RESEARCH AND DEVELOPMENT WITH GAEA SUPERCOMPUTER

NOAA already benefits from DOE's supercomputing resources by leveraging the Oak Ridge National Laboratory's expertise. NOAA's Office for Oceanic and Atmospheric Research has an Interagency Agreement with DOE for HPC Collaborative Services for Climate Modeling through 2025. The Oak Ridge National Laboratory has been procuring, hosting, and operating Gaea, NOAA's largest research and development HPC, under this agreement since 2009. This agreement focuses on sustained access to NOAA-funded computing in collaboration with DOE's leading computing facilities and computational science expertise enabling NOAA to undertake Earth system modeling research and development efforts that span multiple years to complete.

The Gaea HPC system supports research and development activities across NOAA's mission areas. Gaea is capable of more than 10,223 trillion calculations each second, or 10.2 petaFLOPS, making it the largest of the four NOAA research and development systems. This computing capacity allows NOAA researchers to develop and refine advanced climate models, enhances scientific understanding of climate variability and change, and improves the accuracy of global and regional climate model projections at a finer resolution and on a timeframe that is more useful for decision makers and sectors such as agriculture, energy, and transportation. For example, Gaea powers research into the relationship between climate change and extreme weather, such as flooding.

Gaea has been instrumental in the application of NOAA's Flexible Modeling System, a key software framework, for the development of world-class global models and scientific interpretation of the climate and earth system across timescales. Included in this are high fidelity models representing Earth and climate system variability and change. Seasonal real-time experimental predictions from the Flexible Modeling System-based Seamless System for Prediction and EArth System Research (SPEAR) are performed every month on the Gaea computer, and fed into the North American MultiModel Ensemble climate predictions that are freely available to private and public U.S.-based and international entities to make regional or tailored forecasts. SPEAR is also a next generation model for making multi seasonal to multi decadal predictions and projections under climate change. SPEAR predictions for El Niño-Southern Oscillation, as well as decadal predictions for the World Meteorological Organization, are additionally performed on Gaea. Decadal forecasts produced by SPEAR will be made available as part of an international decadal prediction program through the United Kingdom Met Office.

Gaea also supports the development of operational numerical weather prediction systems based on the Unified Forecast System, a community-based, coupled, comprehensive Earth modeling system. The United Forecast System numerical applications span local to global domains and predictive time scales from sub-hourly analyses to seasonal predictions. It is designed to support the Weather Enterprise and to be the source system for NOAA's operational numerical weather prediction applications.

Additionally, the Earth System Model 4 (ESM4) was developed and run primarily on the Gaea HPC system. This model marks the culmination of NOAA's 4th generation climate model development effort that unifies advances across several past development efforts and highlights chemistry, carbon, and ecosystem comprehensiveness. These efforts were merged into NOAA's first coupled carbon-chemistry-climate model with state-of-the-art representation of each, along with comprehensive interactions between components. Over 50 simulations from ESM4.1 have been made publicly available. Analyses of these simulations will serve as the basis for research in years to come, helping to improve our understanding of coupled carbon-chemistry-climate interactions, and reducing uncertainty in projections of future climate change and its impacts and feedbacks. ESM4.1 is also a key contributor to the 6th Coupled Model Intercomparison Project, which aims through a multi model context to better understand past, present and future climate changes arising from natural, unforced variability or in response to changes in radiative forcing.

4. FUTURE OF NOAA-DOE PARTNERSHIP

NOAA's Interagency Agreement with DOE's Oak Ridge National Laboratory for HPC Collaborative Services for Climate Modeling has proven to be beneficial. NOAA's access to DOE's cutting edge leadership-class HPC has been ad-hoc largely through the Innovative and Novel Computational Impact on Theory and Experiment program grant process. NOAA would benefit from partnerships that more consistently leverage DOE's leadership in computing platforms and expertise in computational sciences to explore and develop new HPC infrastructure for NOAA. Running NOAA models on DOE's different computing platforms and technologies could allow for innovation and advancement of new HPC technologies and cutting-edge NOAA models that maximize performance on large-scale HPC systems. These include simulations with large ensembles, more realistic representation of Earth system processes and interactions, and high-spatial-resolution (horizontal and vertical) predictions of extremes and abrupt changes at the county and finer spatial scales. Increasing resolution allows capture of smaller-scale processes and features, which can lead to better representation of severe weather, which could lead to more timely warnings, predictions of extremes and their duration, and climate projections. Furthermore, the application of artificial intelligence and machine learning methodologies to Earth system modeling is a high value area for a future NOAA-DOE HPC partnership. The potential for discovery is large, and NOAA would benefit from DOE's expertise.

In addition, using DOE's computing resources and expertise could lead to improvements in data assimilation by using NOAA's growing collection of high-quality environmental data while also improving model performance (both speed and accuracy), harnessing complex interactions within the models that are often computationally expensive, and leveraging machine learning concepts that could reduce the cost to run high-resolution global models for both research and operations. Collaboration between NOAA and DOE will not only reduce duplication of efforts, but also allow a cost-effective approach to generating additional computational capability for both agencies, resulting in sound decision-making on issues of national importance, such as future energy use and technology options.

5. CONCLUSION

For over two decades, NOAA scientists have defined the leading edge of climate and Earth system modeling. NOAA is the authoritative source of advanced development of Earth system modeling for the purposes of atmospheric, oceanic, and biogeochemical modeling for understanding, and predictions seamlessly across timescales, from short-term weather to decadal and centennial climate simulations.[6] NOAA's partnership with DOE has enabled our scientists to access larger computing capacities using leadership-class technology and services, aiding in the advancement of Earth system modeling. Further collaboration could result in numerous additional benefits such as improved HPC infrastructure, data assimilation, and model performance. Interagency agreements, like those with DOE, and other partnerships with academia and industry provide critical opportunities for NOAA to advance Earth system modeling in order to save lives and property and support the national economy. Strengthening the exchange of information and scientific capabilities with partners will enable NOAA to continue to meet our core mission of understanding and predicting changes in climate, weather, ocean and coasts to protect lives and property.

[6] NOAA Administrative Order (NAO) 216-115B: Research and Development in NOAA, effective June 2022. https://www.noaa.gov/organization/administration/nao-216-115b-research-and-development-in-noaa

Dr Michael C Morgan

Assistant Secretary of Commerce for Environmental Observation and Prediction

Michael C. Morgan, Ph.D. is the assistant secretary of commerce for environmental observation and prediction. In this role, Dr. Morgan is responsible for providing agency-wide direction with regard to weather, water, climate, and ocean observations, including in situ instruments and satellites, and the process of converting observations to predictions for environmental threats.

Dr. Morgan has more than 25 years of demonstrated scientific leadership. Prior to joining NOAA, he had most recently served as a professor and associate department chair in the Department of Atmospheric and Oceanic Sciences at the University of Wisconsin-Madison, where his research was focused on the analysis, diagnosis, prediction, and predictability of mid-latitude and tropical weather systems.

In addition to his roles at the University of Wisconsin-Madison, Dr. Morgan recently served on the World Meteorological Organization World Weather Research Programme's Scientific Steering Committee. In addition, he recently served as a member of the board of directors of the American Institute of Physics and as chair of their Public Policy Advisory Committee. He also recently completed two terms on the Board of Trustees of the University Corporation for Atmospheric Research (UCAR).

Dr. Morgan has previously served as the division director for the Division of Atmospheric and Geospace Sciences at the National Science Foundation, and as an AMS/UCAR congressional science fellow, working in the office of U.S. Senator Benjamin Cardin (MD) as a senior legislative fellow on energy and environmental issues.

Dr. Morgan is a fellow of the American Meteorological Society (AMS). He earned his S.B. in Mathematics and Ph.D. in Meteorology from the Massachusetts Institute of Technology.

Chairman LUCAS. Thank you, Dr. Morgan.
Dr. Jones, you're recognized for five minutes.

TESTIMONY OF DR. SEAN L. JONES, ASSISTANT DIRECTOR FOR THE DIRECTORATE OF MATHEMATICAL AND PHYSICAL SCIENCES, THE NATIONAL SCIENCE FOUNDATION

Dr. JONES. Great, thank you. Good morning, Chairman Lucas and Ranking Member Lofgren and Members of the Committee. Thank you for the opportunity to appear before you today to discuss interagency partnerships, which contribute to our shared goals to spur innovation across the Nation, train the next-generation STEM (science, technology, engineering, and mathematics) workforce, and secure global leadership in emerging technologies. My name is Dr. Sean L. Jones, and I'm the Assistant Director for NSF's Mathematical and Physical Sciences (MPS) Directorate.

NSF is extremely proud of the role the agency has played in our Nation's global leadership in science, engineering and technology. The MPS Directorate has supported some of the biggest scientific breakthroughs of the last few decades, including the first image of a black hole, to the first detection of gravitational waves and the discovery of the Higgs boson.

Many of the technologies that are the drivers of national competitiveness today such, as artificial intelligence and quantum information sciences, are rooted in sustained NSF investments over multiple decades. NSF is grateful for the strong support of this Committee and the Congress, which has made these and many other breakthroughs possible.

With the passage of the *CHIPS and Science Act,* Congress put in place a roadmap for securing U.S. leadership in science and engineering for decades to come. The new law positions the Federal research agencies to strengthen the American research ecosystem to quickly translate research and the impacts that address national challenges and benefit the Nation. The agencies represented here today are critical components of this recipe for success, and it is imperative for us to work together to achieve the goals laid out in *CHIPS and Science.*

Through OSTP's (Office of Science and Technology Policy's) National Science and Technology Council, NSTC, the agencies work together to coordinate across priority areas and to leverage investments and expertise. For example, NSF and DOE, along with NIST, co-chair the subcommittee that coordinates Federal R&D in quantum information sciences, including our implementation of the *National Quantum Initiative Act.* Quantum has created some of the 21st century's most critical tools, such as lasers and broadband communication, and our continued collaboration is vital as new discoveries in quantum physics promise faster, more reliable computers and more secure communication networks.

In January, NSF and DOE's Office of Science signed a memorandum of understanding (MOU) that will enable increased partnerships to address some of our most important challenges. This MOU builds upon previous partnerships and provides opportunities for collaboration on biotechnology, quantum, advanced manufacturing, engineering, AI, and machine learning. Growing a diverse, inclusive STEM workforce is also a priority for both agencies, and the MOU allows the agencies to address this critical need as well.

Importantly, NSF and DOE's robust partnership includes access to various NSF and DOE-managed multiuser facilities around the globe. One recent success from that partnership is the NSF-supported work of researchers at the University of South Carolina, who collaborated with the DOE Sandia National Laboratories. The researchers have created a new type of porous material with unique nanoscale properties that can potentially enable superior hydrogen storage solutions, an innovation that will be useful for fuel cells used in vehicles, backup power supplies, and other applications.

Another example is the Large Hadron Collider, LHC, which is the most powerful particle accelerator ever created, making it the premier facility in the world for research in elementary particle physics. Through a partnership between NSF and DOE, the United States is a major contributor to this international collaboration. A major international effort is underway to upgrade the instrument at the LHC, and our two agencies are coordinating closely to do so.

Beyond the Department of Energy, NSF closely collaborates with many other agencies, including NASA and NOAA. NSF and NASA partner to advance research programs ranging from astrophysics to Earth system science, and NSF and NOAA partner on computer modeling to support the Nation's weather and climate forecast system.

In addition to our partnerships with other Federal agencies, NSF is also developing long-lasting partnerships with industry. NSF's new Directorate for Technology, Innovation, and Partnership, TIP, which was codified in the *CHIPS and Science Act of 2022,* helps position the agency to capitalize on the uniquely American research ecosystem. The TIP Directorate has announced new programs and partnerships with companies such as Intel and Micron to develop bold, potentially transformative solutions to address semiconductor manufacturing challenges and advance opportunities for equitable STEM education.

In closing, NSF has made partnerships a central pillar in our strategy for meeting the challenges of today and laying the groundwork for the research enterprise of tomorrow. These examples provide only a small sample of many collaborations NSF is undertaking both within the Federal Government and with other partners to leverage resources and provide the best possible return to the American people for now and into the future.

Thank you for the opportunity to appear before the Committee today, and I'm happy to answer your questions. Thank you.

[The prepared statement of Dr. Jones follows:]

Dr. Sean Jones
Assistant Director
Math and Physical Sciences Directorate

Before the
Committee on Science, Space, and Technology
United States House of Representatives

on

Innovation Through Collaboration:
The Department of Energy's Role in the U.S. Research Ecosystem

March 8, 2023

Overview

Chairman Lucas, Ranking Member Lofgren, and Members of the Committee, thank you for the opportunity to appear before you today to discuss the National Science Foundation's (NSF) partnerships with the Department of Energy (DOE), which contribute to our shared goals to spur nationwide innovation, train the next generation STEM workforce, and secure global leadership in emerging technologies. I am Dr. Sean Jones, Assistant Director for NSF's Mathematical and Physical Sciences Directorate (MPS).

Established by the National Science Foundation Act of 1950 (P.L. 81-507), NSF is an independent federal agency charged with the mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF is unique in carrying out its mission by supporting research across all fields of science, technology, engineering, and mathematics, and at all levels of STEM education. NSF investments contribute significantly to the economic and national security interests of the nation, and to the development of a future-focused science and engineering workforce that draws on the talents of all Americans and creates new businesses, new jobs, and more exports.

Meeting Today's Global Challenge

Today, the United States faces challenges to our global leadership in science, engineering, and technology as other nations seek to replicate our success to control the future of key technologies. That is why it is critical that we foster the nation's capacity to produce breakthroughs, to innovate, and to power our country forward. Our economic and national security depend on our ability to invest heavily not only in the technologies of today, but to support new discoveries that will become the foundation for technologies of tomorrow. That essential mission requires planting the seeds of innovation *everywhere* — by building ecosystems of innovation in every region of the country.

Over the past 73 years, NSF has funded research and researchers, innovations and innovators, and world-class infrastructure that has garnered incredible benefits to the nation. The Internet, 3D printing, and many of the technologies and industries that are the drivers of national competitiveness today—artificial intelligence, quantum information science, advanced manufacturing, and advanced wireless and biotechnology, to name a few—are rooted in sustained NSF investments in research at the frontiers of science and engineering over multiple decades.

With the passage of the CHIPS and Science Act of 2022, Congress put in place a roadmap for accelerating and expanding the Nation's research enterprise and creating opportunities for innovation in communities throughout the country. The new law positions the federal research agencies to capitalize on the American research ecosystem that is comprised of academia, private industry, the federal government, and other partners to quickly translate research into impacts that benefit the Nation. These partnerships are a central pillar of NSF's mission, and they will be critical to our collective success in achieving the goals of the CHIPS and Science Act and securing the future.

Interagency Partnerships

Inter-agency partnerships and collaborations are a critical part of the federal S&T ecosystem.

Through the Office of Science and Technology Policy's National Science and Technology Council, the federal research agencies work together to coordinate across priority areas and to leverage investments and expertise to tackle national challenges. For example, NSF co-chairs the NSTC's Select Committee on Artificial Intelligence. Through this committee, member agencies focus on policies to prioritize and promote AI R&D, leverage Federal data and computing resources for the AI community, and train the AI-ready workforce. Agencies also partner directly on programmatic priorities, on place-based research and through the use of multi-user research facilities.

Another example is the Subcommittee on Quantum Information Science (SCQIS), which NSF and DOE co-chair along with the National Institute of Standards and Technology (NIST) and the Office of Science and Technology Policy (OSTP). This subcommittee coordinates Federal research and development in quantum information science (QIS) and related technologies. Further responsibilities of the subcommittee are legislated through the National Quantum Initiative Act (NQI Act), which was signed into law in December 2018. The NQI Act aims to accelerate quantum research and development for the economic and national security of the United States. Advances in quantum physics have created some of the 21st century's critical tools such as lasers and broadband communications. New discoveries in quantum physics promise faster computers and more secure communication networks. The diverse scientific fields of physics explore the fundamental workings of our universe, from the smallest quantum-scale phenomena to entire galaxies. From space flight to GPS, physics provides the foundation for countless innovations woven into the fabric of modern life.

In January, NSF and DOE's Office of Science signed a memorandum of understanding that will continue our longstanding collaboration on scientific and engineering research and enable increased partnerships to address the most important challenges of the 21st century. This MOU builds upon previous NSF and DOE research partnerships, such as collaboration on large physics experiments, quantum information sciences and technologies, and access to scientific user facilities. The MOU also provides opportunities for collaboration on biotechnology, quantum information science and engineering, artificial intelligence and machine learning. Growing a diverse, inclusive STEM workforce is also a priority for both agencies. This MOU will help NSF and DOE facilitate fulfilling engagements that will increase the impact of research and development funding.

Additionally, NSF and DOE's Office of Energy Efficiency and Renewable Energy (EERE) signed a separate MOU in March of last year, this one focused specifically on decarbonization and accelerating clean energy technology research and implementation. Among other things, the partnership aims to create advanced new materials to accelerate solutions to the nation's toughest materials challenges in the energy sector. The partnership will build upon previous collaborative activities and could include bioenergy, building and water treatment technologies, hydrogen and fuel cells, and renewable energy technologies, as well as agriculture, critical minerals and materials, and manufacturing, as well as the social, behavioral and economic aspects of new technologies and energy-related policies. Collaboration could extend to research infrastructure, university-industry partnerships, education and workforce development, and activities supporting diversity, equity, and inclusion.

NSF and DOE's robust partnership includes access to various NSF- and DOE-managed multi-user facilities around the globe. One recent success from that partnership is the NSF-supported work of researchers at the University of South Carolina who collaborated with the DOE's Sandia National Laboratories. The researchers have created a new type of porous material with unique nanoscale properties that can potentially enable superior hydrogen storage solutions — an innovation that would be useful for fuel cells used in vehicles, backup power supplies and other applications.

Other examples include the Large Hadron Collider (LHC), which is an international project at the European Organization for Nuclear Research, CERN, laboratory in Geneva, Switzerland. It is the most powerful particle accelerator ever constructed and has the highest energy particle beams ever created, making it the premier facility in the world for research in elementary particle physics. It consists of a superconducting particle accelerator, about 16.5 miles in circumference, providing two counter-rotating proton beams. Four large particle detectors collect the data delivered by the LHC. Researchers use the data to search for new particles and forces. CERN is responsible for meeting the overall LHC project goals and coordinating international participation. The U.S., through a partnership between NSF and DOE, is a major contributor to the construction and operation of two of the largest particle detectors: A Toroidal LHC ApparatuS, ATLAS; and the Compact Muon Solenoid, CMS. A major international effort is underway to upgrade the luminosity of the particle beam at the LHC to increase the intensity of the high-energy particle collisions and unleash a torrent of data for research in elementary particle physics. NSF is one of more than 45 funding agencies contributing to this effort. The upgrade effort, like LHC operations, is being closely coordinated with DOE.

In the field of astronomy, NSF's National Optical-Infrared Astronomy Research Laboratory (NOIRLab) is the U.S. center for ground-based optical and infrared astronomy and operates several observatories where both NSF and DOE research takes place. Two examples of multi-user facilities where NSF and DOE work in tandem include the Vera C. Rubin Observatory and the Nicholas U. Mayall 4-meter Telescope at Kitt Peak National Observatory.

The Rubin Observatory is led by NSF in partnership with the DOE Office of High Energy Physics. DOE is providing the observatory's world-leading digital camera and is contributing to design, development, installation, commissioning, operations, and scientific research support. The Rubin Observatory will become NSF's flagship optical survey instrument, consisting of an 8-meter wide-field ground-based telescope, a 3.2-gigapixel camera — the largest ever made — and an automated data processing system. It will conduct an unprecedented, decade-long survey of the visible sky and will enable new science in four main areas:

- Understanding the nature of dark matter and dark energy;
- Cataloging the Solar System, to help reveal how it originally formed and to protect Earth from hazardous, near-flying asteroids;
- Exploring the changing sky, including cosmic events that are only visible for short periods of time; and
- Probing the Milky Way's structure and formation.

The Kitt Peak National Observatory (KPNO) supports the most diverse collection of astronomical observatories on Earth for nighttime optical and infrared astronomy. KPNO operates several telescopes including the Mayall 4-meter Telescope, which specializes in dark energy science. The Dark Energy Spectroscopic Instrument (DESI) is an international science collaboration managed by DOE's Lawrence Berkeley National Laboratory with primary funding for construction and operations from DOE's Office of High Energy Physics. DESI is installed at the Nicholas U. Mayall 4-meter Telescope at Kitt Peak National Observatory; DOE contracts with NSF's NOIRLab to operate the Mayall Telescope for the DESI survey.

DESI has broken through all previous records for three-dimensional galaxy surveys and has created the largest and most detailed map of the Universe ever. The DESI Legacy Imaging Survey published a new data release just recently, expanding even further upon the largest two-dimensional map of the sky ever created. Over one billion galaxies blaze bright in the colossal map of the sky that was just released, which was made with data from NSF's NOIRLab telescopes at KPNO and Cerro Tololo Inter-American Observatory in Chile. One of the main purposes of this map is to identify roughly 40 million target galaxies for the five-year DESI Spectroscopic Survey, which is aimed at understanding dark energy by precisely mapping the expansion history of the Universe over the last 12 billion years.

Another example of close coordination between DOE and NSF is the orderly transition of NSF's National Superconducting Cyclotron Laboratory (NSCL) to DOE's Facilities for Rare Isotope Beams (FRIB), located at Michigan State University. For 40 years, NSCL served as the Nation's premier user facility for rare isotope beams, which are key to understanding rare nuclear processes and how elements heavier than iron came to be. In 2022, building on NSF's initial investment at NSCL, the DOE Office of Nuclear Physics inaugurated the next-generation facility FRIB, which will keep the U.S. at the frontier of rare isotope science for years to come. This transition would not have been possible without close coordination between DOE and NSF.

<u>Public-Private Partnerships</u>

In addition to our partnerships with other federal agencies, NSF is also focused on developing long-lasting partnerships with industry to help meet the challenges of today and tomorrow. NSF's new Directorate for Technology, Innovation and Partnerships (TIP) — which was codified in the CHIPS and Science Act of 2022 — helps position the agency to capitalize on the uniquely American research ecosystem that includes academia, private industry, the government, and other partners to quickly translate research into impacts that benefit the Nation.

In the past six months, the TIP Directorate has announced new programs and partnerships with companies such as Intel Corporation and Micron Technology, Inc., to develop bold, potentially transformative solutions to address semiconductor manufacturing challenges and also advance opportunities for equitable science, technology, engineering and mathematics (STEM) education.

Last September, NSF announced a new $10 million partnership with Intel to provide funding to support the development of a high-quality manufacturing workforce at all levels of production and innovation. This builds upon a previously announced 10-year collaboration between NSF and Intel that will, over time, invest $100 million to address semiconductor design and manufacturing challenges and workforce shortages around the country.

In October, it was announced that NSF and Micron will each invest $5 million in support of research, education, infrastructure capacity building, and workforce development for semiconductor design and manufacturing. Both of these partnerships will improve and make more equitable STEM education at two-year colleges and four-year universities, including minority-serving institutions.

Just last month, NSF announced a cross-sector partnership with Ericsson, IBM, Intel, and Samsung to support the design of the next generation of semiconductors as part of our Future of Semiconductors (FuSe) initiative. Investments through this public-private partnership will help spur research and innovation leading to breakthroughs in semiconductor and microelectronics technologies, aiding the myriad applications that rely upon these devices.

Summary

NSF has made partnerships a pillar in our strategy for meeting the challenges of today and laying the groundwork for the research enterprise of tomorrow. These examples provide only a small sample of the many collaborations NSF is undertaking both within the federal government and with other partners to leverage resources and provide the best possible return to the American people, now and into the future.

Our partnerships with the DOE and other federal partners are a vital part of these efforts and the research agencies will continue to work together to bring about advances in key technologies that are critical to our economic and national security.

Thank you for the opportunity to appear before the Committee today.

Dr. Sean L. Jones
Assistant Director, Directorate of Mathematical and Physical Sciences
National Science Foundation

Dr. Sean L. Jones is the Assistant Director (AD) for the Directorate of Mathematical and Physical Sciences (MPS), a $1.6B enterprise with over 180 employees and contractors, comprising of the Divisions of Astronomy (AST), Chemistry (CHE), Mathematics (DMS), Materials Research (DMR), and Physics (PHY). Prior to being selected as the AD, he served as the Deputy Assistant Director (DAD) for MPS, Deputy Division Director (DDD) for DMR, and program director for DMR. Sean joined NSF in 2009 and was a member of the DMR Materials Research Science and Engineering Centers (MRSEC) and Partnership for Research and Education in Materials (PREM) management teams. He was also the division's Major Research Instrumentation (MRI) coordinator. Dr. Jones transitioned from leading the MRSEC program to co-managing DMR's National Facilities portfolio, with primary programmatic responsibility for the creation and development of the new Materials Innovation Platform (MIP) program. In addition to MIP, he co-managed the National High Magnetic Field Laboratory (NHMFL) facility, the Cornell High Energy Synchrotron Source (CHESS) facility, the National Institute of Standards and Technology (NIST) Center for High Resolution Neutron Scattering (CHRNS), and the Division's Major Research Instrumentation (MRI) program. In addition, Dr. Jones has co-led a NSF agency reform effort for IT leading to new governance structures and IT tools, co-developed the Sustainable Chemistry, Engineering, and Materials (SusChEM) program in response to Congress, led Broadening Participation efforts resulting increased funding to underrepresented groups, been an instructor in the Program Director Academy, participated as a Directorate's representative for the NSF-wide NSF graduate Research Traineeship (NRT) and the Innovation Corps (I-Corps) programs, and most recently served as the Chief Negotiator for successfully bargaining a 37 year old Collective Bargaining Agreement.

Dr. Jones also served on a 14-month detail as the Assistant Director for Physical Sciences and Engineering for the White House Office of Science and Technology (OSTP). His OSTP portfolio included graduate education reform, grant reform, aquaculture, plant genomics, and broadening participation of underrepresented groups in STEM. Prior to joining NSF, Dr. Jones served as the Director of Engineering for Applied Plasmonics, Chair and Professor for both the optical and electronic engineering departments at Norfolk State University, Technical Manager and Distinguished Member of Technical Staff at Bell Laboratories of Lucent Technologies, Senior Scientist for Luxcore Networks, and lead line engineer for Hoechst Celanese. He has authored numerous publications and has been awarded 9 U.S. patents. He is an industry-recognized expert in luminescent materials and the fabrication of optical waveguides. He is the co-inventor of Lucent's high bandwidth multimode optical fiber used in today's Fiber-To-The-X (FTTX) applications such as FiOS cable television and Fiber-to-the-Home applications. His work led to the IEEE standards for 10G multimode optical fiber as well as the lasers and detectors employed in these systems. Dr. Jones received his B.S. in Ceramic Engineering (now Materials Science and Engineering) from Clemson University and his Ph.D. in Materials Science and Engineering from the University of Florida.

Chairman LUCAS. Thank you, Dr. Jones. And thank you to all the witnesses for your testimony.

The Chair now recognizes himself for five minutes for questions.

Dr. Kung, as you note in your testimony, many of the Department of Energy's successful interagency partnerships are enabled by DOE research infrastructure like the Office of Science user facilities and upgrades recently authorized in the *CHIPS and Science Act*. What DOE facility investments are necessary to ensure that our science—our Federal science agencies are equipped to compete together against our adversaries?

Dr. KUNG. Thank you very much for that question. We're, indeed, very, very proud of the 28 scientific user facilities that we have stewarded. In fact, it's really the cutting-edge technology, expertise, resources that we offer free of charge to publish more research for the whole community that really make them unique. We do need to make sure that these facilities are continuing to stay at the cutting edge. We also need to make sure that they are fully resourced. We can make these resource and the talents of the staff available to the whole community, not only to support the DOE science, but also to support our interagency partners. But we're also safeguarding the research that's being produced at our facilities to protect any unintended sharing of information and technology. So all in all, we're taking the stewardship responsibility very seriously, making sure that they're indeed serving the American people's the best interest.

Chairman LUCAS. Along that line of questioning on my part, I'm going to ask kind of a challenging question, I know. But we will be operating in a very restricted budget environment this fall, I suspect. Tell me what kind of investment should be prioritized. And I know that's never a pleasant question, but——

Dr. KUNG. Absolutely. In fact, this privatization is part of our DNA as a Federal steward of these resources. We are grappling with the privatization decision every day, amongst the six programs that I'm overseeing, within each program, the program also needs to prioritize their resources in order to maximize the productivity and impact. But we're not making these decisions in vacuum. We're actually surrounding ourselves with a guidance from Congress, from the Administration, but also from the community. For example, several of our sister agencies and I, we work together to set priorities on the topical areas that we need to jointly invest or individually invest in making sure there's no duplication, but that there are also synergistic opportunity to working across the agency boundaries.

Chairman LUCAS. Continuing with you, Doctor, on the Science Committee we know that DOE plays an important role in supporting research across the Federal Government, even in agencies that are outside this Committee's jurisdiction—hard to believe there are such agencies, aren't there, Ranking Member—but outside our jurisdiction. As a farmer and rancher, I'd like to take a moment to highlight the Department's work with the U.S. Department of Agriculture. DOE and USDA have an established history of partnering to address important research challenges in areas like biomass, biofuels, genomics, integrated water resources, rural energy development, and much, much more. Doctor, in the past few years, what steps has DOE taken to strengthen ties with USDA? And I ask that as we consider legislation to support the DOE–USDA relationship.

Dr. KUNG. Again, thank you for that question. We indeed have a longstanding partnership in both science and also the applied research development being conducted across the whole department. Maybe I can focus my response on the Office of Science part of interactions that we have conducted with USDA. Let's take the bio-research centers (BRCs) supported by our biological environmental research program as an example. We currently support four of these BRCs that are being tasked to explore better ways and addressing bottlenecks in making sure biofuels overcome some of the bottlenecks, making sure they are cost-effective, and being able to being used in the commercial sectors.

And this is a very strong partnership that we have with the USDA, for example. The Agricultural Resource Services at both Louisiana and in Illinois are working with one of our BRCs. They're taking this integrator research idea as essentially turning each of these plants as a factory to make sure that we actually get as much functionality out of these plants. And this integrated research approach is actually very, very powerful. For example, one of the very exciting success stories that we worked between DOE and USDA is this oilseed example, where, during the non-crop, non-grow seasons, we actually allowed the farmers to grow these cover oilseed. It's called pennycress. This is a oilseed that, based on DOE's expertise, we actually built in functionality to increase the seed population and also the oil content that can grow—be derived from these oilseeds, while USDA contributed their expertise to make sure that these plants are drought-resistant, they are more resistant to disease and so forth. It's really a perfect marriage in the way that we're contributing the fundamental science on the genomics microbiology perspective where the USDA coming from the agriculture attributes. So in a way we're able to produce this oilseed and make them into a commercial application.

Chairman LUCAS. Thank you, Doctor. With that, my time is expired. I recognize the Ranking Member for five minutes.

Ms. LOFGREN. Thank you, Mr. Chairman.

Dr. Kung, my understanding is that you are the Acting Director at this point of DOE's Fusion Energy Science Program. I've got questions for everybody, but I only have five minutes, so I want to talk to you about some of the issues of concern that I have. As you know, Congress has passed in the last five years several bills that came out of this Committee with bipartisan support, and they were based on the Fusion Energy Science Advisory Committee and the National Academies' recommendations. We'll get—we'll find out what the President's budget is tomorrow, but I want updates on where we are on some of the requirements that Congress has put on the DOE. For example, it's my understanding that although directed, the Department has yet to establish an inertial fusion energy (IFE) program that could leverage the recent accomplishment at the National Ignition Facility (NIF), as well as the Department's other nuclear security facilities, nor have you established an alternative and enabling concepts program to assess and accelerate the development of the next generation of fusion technologies toward commercial development. So I'd like to know what the Department is doing today to ensure that you're complying with the *Department of Energy Research and Innovation Act of 2018.*

And additionally, my understanding is that the milestone-based public-private partnership was only established last September, but it's now at $50 million, completely oversubscribed, and I'm concerned and would like your input on the status of that.

And last, I understand there's a pressing need to identify and develop fusion materials, as highlighted in the recent reports that I mentioned a minute ago. It's a major challenge to ultimate commercialization of the industry. Yet, this R&D is significantly underfunded when compared to the authorization. So can you address those gaps for me, please?

Dr. KUNG. Thank you, Ranking Member Lofgren.

Ms. LOFGREN. Could you turn on your mic? It's hard to hear you.

Dr. KUNG. OK. Thank you. Thank you for that question. I also would like to take this opportunity to thank you for your strong support for Office of Science and also for the fusion energy in particular.

I would like to first address the inertial fusion energy topic and actually have wonderful news to share is that starting in Fiscal Year 2023, we are starting an IFE programs. And this is actually based on the excellent work. We recently tasked two very talented researchers. You may know Professor Tammy Ma and Professor Riccardo Betti from Rochester, or University of Rochester. Both of them led a base research need for inertial fusion energy workshop last year. And based on this excellent workshop report, we're actually formulating a funding opportunity announcement (FOA) that will be released later this year, probably later this month even to stand up a IFE program. We're very, very excited to see especially the Livermore NIF results. I think that is a giant leap forward for the whole fusion energy science, as well as the technology, and we're very, very proud of that.

And also recognizing that particular result really grew out of almost six decades of very substantial science and technology research in physics, in materials, in laser, and also in all these technology developments, so we definitely agree completely with you and the Committee that we need to continue and enhance our investment in fusion energy technology, in particular, with the view of bringing fusion energy onto the grid.

And you have mentioned several reports, the Fusion Energy Science Advisory Committee long-range report—long-range planning report, the NASEM (National Academies of Sciences, Engineering, and Medicine) report, all are strongly advising us to increase our investment, along with the *CHIPS and Science* and various authorization bills that your Committee has provided, and we are taking them to heart.

In particular, you mentioned the milestone-based program.

Ms. LOFGREN. Right.

Dr. KUNG. We're very excited to be able to launch that program. Actually, we issued the solicitation earlier that year. The plan is to look at the awards, which hopefully will be announced in a couple weeks. Based on that, also inform our future trajectory. We understand there is a gap between the funding available that we put into the solicitation and also the authorization level. We are taking the authorization level as the guide as we're designing this program, but we're very excited about the milestone program. We think that this is a very important program to help us design this fusion power plan, but also develop a technology roadmap jointly with the private sector. I think those are very important information to inform our overall strategy for fusion, especially bringing fusion on the grid. Thank you.

Ms. LOFGREN. I see my time has expired, but I know the Chairman shares my interest in fusion, and I'm sure we'll be pursuing it further in, you know, hearings in the future. So with that, I yield back, Mr. Acting Chairman.

Mr. WILLIAMS [presiding]. Thank you. Sorry. The Chair recognizes the gentleman from Florida, Mr. Posey, for five minutes.

Mr. POSEY. Thank you, Mr. Chair. With China controlling more and more of the global supply chain of critical minerals and materials, does the Department of Energy consider this a serious threat to the national security of our Nation, Dr. Kung?

Dr. KUNG. Thank you for that question. There are critical resources, including critical minerals, critical materials.

Mr. POSEY. I can't hear you.

Dr. KUNG. I'm sorry. Should I stop?

Mr. POSEY. No, that's good.

Dr. KUNG. I think I understand your question. It's about resources that China is controlling. If it's not the right question, I stand corrected.

Mr. POSEY. Yes. Let's try this. What is the Department of Energy's Office of Science and Policy and their commitment to establish a domestic supply of minerals that come from China that are rare?

Dr. KUNG. Thank you. Thank you very much for that question. Indeed, we're taking these resources—the availability of these resources very critically, very importantly, and we recognize that these critical minerals and materials are essential for a number of the U.S. application, industry, commercial, and that's really impacting not only our national security——

Mr. POSEY. What are we doing about it?

Dr. KUNG. What we're doing about it, we're doing it—we actually are having a whole-of-the-government approach not only within the Department. We're coordinating across the different programs in the Department of Energy but also with our sister agencies, NSF, NASA and Department of Defense to name a few.

I think from—speaking from my own office perspective, it's very, very important that we take a dual approach. One is to be able to find substitute alternatives to these critical materials and minerals so we're no longer at the mercy of China controlling——

Mr. POSEY. I get that.

Dr. KUNG. And the——

Mr. POSEY. Give me an example of one that we've done like where we've sought another alternative. Like we had a witness last week said 90 percent of our graphite comes from China——

Dr. KUNG. Right.

Mr. POSEY [continuing]. So what are we doing about that?

Dr. KUNG. So we may want to develop other graphite sources not from China. But also in addition to graphite for example, neodymium is one of the critical materials. There are super exciting properties that neodymium possess that we may find alternatives to having neodymium, for example, in high fuel magnets. So that's exactly—trying to understand what makes these critical mineral—critical materials so special that impact our clean energy application, our other applications, and then find——

Mr. POSEY. How much money have we spent searching for alternatives so far?

Dr. KUNG. I'm sorry?

Mr. POSEY. How much money have we spent searching for alternatives in the last 10 years?

Dr. KUNG. Right. So within—there are several pieces in the Department of Energy. In the Office of Science, we're spending about $20 million per year for the past 10 years or so. But there are a dedicated program called Critical Material Institute being supported by the Energy Efficiency and Renewable Energy that had—that program has been going on for 10 years. So each year it's funded at $25 million, so over a 10-year span, it's $250 million. That is not the program that's supported in my office. If you're interested, we can get you additional information from——

Mr. POSEY. Yes.

Dr. KUNG [continuing]. My colleagues.

Mr. POSEY. I would appreciate that. How many commercial minerals and materials production facilities have resulted from these expenditures?

Dr. KUNG. Yes, that's exactly the question that my colleagues in the Energy Efficiency and Renewable Energy will be able to answer. I will be happy to get back with you on the details of that.

Mr. POSEY. How can the Department of Energy ensure that its research funds are used in a way that promotes American companies?

Dr. KUNG. Indeed, we are keenly aware that the Department also is putting—protecting the benefits of America's investment in R&D, making sure that we fend off unneeded, unintended sharing of information, especially recognizing there are countries that are not really adhering to the same code of conduct such as in terms of respecting our IP (intellectual property) rights, respecting the IP rights, and also intellectual property rights, as well as protecting research——

Mr. POSEY. All right. Time's almost over. If we have a foreign company competing with an American company, would we ever fund a foreign company?

Dr. KUNG. So the Secretary actually started——

Mr. POSEY. Yes or no would be helpful because we're almost out of time.

Dr. KUNG. OK. So the Department had put in a very rigorous vetting—risk-based vetting process to make sure that the American derive the—from the maximum benefit from the American investment in R&D. It's case by case. I—my understanding is that, and if you—I will be happy to get back with you with additional information on—if you have specific case you would like to—us to address.

Mr. POSEY. Thank you, Mr. Chair. My time's up.

Mr. WILLIAMS. The Chair recognizes the gentleman from North Carolina, Mr. Jackson, for five minutes.

Mr. JACKSON. Thank you, Mr. Chair. And it's a pleasure to serve with you, sir.

Dr. Morgan, good morning.

Dr. MORGAN. Good morning.

Mr. JACKSON. I want to speak with you for a moment about the somewhat notorious, where I'm from, radar coverage gap in North Carolina. This is something I was not an expert in, am still not an expert in. I just want to give you a sense of what I've heard from some folks back home. And if I explain this in a way that's inaccurate or leaves out some important context, I want to give you the opportunity to correct me and fill in anything that I'm missing, OK? I just want to make sure we're all sort of on the same page with the situation.

Years ago, I had a meteorologist in my district educate me about this. He asked me if I could do anything. I told him I was in the State legislature. I didn't think that I could. But now I found myself running for Federal office, and he reapproached, along with a number of other meteorologists. As it turns out, the nearest Doppler radar is about 80 miles away. This was a decision that was made many decades ago. I think there was some defense industry input for this. It was part of a larger cold war calculus about how to spread out Doppler radar across the country. And back then, the Charlotte metropolitan region didn't have the three million people that it has today, and nothing has been done to close that coverage gap. I know a report was issued by I believe NOAA a couple of years ago that kind of downplayed the significance of the gap. There was some dissent. There was disagreement about its significance.

Again, not an expert in this, but I can tell you that the meteorologists in my district say that when it comes to predicting and warning people about tornadoes and flash floods, that they consider themselves severely hampered by existing within this radar coverage gap. My understanding is for very severe tornadoes, the coverage gap is not really a problem. But for F–1, F–2, and for flash floods, being able to detect weather below a 6,000 foot level is a major problem for the three million people who live in this metropolitan region.

I would like to just give you some time to correct me if I got anything wrong, and ultimately, I'm going to ask your advice on how we proceed to rectify this.

Dr. MORGAN. OK. Thank you for the question, Congressman. We—your question recognizes the critical importance of observations broadly in our predictive capacity in this country. And NEXRAD (Next-Generation Radar) radar is one of the key tools that we use for high-impact weather events like severe thunderstorms, tornadic thunderstorms, and heavy precipitation. And we use those tools to protect lives and property.

I cannot fully address to you right now how the siting was done decades ago. NEXRADs were built, sited, and deployed, as you acknowledged, well over 30 years ago. And while we're continuously upgrading them through our service life extension programs and we're improving them with the latest technology, we're also recognizing that where we have those gaps, because the scan angle, the further out you go, the further up it's going to be, that's absolutely correct. And so what we've done is found ways of lowering that scanning techniques so that we can cover more of the lower troposphere closer to the Earth's surface.

If—you know, those gaps may still remain, and we're trying to understand how we can better cover areas like Charlotte. They're part of an aging—they're aging part of our critical infrastructure, and we recognize that there's some inherent limitations with our current technology.

So what NOAA is doing right now is we're really hard at work at looking at the next system, the follow-on system to the NEXRAD radar, and that what we're focused on is what's called phased array radar, or PAR, and these systems are going to allow us to greatly improve the scan times, as well as allow for better forecasts and warnings.

Going back to the concern about warnings, that report that was issued a couple of years ago, I believe, found that—from the National Weather Service's analysis that, you know, we—one of the key takeaways from that report was that for predicting severe weather, it's not just the radars that are used, but there are other observational platforms, surface observations, spotter reports, et cetera, that help us fill in some of those gaps, so it's not just the radar that's critical for that. But we recognize where there are gaps, we are looking at new technologies, looking at the—some technologies with the private sector perhaps that might help to fill those in.

I would be happy to work—and my team—to follow up with you on this and to discuss how NOAA is working to work—you know, how we can best work with Congress to move forward in this particular area.

Mr. JACKSON. Well, I appreciate that. I accept your invitation, would love to work with you, will say as a first thought reporting back to my constituents that there may be a new technology that's going to be invented, funded, deployed, and rolled out, and we may be the beneficiary of that probably is not going to cut it with them but look forward to having a conversation.

Dr. MORGAN. Right. But I think that lower scanning angle that we're using now hopefully is beginning to ameliorate part of that gap.

Mr. JACKSON. Thank you.

Dr. MORGAN. Thank you.

Mr. WILLIAMS. The Chair recognizes the gentleman from Texas, Mr. Babin, for five minutes.

Mr. BABIN. Yes, sir. Thank you, Mr. Chairman. I appreciate it and appreciate all the witnesses for being here.

I have some very specific questions that I'd like to have answers to if possible. For either Dr. Kung or Mr. Reuter, NASA currently pays DOE to operate the facilities necessary to produce plutonium-238, the isotope that is used to power many of NASA's planetary probes and rovers. How much is NASA currently paying DOE for plutonium-238 production?

Mr. REUTER. I don't think I have—we'll have to get that information for you. I don't have the exact number of how much we're paying for plutonium-238. We do have a great relationship with the Oak Ridge National Laboratory and got an agreement on continuous production rates that really serves our needs and we'll address in the future.

Mr. BABIN. OK. And I've got some more specific, and I hope we get the answers to this, too, maybe if not today——

Mr. REUTER. Yes, we'll be glad to get you the information.

Mr. BABIN. How much has NASA paid DOE since 2011 when Congress began to provide funding to restart domestic production for civil space applications?

Mr. REUTER. Yes, we'll get you the information for the cost and——

Mr. BABIN. And then how much plutonium-238 is being produced this year, and how much has been produced since the restart in 2011?

Mr. REUTER. Again, I'll get you the exact information as we go along. What we've done is we have five active missions that use radioisotope power systems. We've had over 30 over the years, and we know Dragonfly is coming up. We'll use it. And, you know, the exploration of the Moon and beyond is really going to—really help our need—and so what we've done is got a kind of a 10-year rotating supply, you know, average so we have constant production rate from DOE that really services our needs, and then we'll be glad to get you the total mounts of how much we're producing and the cost.

Mr. BABIN. All right, thank you. DOE uses the High Flux Isotope Reactor (HFIR) at Oak Ridge and the Advanced Test Reactor at Idaho National Lab to produce plutonium-238. Has production at these facilities been constant or has it been interrupted for maintenance, servicing upgrades, or safety concerns? And do you anticipate any interruptions?

Mr. REUTER. Again, I'll get you the exact information, and I'll be glad to come talk to you and get all the questions answered. What I would say is we—with going to the constant production rate, what we're anticipating doing is smoothing out those interruptions as we go through it. And we really think that will service our needs in the future, and we can adjust it on a yearly basis but kind of keep a production rate looking 10 years in advance.

Mr. BABIN. So you do anticipate some interruptions then going forward?

Mr. REUTER. You can't say that—anticipate interruptions. What we're trying to do is make sure that we have the supply we need when we need it and do so at a constant production rate. You never know with the unknowns, and so the—you never know that there won't be any, but right now, we're confident in our plan.

Mr. BABIN. Have you had any interruptions that you know of? And has that had an impact on production?

Mr. REUTER. We'll get you the information when we come with a complete story.

Mr. BABIN. OK. If NASA was constrained by the availability of plutonium-238 for exploration missions, how would this change the space science program and the design of future missions?

Mr. REUTER. When we do—when we go to future missions that are beyond—you know, out to Mars and beyond, it's critical for us to have a supply of—a constant supply of power and heat energy in order to be able to use these because we don't have the ability to utilize sunlight out there. And so all those missions are—as we advance them and as we're going through these things are critical for that need for us.

Mr. BABIN. OK. And then you've hit—alluded to some of this, but what's being done to encourage the development and use of low-cost commercially available nonplutonium radioisotope power systems?

Mr. REUTER. Yes, we actually are looking very seriously at that. It offers a potential to go to a more cost-effective solution as we go through this, and it's one that would be—that some members of our—you know, it's easier for the commercial community to—so we're looking very seriously at that.

Mr. BABIN. OK. And then one more for you, Mr. Reuter. Last May, NASA announced that it would reexamine the viability of space-based solar power. What is the status of that review?

Mr. REUTER. We have studies going on that—to look at that. We've had—held workshops for power—space power. And we're looking very seriously, especially as you go to the Moon, application—lunar applications when you don't have cables present and stuff. We're looking very seriously as—are there places there that we can use power, power beaming and wireless power, basically, as we go through it. It's a key part of what we're looking at. It's not necessarily the only way we'll go. But we're looking very seriously at that. And then the—further, the extrapolation of what that can be for the commercial——

Mr. BABIN. All right. Thank you very much.

Mr. REUTER. Thank you.

Mr. BABIN. I yield back.

Mr. WILLIAMS. The Chair recognizes the gentlewoman from Ohio, Mrs. Sykes, for five minutes.

Mrs. SYKES. Thank you, Mr. Chair. And thank you, to you and the Ranking Member, for assembling this presentation, as well as to our witnesses for your testimony.

My first question is going to you Mr. Reuter. We in Ohio are certainly proud of the NASA Glenn Research Center, and it's just north of my district, Ohio 13 in Akron. And we know that the road to Mars goes through Ohio. I think that's what somebody said or unless I just made that up today. That's fine, too. Oh, I have more. I have more. So the research and development that you all are facilitating certainly has some far-reaching impacts, particularly for Ohio and our advanced manufacturing sector, which has benefited immensely from technology transfers that NASA has engineered and helped spin off, and we thank you for that.

But in particular, I want to talk to you about—or want you to talk to us about the Defense Advanced Research Project Agency (DARPA) where you all are focusing on nuclear propulsion. And can you discuss a bit more about NASA's partnership with DARPA, and can you share with us what lessons we should take from the interagency cooperation that we can apply more broadly for the Federal research ecosystem that you're discussing today?

Mr. REUTER. Yes, thank you, Congresswoman. And we wholeheartedly agree the Glenn Research Center is one of our absolute best research centers at NASA. We do a great deal of work with them, over $2.5 billion dollars of economic development, over 10,000 jobs in the area as a result of that. And it's really a tribute to those. And for us, we utilize their expertise in propulsion systems, in power, in thermal, in situ resource utilization on the Moon, communications, and so on as we go through this.

Now, you asked about the particular agreement we have with DARPA, and that has been, you know, several months in the making. What I would say is this is a revolutionary time for potential of using nuclear systems in space to change the way we think about traveling in space. And so we're really excited about doing that. And, as a result of that, it's something that's multiagency interest. Department of Energy we work very closely with on this and in DARPA. The nice thing about the DARPA agreement was we've recognized over the last couple of years that we have common interests, and we worked really hard to get the objectives we have overlapping to the point.

So what we're trying to do—what we recognize them as we were going through this development, and they have the DRACO (Demonstration Rocket for Agile Cislunar Operations) program that we're co-partners with now and is a great opportunity for us to combine our resources. So neither one of us could afford to do this on our own, but we've done so and outlined the objectives that each of us will—and requirements each of us will have, and then—and we're working with a common contract but different parts of it that we fund, and so there's no exchange of funds between us, each to the partners. And it's really—it's—we're really excited about it.

I think it's—you know, when you have the need together and you have the willingness to compromise a little bit on where your objectives are, then, you know, it's the way—especially in these times where budget will be restrictive. It's the way we're really looking at as how do we utilize the whole of government?

Mrs. SYKES. Thank you very much for that answer and specifically for your conversation about the budget and using it in the most efficient way and working across agencies. And if you could just dig a little bit deeper into how some of the research and development at NASA is benefiting our local communities. Like I said, I don't represent the district where NASA Glenn is, but I'm confident our district is receiving benefits and participating in the pipeline and getting us closer to Mars as we were first in flight. Isn't that right, Congressman Jackson? I had to. I had to do it.

[Laughter.]

Mrs. SYKES. Well, thank you for allowing us, Mr. Chair, to have a moment of levity there. But if you could just discuss how these partnerships are helping local communities throughout northeast Ohio and probably——

Mr. REUTER. Sure.

Mrs. SYKES [continuing]. Throughout other areas in the country who benefit from NASA's research?

Mr. REUTER. What I would say is a core part of our—NASA's mission is to transfer our technologies and—for the benefit of the economy, the space—the economy—both the space economy and the rest of our economy. And Glenn Research Center is one of our most active participants with—across our centers on trying to help us on technology transfer. We view our technology transfer program, which I run, as being an essential part of—and not just about numbers of this number of patents, licenses, or this many software licenses that we've released, but really taking that and helping the economy directly.

So we really have—we look for regional economic development across the country hoping to try to reach the 50 States, but one of the core areas that we've done a lot of work is in Ohio. One of the ways we do that is these programs that they're helping us run and things like what we call T2U (Technology Transfer University.) We work with universities, take NASA technologies into the business schools and use that as test cases for them for things, and it's actually produced companies out of it. So that area is especially good for some things like that. We also have a Fed Tech program that takes NASA technologies, working with entrepreneurs and stuff. And so it's kind of our core for what we're trying to do and broaden from there.

Chairman LUCAS. I thank the gentlelady.

The Chair now recognizes the gentleman from Tennessee, Mr. Fleischmann, for five minutes.

Mr. FLEISCHMANN. Thank you, Mr. Chairman. I want to thank this distinguished panel. It's great to be with you all today. I started many years ago on this Committee under Ralph Hall. As most of you know, I'm Chuck Fleischmann. I represent the great DOE reservation at Oak Ridge and all it does. I am also the Chairman of the Energy and Water Subcommittee on Appropriations, so as an appropriator, we fund all of your endeavors, and I think this is probably one of the best Federal investments I've seen in my congressional tenure. We've got Oak Ridge National Lab, the Y–12 plant, we're building the UPF, uranium processing facility. We have a great legacy cleanup. Science is critical to all of this, and I thank each and every one of you for your advocation.

My first question is going to deal with supercomputing. I was there when we launched Frontier at Oak Ridge National Laboratory. This was the first supercomputer in the world to break the exascale barrier. The machine unlocks new possibilities to benefit our country's economy, competitiveness, and national security through scientific advantage. We will be able to take more data than ever before, analyze it faster than ever before. For everyone's knowledge, this is the fastest smartest supercomputer in the world. We have beaten the Chinese and our other competitors.

Dr. Kung, can you tell us how the Department of Energy plans to integrate these new capabilities into our existing system so we can take advantage of big datasets, artificial intelligence technologies, and machine learning, for example, to solve big problems? Thank you.

Dr. KUNG. Thank you for that question. We're indeed so excited and so proud of the accomplishment at Oak Ridge National Laboratory delivering Frontier, the world's very first exascale computer system. But the job in delivering exascale computer is not done. We have another system that needs to be deployed at Argonne National Laboratory at the same time. In addition to deploying the hardware, we're also supporting a suite of applications. We want to make sure that these scientific applications can take full advantage of the super power that these high-performance computers are delivering, and the suite of application ranging from a new code for predicting cancer, new codes to be used for discovery of new forms of materials, new accelerated technologies, and so forth. So our emphasis has been how do we really maximize the investment we have made already in exascale computer?

And you have also mentioned AI machine learning, and that's such an absolutely excellent accelerator. We can even derive even more higher performance and efficiency out of systems such as Frontier. So that is our current focus, making sure to really maximize the precious taxpayer dollars that we have invested in the wonderful machines——

Mr. FLEISCHMANN. Thank you.

Dr. KUNG [continuing]. At Oak Ridge and others.

Mr. FLEISCHMANN. Thank you very much.

This next topic I'm going to open up for the entire panel, but I do want everyone on the dais to understand this. Isotope facilities, we're talking medical isotopes, scientific isotopes, defense isotopes, manufacturing isotopes, the Oak Ridge National Laboratory in Tennessee plays a central role in the Department of Energy's isotope program. In fact, Oak Ridge provides 283 of the 325 isotopes produced by the Federal Government. Why is this important? Because the only other source of many of these in the world is Russia right now. So Oak Ridge is the source of these key isotopes. It's critically important.

Without Oak Ridge's unique facilities, including the High Flux Isotope Reactor—that's what we call HFIR—nuclear hot cells, and radiological facilities, the United States and many of our allies would have to turn to other sources, particularly Russia, to obtain many of these important isotopes.

My question is this. Would you agree that maintaining these facilities used to produce isotopes at Oak Ridge should be a priority to the Department of Energy? Would you also agree that if the United States doesn't maintain our ability to produce isotopes domestically and has to rely on foreign sources, that it could have significant national security implications? Thank you.

Dr. KUNG. Congressman, thank you for that question. We fully agree that extremely important, our role, both stable isotope and radio isotope contribute to the U.S. economic, health, energy, and national security, as you noted. And we take our responsibility and stewardship of the isotope production capability very seriously, including stewarding our facilities at Oak Ridge National Laboratories.

As you noted, we are facing a global challenge in producing these isotopes domestically, especially since the Russian invasion of Ukraine. We already are dramatically seeing that challenge further cutting into the supply, the dwindling supply of the U.S. available supply chain of these isotopes. And the DOE isotope program actually has been working on a strategy for six years. We didn't wait until the Russian invasion of Ukraine to start worrying about the isotope. In fact, we have six years of planning and getting a head start in making sure we have a strategy that really can alleviate the U.S. dependencies on these foreign sources, especially from Russia.

So with that, with the funding appropriated to Office of Science, we actually have a number of projects ready to stood up, including the SIPRC (Stable Isotope Production and Research Center), which is a—we just had a groundbreaking at Oak Ridge National Laboratory. We're making sure that these stable isotope which impacts science and technology, impact many, many important applications, including oil exploration, that we have a stable and adequate supply of stable isotopes. So this SIPRC facility will be a flagship facility when it's constructed. We're very proud of the progress it's made. Thank you.

Mr. FLEISCHMANN. Thank you very much, Mr. Chairman. I yield back.

Chairman LUCAS. Gentleman's time has expired.

The Chair now turns the gentlelady from Colorado, Ms. Caraveo, for five minutes.

Ms. CARAVEO. Thank you, Chairman Lucas and Ranking Member Lofgren, for putting this hearing together. And thank you to the witnesses for taking time to come and speak with us today.

I represent Colorado's new 8th District, and have a scientific background, though it is in medicine. And while preparing for this hearing, I really started to think back to my days in medical school and learning about the impacts of radiation exposure and in particular exposures in—at work. Obviously, a frequent exposure to radiation leads to harmful effects on the human body. And in 2018, the *Department of Energy Research and Innovation Act* was signed into law, which required DOE to reestablish a Low Dose Radiation Research Program to enhance the scientific knowledge of and reduce uncertainties associated with the effects of low dose radiation exposure.

Since then, other bills have been signed into law authorizing more specific program requirements, including authorization of appropriations through 2027. The line instructs DOE to carry out agency-specific program—an energy agency-specific program in line with underlying statute that authorizes interagency coordination mechanisms on low dose radiation via the National Science and Technology Council, specifically identifying DOE, NASA, and NSF. I was encouraged to see that the National Academies released a report which recommends a long-term strategic and priority—prioritized research agenda for DOE's Low Dose Radiation Program in response to the *Energy Act of 2020*.

So for Mr. Reuter and Dr. Kung, understanding the risk and mitigating the harmful effects of in-space radiation to human tissue is really going to be critical for human spaceflight programs and our astronauts' ability to explore deep space from the Moon to Mars and beyond. What more is needed to advance this research, and what are the unique capabilities, expertise, and/or facilities of the Department of Energy that can benefit NASA's efforts?

Mr. REUTER. Yes, thank you, Congresswoman, for that question. We certainly agree at NASA that this is one of the most critical areas of research needed in order to help us sustain a Moon-to-Mars program and then—and beyond, absolutely one of the most difficult things and challenges we have.

We work closely with DOE on this. The Brookhaven facility in particular is a great facility for us to help, and it has to be a multi-agency look at it. We also have learned a lot from our experiences on the International Space Station. It's for a long-duration stay. We've had had astronauts stay for a year, and we go through that. And then actually also then in the recently very successful Artemis 1 flight, we were heavily instrumented there to really understand the radiation effects, as the Orion capsule goes through the Van Allen radiation belts and onto the Moon.

So it's absolutely essential we do this. It's something NASA takes very seriously. It's also one of the more challenging problems, especially collected cosmic radiation and stuff of how to provide shelters and stuff as we go through it. But it's active research and one of the top risks we have.

Ms. CARAVEO. Thank you. Dr. Kung?

Dr. KUNG. Thank you. Let me just echo my colleagues. I think this is a very important topic. And we actually really value the partnership we have with NASA, as well as with National Cancer Institute (NCI). For the Office of Science, our approach has been utilizing and capitalizing our high-performance computing, and also genomics and microbiology expertise. We're actually utilizing high-performance computing, artificial intelligence, and also really exploring the big data techniques so we can assemble big data sets for us to really analyze partnering with NASA and also NCI to probe the molecular signatures of cancer associated with low dose radiation as people associate exposure and dosage across multiple available datasets.

We are currently funding a multi-laboratory team at Argonne National Laboratory that actually partnering with NCI has the benefit that they have the human health angle that we can actually tap into their perspective and expertise. And actually, as Reuter just mentioned, the NASA expertise and the use cases they have is actually providing a very rich data set for the multi-agencies to work together, and we're continuing to explore that partnership. Thank you.

Ms. CARAVEO. Perfect. Thank you, Doctor, in particular for mentioning the funding. I know that in 2010 there was a termination of low dose programs and joint projects between DOE and NASA, and so I was glad to have you touch on funding for what is going to continue to be important research.

I yield back my time. Thank you, Mr. Chairman.

Chairman LUCAS. The gentlelady yields back.

The Chair now recognizes the gentleman from Georgia, Mr. Collins, for five minutes.

Mr. COLLINS. Thank you, Mr. Chairman. As you can tell, I'm new. I'm just a small businessperson in the trucking industry, so I'd like to focus from a business standpoint and see if there's any problems or solutions.

And I understand that the exascale computers are expected to greatly enhance our ability to do things like predict weather and innovate across several industries from energy to healthcare. And I'm told the United States will have three operational computers by the end of 2024, while China will have 10 by 2025. And, Dr. Kung, is the United States or China in the lead when it comes to developing supercomputers, and what is the disparity?

Dr. KUNG. Congressman, thank you for that question. As Congressman Fleischmann just mentioned, we are the current lead in the high-performance computing. We have the world's first exascale computer. But the Chinese competitions are really fierce, and they are really chasing after us. And that's why it's very, very important that we keep up our investment in computing because computing really underpins most of the modern science and technology. But we also—I think our system really has the advantage is when we're designing these hardwares. We have the software to go with it. So these hardwares, the computers do not just stand alone. They are designed to really advance the cutting edge of science and technology so we can deploy the hardware computers but also applying them to the most challenging science and technology problems that the country is currently facing. Also, pairing was the mission space was our sister agency, not just benefiting DOE's mission but the NASA mission, the NOAA mission, USDA mission, and NSF mission.

Mr. COLLINS. So the fact that they have more doesn't mean that they're better. Is that what you're saying?

Dr. KUNG. I think quantity is one thing. Quality is another. Impact is yet another. For us, one of the challenges is the Chinese system is relatively opaque. It's kind of hard for us to really gauge except the numbers that we're seeing, the level of impact because some of the applications are military, and it's not really in the open domain. So I think our strategies, we need to run as fast as we can. So we actually are already jumping—leapfrogging the competition. So—and that—the American system is really that secret sauce. It's that open system for us to really outcompete our competitors is to have that, the best ideas, the best machines, the best application for it.

Mr. COLLINS. When you were talking about unintentional sharing, was that a reference toward China?

Dr. KUNG. To a great degree, but there are other countries that do not play with the same rules that we have with—in terms of respect for the intellectual properties. And we need to guard against not just the Chinese Communist Party but all other adversaries that do not really adhere to the same code of conduct that most of our allied countries and U.S. adhere to.

Mr. COLLINS. So what role should the government play in helping us stay in the lead and with the—as far as China? And how is that different from the private sector in what their goal is?

Dr. KUNG. So I think we can really look at it from two aspects. One is the protection. We need to make sure that we put in all the protective measures and guardrails, and that is an area of very active interagency collaboration. I may turn to my colleagues to also comment on that. There are common forms, disclosure policies that we're working on not only from the NSPM–33, but also the provisions in the *CHIPS and Science Act* that we're implementing.

In addition to the—putting in the protection measures, we're also making sure that within the Department, for example, we have a working group that are actually coordinating across not just Office of Science, but all elements in the Department that similarly for my—the sister agencies. And at the interagency level, we're also making sure that we have a clear, consistent approach because in order to maximize researchers' security, we need to have that consistency across interagency. So that is the protection part. And the promotion part is really trying to outcompete and out-innovate our competitors by really staying at the cutting edge in science and technology, and the partnership with our interagency partners are going to be key.

Mr. COLLINS. All right. Thank you, ma'am. Mr. Chair, I yield back.

Chairman LUCAS. The gentleman yields back.

The Chair now recognizes the gentleman from Illinois, Mr. Casten, for five minutes.

Mr. CASTEN. My thanks the gentleman from Oklahoma. Thanks to all our witnesses for being here. The—I am—I have to start by saying that I'm so proud of the work that this Committee did last term with the *CHIPS and Science Act,* so grateful for all of your work implementing this bill. It is truly transformative on—as industrial policy, as education policy, and I think we've got a lot to be proud of.

That said, we didn't get it perfectly right, and I want to just focus on an issue that I don't think we can resolve now, but I hope that this Committee, and particularly on the side of the Capitol, can focus on it going forward.

Dr. Jones, I don't want to pick on you, but I think you might have the closest experience to this. Are you familiar with the EPSCoR program, the Established Program to Stimulate Competitive Research? You might just——

Dr. JONES. Yes.

Mr. CASTEN. You might give us a quick overview of what its purpose is.

Dr. JONES. Well, thank you very much for that question on EPSCoR. The EPSCoR program, which many of our other agencies actually do have EPSCoR programs as well. The National Science Foundation has an EPSCoR program that really seeks to address inequities with States that have less Federal funding than some of our larger States across the country. And so it really is about competitiveness across the whole country.

Mr. CASTEN. Yes. And I think, you know, the intention of the program, I think, is good because, as we all know, there's a handful of really elite institutions that would gobble up all of our research dollars otherwise.

Coming from Illinois, which is not an EPSCoR State, if I had a university that was on the Illinois border with Iowa and another university that was on the Iowa border with Illinois, both of them serve the same rural population, neither of them are that University of Chicago tier, do I have it right that the Illinois University would not be eligible for EPSCoR, but the Iowa one would?

Dr. JONES. That is actually correct. And thank you for that question. One of the interesting things about EPSCoR jurisdictions and those institutions that actually are in EPSCoR jurisdictions, they partner with other institutions within the EPSCoR jurisdiction, but they also partner with institutions that are in non-EPSCoR jurisdictions. And they partner, of course, to deliver the best science and the most robust science for those EPSCoR projects. So it is possible that an EPSCoR award in another jurisdiction could partner with an institution in Illinois——

Mr. CASTEN. Sure, but it's not an obligation, right?

Dr. JONES. It's not an obligation.

Mr. CASTEN. So——

Dr. JONES. It's an opportunity.

Mr. CASTEN. So the concern I have—and I'm—this isn't gotcha, it's just math, and I was running through, you know, the total number of Americans in EPSCoR States versus non EPSCoR States? Again, it's not a gotcha. Sixteen million live in non-EPSCoR—in EPSCoR States. Two hundred and seventy-three million live in EPSCoR States. Do you know the number of four-year institutions between the two? It's a 2:1 ratio, 208 four-year institutions versus 529 in the non-EPSCoR States. The number of students who attend those institutions, 3.5 million in EPSCoR States, 16 million.

And so the reason I say this matters for this side of the institution is that we are the House of Representatives. We are designed to represent all American people. The only thing that EPSCoR States have more of than non-EPSCoR States is Senators.

Dr. JONES. Well——

Mr. CASTEN. Like—and like—and I'm all for making sure that we spread our research dollars around. I'm all for encouraging competition. But it is a concern that if we're sitting there saying, our purpose is to do the best science, our purpose is to implement science policy and industrial policy, our purpose is to spread that through urban and rural areas, top tier, lower tier, there is nothing in that policy that says it is important for us to get 26 Senators on board.

Dr. JONES. Well, thank you so much for that question and that perspective of the impact of EPSCoR States. It's imperative as we look at STEM careers of the future and the grand challenges of our day, we have to empower innovation and our ecosystem across the whole United States. And so while you do give some very compelling statistics, we have to ensure that citizens, students, faculty, research institutions in all parts of the United States are part of the research ecosystem. So the EPSCoR program really does seek to help enable an all-of-America approach to research innovation.

Mr. CASTEN. And so——

Dr. JONES. It's very important to the overall national strategy for sure.

Mr. CASTEN. And I agree with the intent, but again, coming from Illinois, downstate Illinois is a much more rural area than upstate Illinois where I live, right? The fact that there is not a state line between the two areas doesn't change the equity that has to be covered between those areas. And I think it's a concern we should fix, and certainly, I think us in the House should be pushing to represent the interest of the House. Thank you. I yield back.

Dr. JONES. Thank you. I appreciate your perspective.

Mr. COLLINS [presiding]. So they put the new guy in charge.

The Chair now recognizes the gentleman from Montana, Mr. Zinke, for five minutes.

Mr. ZINKE. Thank you, Mr. Chairman.

Dr. Kung, I'm a little concerned, as most of Americans are, about China. And I'm concerned about uranium, critical minerals that are being processed primarily in China and our dependency upon their supply system for ours. What is the Department of Energy doing, if anything, to look at the critical minerals array and to reduce our dependency on China?

Dr. KUNG. Thank you for that question. We absolutely share your concern about being beholden to a country who doesn't play by the same rule as the United States and the rest of the allied countries. So we're taking the supply chain of critical minerals and materials very seriously. Within the Department, there are several offices contributing to developing a critical mineral material strategy. We actually just updated our critical minerals material strategy in 2021. We identify a number of critical materials and minerals. And without—based on the level of critical supply chain issue, we are designing a whole range of R&D efforts to address them.

Speaking from the Office of Science, we're at the very low end of the TRL (Technology Readiness Level). We're primarily looking at finding alternatives and substitute for the critical minerals so we no longer are being beholden to countries such as China holding this precious supply. And that will really, really depend on us understanding what makes these critical mineral materials that behave so in their own way that make them so critical for these various important applications. So that's one thing.

And the second thing is that we really need to broaden and develop a sustained U.S.-based domestic supply chain, so that will actually require better mining, better processes of—speaking from a materials and chemistry point of view. There are a lot of advances in separation chemistry, so we can actually be able to use better mining and processes to derive even higher yield in—from the U.S. mining perspective. And these are the advances basic research and science can contribute to that. And we actually have very strong partnership with NSF and other agencies. This—there's actually a White House-led NSTC critical materials and mineral committee that are working across the different agencies to come up with a national strategy for that.

Mr. ZINKE. My understanding on the EV (electric vehicle) world alone, it would take a 2,000 percent increase of mining for 20 years to catch up to where we are today. I'd be interested in the Department of Energy's view on such things if your data matches mine.

Dr. KUNG. We'll be happy—I do not have those data in my—at my fingertips, but we'll be happy to get back with you.

Mr. ZINKE. And lastly, do you share the same concern about interception of IP property from China within your department.

Dr. KUNG. Absolutely. We believe that the protection of the American-funded R&D, we need to actually enhance our protection against those. And there are various measures that are being put in place to make sure that we safeguard the protection of the IP rights from foreign actors with intellectual property theft.

Mr. ZINKE. And are you pretty confident that will be in the President's budget, protection of——

Dr. KUNG. I know that—I do—I cannot comment on the budget, but my sense that this is a very high priority, and all parts of a department are treating this very seriously. In fact, Secretary

Granholm had put in in July of 2021 that the innovations that come out of the energy—science and energy investment need to have a substantial—need to be substantially manufactured in the U.S. even though they can be sold and utilized worldwide. So there are measures being put in place to safeguard the protection of IP but also making sure that the benefits are directly feeding into American people.

Mr. ZINKE. I look forward to seeing the President's budget. Thank you, Mr. Chairman. I yield back.

Mr. COLLINS. Thank you. The Chair recognizes the gentlelady of Michigan, Ms. Stevens, for five minutes.

Ms. STEVENS. Thank you so much. And what a delight to continue this conversation on regional collaboration, particularly on the heels of last Congress, where we were discussing some of the benefits coming out of our *CHIPS in Science* legislation. And thank you to our witnesses.

My question is for Dr. Kung. I very much appreciated your testimony. And certainly, as we're looking at regional collaboration and collaboration across government, regional being what happens at the local level, cross-government, which is exercising all of government, I wanted to ask you about some of the barriers. You specifically talked about MOUs with other Federal agencies. There was an MOU signed in 2020. Hurray, because 2020 came with its set of challenges. But as someone who has been involved in the MOU process at the Federal level, is there any improvements that we could be making or understanding? I know sometimes there's delays or complications and maybe doesn't necessarily take an act of Congress, but giving you some time to just reflect on that MOU process and where it's necessary, and maybe where it's not necessary.

Dr. KUNG. Thank you for that question. Reflecting on the MOU we recently signed with NSF, this may sound a little cheesy, but I believe collaboration and coordination is really a contact sport. We need to have very, very close contact with our agency partners to make sure that we communicate frequently, we understand where each of our mission space is, where the potential synergy, where are potential overlaps, and that really require a lot of interaction, a lot of communications. I think that is the basis—if Dr. Jones may also comment. That's really the basis of the DOE-NSF MOU. And I believe that's really a good example of how we can—not just having a piece of paper, but really having it be applicable to really make our Federal stewardship really efficient and also effective.

Ms. STEVENS. Yes, it's an intentionality, right. And if folks don't realize, I mean, where you are located and where NSF was located, you're not right next door, and you've got lots of employees who you want to be collaborating. So yes, Dr. Jones, if you wanted to also contribute.

Dr. JONES. Great, thank you. And thank you for the question. I totally agree with Dr. Kung. It's about coordination, cooperation, and collaboration. And so these MOUs, the umbrella MOU that we signed with DOE is really all about reducing barriers for us to actually collaborate——

Ms. STEVENS. Yes.

Dr. JONES [continuing]. And actually to invest better for the taxpayer, for the American taxpayer, for example, being able to share research proposals, being able to review with each other to be able to co-fund things much easier to reduce significant barriers. And so it's very important——

Ms. STEVENS. Co-funding, they don't need to come back to Congress and ask for more dollars. We'll take it. That's great.

And, Dr. Kung, we were thrilled to see the RFI (request for information) that came out of the *CHIPS and Science* legislation that your agency promoted last month, the RFI on the Clean Energy Regional Innovation Programs. And obviously, it's not your first go-around with promoting regional innovation clusters but just a chance to talk about past lessons learned, things that you're looking for, for this next round. It's certainly galvanizing our folks on the ground in Michigan.

Dr. KUNG. We are certainly very excited about the opportunity to contribute to regional innovation. We actually firmly believe that public resources should benefit the public generally, and that's really behind the regional innovation concept. And actually, from the DOE, especially from a national laboratories' point of view, we believe that our national laboratories really are the regional anchor and leader in technology innovation, and they have—they could have a lot more—they could have—contribute a lot more to the regional innovation.

Based on the prior experiences, we know that our sister program, the Office of Technology Transition (OTT), actually has very substantial experience in actually surveying the companies that involved in regional innovation. And what we have learned is that a lot of these incubators are—actually may not necessarily have resources that can contribute to the traditional FOA. For example, most of our programs have FOAs, but some of these incubators, small companies, they may not even have resources to contribute and be able to be competitive in FOA. And that's actually one of the areas that the OTT program has identified. There is actually a very insightful analysis. They have confirmed that with their stakeholders. I think it's this type of lessons learned I think it's very important, as all of us grapple with the regional innovation to understand what are the barriers so we can then——

Ms. STEVENS. And as we're looking at global competition, that tech transfer point remains very important, so thank you for that contribution.

My—the rest of my questions, I'll submit for the record. Thank you, Mr. Chair. I yield back.

Mr. COLLINS. Thank you. The Chair now recognizes the gentlelady from New York, Ms. Tenney, for five minutes.

Ms. TENNEY. Thank you, Mr. Chairman, and thank you to the witnesses for your testimony today. I'm sorry I missed some of it. But I want to thank you also for holding this meeting on the Department of Energy's critical role in funding U.S. research and development, and thank you for your insight, as well as all of you and your work that you've been doing in your fields.

I'm honored to represent New York's new 24th congressional District, which includes all the remaining active nuclear plants in the State of New York. As New York State rushes to mandate a fully carbon-free grid by 2040, nuclear energy is going to be increasingly a critical player in this space. Nuclear energy is one of the few carbon-free energy sources that works regardless of the weather, which we have a lot of interesting weather in upstate New York. And that's why I strongly support the nuclear and energy research being conducted by the Department of Energy both in partnership with NASA and through its Office of Nuclear Energy (ONE).

Additionally, New York's 24th Congressional District has a strong history as the home to the Erie Canal, one of the first regions of our country to enter the Industrial Revolution, thanks to the innovations on the canal. We also have Niagara Falls at the other end, which provides us with hydropower.

I believe that we must restore American manufacturing, particularly in regions like upstate New York. The work that the DOE and NSF are doing to support advanced manufacturing is critical for our revitalization of American manufacturing, particularly in Rust Belt regions of this Northeast, like upstate New York.

And finally, New York 24 is the largest agricultural district in the Northeast, and the research that DOE and USDA do together has helped numerous farmers throughout my district by developing more advanced 21st century farming techniques.

And so I want to direct my first question to Dr. Kung and also to Mr. Reuter. In both of your testimonies, you discuss the importance of interagency research opportunities. My first question is can you just briefly tell me how the Department of Energy's Office of Nuclear Energy and NASA has worked together on advancing nuclear technologies benefit the future of nuclear energy? If you could just give me a real quick capsule summary, both of you.

Dr. KUNG. My remarks will be very brief. I'm from the Office of Science. But from my understanding, we have a lot of great work in the Office of Nuclear Energy, especially in preparing the space power that Mr. Reuter has talked about. And that's really a decade-long partnership by providing NASA with a power source so they can venture into Mars and beyond.

So with that, I'm turning over to Mr. Reuter.

Mr. REUTER. Yes, and thank you, Congresswoman. It's very accurate. We think nuclear systems in development in space is critical to our exploration needs as we go to the future. We work very closely with the Office of—ONE to help develop the systems as we go through it for both power and propulsion. One of the critical first steps is a power system on the Moon, where we do have—we experience long times with—a couple weeks without any solar power and stuff. And what—and so for us, the critical needs that we get fulfilled by the Department of Energy include indemnification, subject matter expertise, test facilities that are really critical to us. They really were—it's really part of a team that works together for this. And so it's critical for us as we go forward.

Ms. TENNEY. Well, let me ask you that now since I know one of the—my colleagues, a new colleague is a former nuclear submarine officer, and my former husband is a former nuclear submarine officer, and I see them as sort of modular nuclear plants in and of themselves. Can you discuss how NASA's space nuclear technologies can help benefit the small modular nuclear technology? And is that something we can see as a reality for the future in providing our energy needs, particularly in places like New York, where we're doing this race to carbon-free existence and with such a great need right now with about, I don't know, 30 percent of our power grid is still coal-based?

Mr. REUTER. Yes, you're right. There's actually—there's a very strong connection between the things we want to do in space and having a modular reactor applied. In each case, the basic fundamental requirements are very similar. The power levels aren't that much different. There—it's a bit higher for the ground applications than what we want, but they're in the ballpark for each other. The transport—ability to transport, ability to set up local networks and stuff like that with power grids stuff, it's all really very common. The basic technologies of making these reactors work is very similar between them. And so for us—we have a bit—and both of us have driving requirements to get the system down in size because it needs to be transportable and so that kind of restricts it on the ground and for us to be able to land on the Moon or launch it, then it's got to be a certain size, too. So for us, all those things are related. The basic technologies are things—moderator blocks and other things are very similar between them.

Ms. TENNEY. Well, let me ask you something. So this is a very feasible type of technology that we can use in a more expanded way, in an industrial way. What about the cost and the safety issues that have been raised on this issue? Is that something that we—that NASA and our Energy Department can work together in making those——

Mr. REUTER. Yes——

Ms. TENNEY [continuing]. Something that would keep the public positive about those issues?

Mr. COLLINS. Would the gentlelady suspend for a minute? The clock had stopped and restarted and stopped and restarted, so if you could finish up your question and answer pretty quick, and then we'll move on. Thank you.

Mr. REUTER. OK.

Ms. TENNEY. Oh, OK.

Mr. REUTER. All right.

Ms. TENNEY. Keep—can you tell me how much time I have? None? OK. It said five minutes for a long time, so I figured you gave me a—this is part of the nuclear technology we're going to have. Like we stopped the clock.

Mr. COLLINS. I told you that a new guy was in charge.

Ms. TENNEY. I look younger already, right?

Mr. REUTER. Thank you. And if I'm allowed to answer the question, would you repeat it, please? I forgot it.

Ms. TENNEY. Yes, I was just—it was about the safety and the——

Mr. REUTER. Oh, safety, yes.

Ms. TENNEY [continuing]. And the affordability——

Mr. REUTER. Affordability of the—yes.

Ms. TENNEY [continuing]. Of having modulars, nuclear technology.

Mr. REUTER. Look, we treat the safety of these reactors very seriously. The good thing about this is for us in a—in an environment for space, we don't have to activate the reactor until we get to orbit and in a particular orbit that's far away from any ground systems. There's lots of research we've done in terms of fault-tolerant—managing faults and responding to it. And the KRUSTY (Kilowatt Reactor Using Stirling Technology) reactor that we did with DOE back in 2018 demonstrated several of those technologies. Cost is something, as we get multiple uses for it, it will come down. It's certainly a very expensive proposition now, but I think, especially in the modular reactor area with all the work that's going on, we can make real strong advances there.

Ms. TENNEY. Thank you so much. I yield back. And I wanted a question for Mr. Jones—or Dr. Jones about Micron, but we'll get to that next time and submit those questions for the record. Thanks so much.

Mr. COLLINS. Thank you, Ms. Tenney.

All right. The Chair now recognizes the gentlelady from Oregon, Ms. Bonamici, for five minutes.

Ms. BONAMICI. Thank you so much, Chair Collins. Thank you, Ranking Member Lofgren, and thank you to the witnesses for your testimony and your expertise. We know how important Federal agencies are to America's vital research efforts, and interagency collaboration is so critical and can really be a significant catalyst for positive advancement in research, enabling innovation, more sophisticated research than can be done by one agency alone.

Climate change, as we know, is a multifaceted challenge. It requires a coordinated effort from multiple agencies, and I'm going to focus on the partnership between DOE and NOAA and the valuable opportunities there. NOAA's climate trends and environmental conditions data can inform a Department of Energy's efforts to develop more sustainable energy sources, and Department of Energy's expertise and energy production and emissions reduction can be leveraged to support NOAA's efforts to mitigate the harmful effects of climate change.

One of the most critical aspects of this collaboration is the joint effort to keep the ocean healthy. As the co-Chair of the Oceans Caucus, it's—and a Representative of a coastal district, I care about it greatly. We know how important it is in regulating the planet's climate. As the ocean absorbs vast amounts of carbon dioxide, it becomes a more acidic, harming, as we know, marine life and ecosystems.

So I've been advocating for increased resources and support for Federal agencies tasked with implementing the response to declining ocean health, and to address this issue, DOE and NOAA are working together to develop technologies and approaches that can help mitigate ocean acidification, including research into carbon capture and storage and developing technologies to remove carbon dioxide from the atmosphere.

So, Dr. Morgan, I often speak about the importance of science communication, highlighting that there is more we can do to communicate with our constituents and the public about the investments that Congress is making in science and scientific research. And this is especially important regarding climate change. So how can interagency collaboration between NOAA and the Department of Energy be leveraged to promote public awareness and engagement on issues like ocean health?

Dr. MORGAN. Thank you for your question. And I think you really framed it nicely. The importance of the oceans and our climate system, they have a long-term memory, right? The heat that's absorbed, the net heat that's absorbed warms the oceans. The ocean is warming faster than the—on land and the atmosphere. And so part of this understanding that we get comes from the observations that we develop, that NOAA has access to through observing platforms, but also from looking at the work that DOE does with their ARM program, Atmospheric Radiation Measurement program, which allows us to better understand the processes of radiative transfer and looking at the energy budget of the entire Earth.

So it's the modeling, it's the observations, and it's the blending of those models with observations that allows us to develop a predictive capacity for understanding what the changing climate is.

We also have to make investments as well in the ocean. Ocean acidification, as you mentioned, is a very serious issue, and that's something that our—we're using modeling efforts to understand how rapidly that acidification is occurring, as well as using observations. And it's the responsibility of NOAA to make sure we can report those findings to the public. And it's the—again, the relationship, the collaborative research not just with DOE, but with NSF that does—also is invested in climate modeling, as well as with NASA, which has invested in their system modeling that really helps us develop that—I hope I have addressed your question.

Ms. BONAMICI. And Dr. Spinrad is an Oregonian of course.

Dr. MORGAN. That's correct.

Ms. BONAMICI. I know he appreciates the importance of the ocean.

Dr. Morgan, I want to follow up. In your testimony, you noted that the Department of Energy has some of the world's most powerful supercomputers——

Dr. MORGAN. That's correct.

Ms. BONAMICI [continuing]. And they can process vast amounts of data quickly. So how would allowing NOAA to use these resources to assimilate more data into their models improve accuracy and reliability? And why is it essential to have better weather forecasts? You might have heard, our in-house meteorologist Mr. Sorensen—Representative Sorensen isn't here right now, but you maybe heard from him about why is it essential to have better weather forecasts and an improved understanding of oceanic and atmospheric processes and better predictions of extreme weather events?

Dr. MORGAN. OK. Thank you. In my earlier testimony, I noticed that models to a certain extent represent our codifications of our understanding of the Earth's system. We know actually more about that system than we can actually represent due to computational limitations. So having access to really robust HPC resources allows us to better represent the processes with greater fidelity and realism, which then allows us to provide better guidance, forecast guidance to the country. Also, it allows us to increase the number of models that we can run in an operational sense because by doing that, that allows us to understand the probability, distribution of possible forecast states, so we can actually give people a greater sense of what the risks are for upcoming weather events, high-impact weather events.

So the greater resources also means that you have timely forecast dissemination and the concomitant greater lead times for high-impact weather events, including severe storms and hurricanes. Having this, you know, greater realism and the processes that we can model allows us to better understand the relationship between the atmosphere and the ocean, the interactions that we've already discussed. And again, it improves our predictive capability, which improves economic output. It improves—basically improves and makes more efficient the conduct of commerce across United States, and while at the same time, helping to protect lives and property.

Ms. BONAMICI. Sounds very beneficial. And I'm out of time. I yield back. Thank you.

Dr. MORGAN. Thank you.

Mr. COLLINS. Thank you. The Chair now recognizes gentleman from Ohio, Mr. Miller, for five minutes.

Mr. MILLER. Thank you, Mr. Chairman and Ranking Member Lofgren. It's my privilege to represent NASA's Glenn Research Center as a part of Ohio's 7th Congressional District. In northeast Ohio, we've had the privilege of watching NASA Glenn lead the way on cutting-edge technology developments. This has included taking the lead on NASA's work on nuclear electric propulsion and fission service power through the Kilopower project and others.

Mr. Reuter, you briefly referenced these sort of projects in your testimony. What role do you see advanced nuclear reactors playing in future American space travel?

Mr. REUTER. Yes, thank you, Congressman. And I will say that Glenn Research Center is a pride for us. They do an outstanding work, and they support my office very strongly, one of the best research centers we have.

Mr. MILLER. They're amazing.

Mr. REUTER. And what I'd say is the areas of advanced reactors, that's what you asked, right? I blanked out on——

Mr. MILLER. Yes.

Mr. REUTER. OK. Yes. So the advanced reactor for us is really—can be fundamentally change—foundationally game-changing for us in terms of the missions that we can enable as part of it. A large part of what we do is always—power is always king. And how you distribute that power and generate it is critical to exploration of space. We also need to have it in a compact package. And nuclear reactors are very—highly dense energy that can really help us enable new missions as we go through it.

So for us, we can—we see for the Moon where there's 14—there's 14 day-long nights, if you will, where we don't have access to solar energy, it really opens up exploration of the lunar surface as we go through it. That same technology can use—be used on Mars where on the surface of Mars with the dust storms and other things in the atmosphere, it's very difficult to get solar power. And then anything that we want to do beyond Mars and stuff, essentially, needs to utilize a nuclear source for power and stuff.

So for us, it's fundamental that the types of things we do. It can enable us to go faster around the entire solar system and open up new ways of getting there. In fact, even then, if we can do this and go much faster to the Moon and back, to Mars and back, then it can enable human exploration more as we go through it.

Mr. MILLER. Yes. So it seems as if it'd be—the only really primary function that we would have to go further than where we already are.

As a follow up question, Mr. Reuter, can you also elaborate on the importance of NASA's collaboration with the Department of Energy on the Kilopower project and other related projects, as well as the need to continue this relationship in the future?

Mr. REUTER. Yes, it's essential for us, and we really—the project you're talking about, the Kilopower project we call KRUSTY was something that was a test that we did together—coordinated together for a one kilowatt power system. And we did so at—tested at the Nevada National Security test site. We—it was a partner between NASA and DOE where we each funded our responsibilities as we went through this. We conducted this entire test, including demonstrating fault tolerance of the capabilities, transient behaviors as through it. We did that, and it worked flawlessly. And we demonstrated that for something that was less than $20 million total between the two agencies as we went through it.

So for us, that has taught us an awful lot of the things that we apply now. And now, we're looking for in a fission surface power not just a one kilowatt system, but about a 40-kilowatt system and the Moon. Glenn Research Center is our key center for leading the fission power type development as we go through this.

Mr. MILLER. Yes. Thank you. And I just want to thank all the witnesses for your time and your testimonies today. With that, I yield back.

Mr. COLLINS. Thank you. The Chair now recognizes the gentlelady of North Carolina, Ms. Ross, for five minutes.

Ms. ROSS. Thank you, Mr. Chair. And thank you, Madam Ranking Member, for holding today's hearing. And I thank our witnesses for joining us.

My district encompasses a large part of the Research Triangle Park in North Carolina. And I know the value of collaboration in advancing research initiatives that will improve the lives of so many. I specifically want to draw attention to the importance of including universities and community colleges in this collaboration. Last Congress, I worked to get several related measures included in the *CHIPS and Science Act* from securing increased NSF grant funding for community colleges to facilitating the commercial application of clean energy by universities and private companies to mandating the development of a comprehensive National Science and Technology Strategy. My priority is ensuring government agencies overseeing cutting-edge research can work with other institutions to ensure that they have the resources needed to cultivate the brilliant scientists of the future. And I appreciate hearing from you about your work to create a more effective and collaborative research environment and how Congress can support it.

My first question is on climate science and computing modeling. Across the country, severe weather events such as lengthy droughts, extensive flooding, and worsening wildfires are occurring every year. NOAA already requires extensive computing to run several different models, ocean models, as we discussed, land models, atmospheric models, and other models to develop forecasts and inform communities of such extreme weather events.

Dr. Morgan, you touched lightly in your testimony on NOAA's goal to advance its Earth systems model, a model that would put together all models and give us a better understanding of the Earth process as a whole. How important is high-performance computing to NOAA in achieving its mission, including assisting our communities in becoming climate-resilient, and weather-ready?

Dr. MORGAN. Thank you for the question. And it is absolutely critical to have the high-performance computing resources because, again, what that means to NOAA's modeling enterprise is—there's two aspects of it. If you currently look at the ratio of our research computing relative to operational computing, it's about .75 to one. We recognize that we need to put greater investments in our research and development computing facilities with ratios looking at five to one or perhaps even 10 to one. Our priorities for weather research report, which was requested by the House a couple of years ago, identified a need for a 10 to one increase in our numerical—in our research and development for numerical weather prediction.

What do we get from that investment if we had those resources? First of all, we could readily make use of the research and development computing right now if we had access to it. And what that would give us is better use of the investments that we've already made in our observing platforms. And what I mean by that is how we can get that data from the observing platforms into our models more effectively and using a greater volume of that data to help improve our forecast.

In response to an earlier question, I talked about the greater resolution of the models that allows us to resolve finer scale processes with greater fidelity. That gives us more realistic depictions of high-impact weather events that are already impacting our Nation.

Finally, making sure that we can take that data and effectively disseminate it to a broader—to the Nation is part of not just the supercomputing, but our data management aspects of this.

And the final thing I'd like to say is we're also working with DOE, as an example, with NSF and also with NOAA looking at issues related to the ability to take artificial intelligence and machine learning and have them integrated into our modeling efforts, which will speed up our ability to run the models much more quickly, which allows those results to get out so people can make decisions more effectively.

Ms. ROSS. Thank you very much. I'll try to be quick on my next one, which is on quantum information science. And we're likely to take up the reauthorization of the *National Quantum Initiative Act.* Dr. Kung, can you talk a little bit about how the Department of Energy coordinates with NIST, NSF, and other agencies to advance quantum information science?

Dr. KUNG. Thank you for that question. Quantum information science continues to be one of our highest priorities, and we really take a lot of pride in working with our sister agencies, especially NIST and also NSF. In fact, through an NSTC site committee—subcommittee on quantum information sites, we're actually cochairing the Quantum Information Science Subcommittee. We actually do a lot of cross-agency——

Mr. STRONG [presiding]. Thank you. The gentlewoman's time has expired. Thank you.

I'd like to call for a five-minute recess. We'll reconvene at six minutes after 12.

[Recess.]

Mr. STRONG. We'll call our meeting back to order. I'd like to call on Mr. Williams from New York and recognize him for five minutes.

Mr. WILLIAMS. Thank you, Mr. Chairman. I look forward to working with you. I'm way over here in the corner. I'm not sure what I did, but I'm over here in the corner.

I just have a series of informational questions. I don't think any of them are controversial. But what's the total DOE funding for the science programs sort of in your world? What's that total budget?

Dr. KUNG. Our annual budget in Fiscal Year 2023, it's about $8 billion, slightly over $8 billion.

Mr. WILLIAMS. And I noticed in your testimony that one of the components of your mission is national security. Can you tell me more about how your office fulfills that national security mission?

Dr. KUNG. It's a shared mission across the whole department. We have a National Nuclear Security Administration (NNSA) part, which is the primary office that—our Administration, the part of the Department that is stewarding the national security mission. But we have very broad and deep collaboration across the Department to make sure that we're also supporting the national security part of the mission.

One example I can give is that for a lot of the material qualifications, the requirements needed by the NNSA, we're actually devoting part of our light sources to help characterize and qualify some of these materials. So there are a lot of these cross-fertilization of pooling our resources together so NNSA does not need to support a standalone light source. Instead, they can come to the light sources that Office of Science support to help serve their needs.

Mr. WILLIAMS. Are there any other—other than supporting NSA are there any other things that come to mind that specifically are equated with supporting the national security priorities other than materials, which I've been a customer of those, so I know what those are?

Dr. KUNG. Right. So if we look at the emerging technologies, all of them have a national security component, from quantum information science to artificial intelligence, even biotechnologies, all of them. So from a fundamental science point of view, we're providing that science underpinning. Hopefully, the knowledge and the innovation can then be translated to support the Department's national security missions.

Mr. WILLIAMS. Those are good examples. Quantum, I think you said digital intelligence, biomaterials. Are there any specific programs or a laundry list of programs that I should be—that all of us should be aware of that come to your mind specifically that have national security emphasis or priority?

Dr. KUNG. Yes, I believe the list is—could be quite long. If it's OK, if we could get back with you with a more comprehensive list.

Mr. WILLIAMS. Certainly. Beyond the material and supporting NNSA, when the DOE hands out grants, and specifically the science programs just because that's your purview, when they hand out or make awards and grants, what factor or what weighting does meeting the national security priorities—how does that come into play for those awards, particularly in—where they're competitive?

Dr. KUNG. So our grant selection process follow a set of review criteria that's codified in our 10 CFR (Code of Federal Regulations) 605. It has scientific merits as the—No. 1, there's—we look at the performance qualifications, their expertise, the budget. They propose whether they're reasonable, whether—also the relative expertise and instrumentation setting they have, whether these are suitable to carry out these experiments or proposed research they propose.

Mr. WILLIAMS. Sure.

Dr. KUNG. All of these are our standard criteria for evaluating the merits of the grant. But for given topics, we can also put in additional program policy factors. For example, quantum information science would be one that we may be looking at potential broader applications and so forth. So given the topical areas of the research, we can then broaden the lens of the review criteria, especially addressing potential dual use of example topics such as——

Mr. STRONG. Thank you. The gentleman's time has expired. Thank you, Mr. Williams.

The Chair recognizes Mr. Sorensen of Illinois for five minutes.

Mr. SORENSEN. Thank you all for being here. I have spent the majority of my career in STEM as a broadcast meteorologist in northern and western Illinois. Much of what I accomplished in my career, researching and presenting weather and climate data, was only because of the collaboration between the DOE, the USDA, NOAA, NASA, and NSF. And so today, I'd like to focus on this working relationship that we have, how Congress can best facilitate and shepherd more collaboration in the future.

And my first question, I'm asking this on behalf of our farm families in northern and western Illinois, who ask me what's next after ethanol as we buy more electric vehicles? You know, last year, the DOE, along with other Federal agencies, developed the Sustainable Aviation Fuel Grand Challenge roadmap. This is a strategy for scaling up advanced technologies to produce sustainable aviation fuels. And I believe that our farmers are going to be heroes in this endeavor.

What is the status of the implementation of the roadmap? What are some of the barriers that exist, and how can we make sure that the progress continues to accelerate? And if I could ask this question to Dr. Kung and Mr. Reuter.

Dr. KUNG. Thank you very much for that question. We're actually very proud of the work the Department is leading in the sustainable aviation fuel. It really capitalizes on decades of investment across the whole department, from Office of Science, to the Energy Efficiency Renewable Energy, which is leading the Sustainable Aviation Fuel Grand Challenge. So I think building on this decades-long of really science foundation, they're able to really upgrading the biofuels in order to add functionality, efficiency, and also performance into the sustainable aviation fuel. I'm not personally involved in the roadmap, but I'll be very happy to get back with you based on my colleague's input.

Mr. REUTER. And would I would say is we do support—NASA does support the biofuel area and stuff in the production of those, and we certainly see a lot of opportunities there. We're mainly in a support role to others like DOE as we go through that.

The other thing, though, that is core to us also is zero net carbon emissions for airplanes and electrification of the—of propulsion system and batteries and stuff. And there, we do play a very active role, and we have a lot of activities going on to a demonstrator vehicle.

Mr. SORENSEN. Thank you so much.

Dr. Morgan, there have been proposals to separate NOAA from the Commerce Department. Could you tell me some of the drawbacks or some of the benefits? Should NOAA become an independent agency and whether or not you support this move and whether or not this meteorologist now in Congress should do the same?

Dr. MORGAN. Thank you for your question. That's—there's a lot to unpack in that in terms of the separation of NOAA from the Department of Commerce. I mean, as has been mentioned earlier in my earlier testimony, the work that NOAA does, does have—does inform how the conduct of commerce is actually done in the United States, in fact, and, frankly, globally in terms of our ability to produce highly accurate forecasts that allow for ship routing, for transportation, et cetera, to be done effectively.

I think one of the big questions that has to be asked in any possible change to NOAA's authorization really has to focus on what are we as an agency fundamentally authorized to do? What are the capabilities that we would have when that actually is—if that were realized? I think where we sit certainly is important, but I don't—I'll be frank, I don't have a direct answer to your question on what that looks like. But I think the key thing is ensuring that NOAA has the authorities it has to conduct its current mission and perhaps future missions that are going to benefit the American public in terms of science, stewardship, and service, particularly as it relates to the Earth's system. That's going to be really critical.

Mr. SORENSEN. And I—my final question, as a meteorologist who spent his life on television, my constituents know that when a big snowstorm is coming that Eric Sorensen looks at the European computer model. That's the accurate one, right? It should be the global forecast model. It should be our model. How can I as a meteorologist in Congress, how can we work together to increase the accuracy so that our lives can be protected and people can make the right decisions during severe weather?

Dr. MORGAN. Sir, I'm a weather enthusiast. I often use the term weather weenie.

Mr. SORENSEN. I love it.

Dr. MORGAN. That's never been said in the halls of Congress. But I think what's really necessary is ensuring we have the high-performance computing. It's also essential that we make significant investments in atmospheric and basically coupled data simulation for the system to make the full use of the observations that we have.

And we have, again, the computing to allow us to look at an ensemble of forecast. I look at the GFS (Global Forecast System). The last couple of weather systems that have gone through the United States, GFS——

Mr. STRONG. The gentleman's time has expired. I'm sorry. The gentleman's time has expired.

Mr. SORENSEN. Great. I yield back.

Mr. STRONG. Thank you.

Next is Mr. Kean from New Jersey. You'll be recognized for five minutes.

Mr. KEAN. Thank you. Thank you, Mr. Chairman. I would like to thank all the witnesses for being here today and their testimony.

It's vitally important that DOE maintain and improve their collaboration with other key Federal agencies such as NASA, NOAA, USDA. It is only through the efficient collaboration between these agencies that, again, the DOE ensure that providing America's security and prosperity by addressing its energy, its environmental, its nuclear challenges through innovative science and technology solutions.

Dr. Kung, how is the Department of Energy uniquely qualified to provide leadership in U.S. biological science, research, and development activities?

Dr. KUNG. So thank you for that question. As mentioned earlier, many parts of the Department actually have expertise and capability in biological science and technology. Speaking from the Office of Science where I'm sitting at, we have decades-long of expertise and support for biological and environmental science and actually grew out of our health science roots. The—but the biology currently is actually deeply rooted in our genomic science and also very high-fidelity model that we can actually use to predict and model biological organisms from both energy point of view, but also just providing that broad base of biological science.

So—and I'm working between Office of Science and the technology programs such as the ones in our Office of Energy Efficiency and Renewable Energy. We are really pairing our expertise and capability together to deliver the Department's mission in bio-related technology. And we are working together, along with our sister agencies, implementing a recent Executive order on biotechnology, biomanufacturing, a really exciting frontier, not only with our NSF and USDA partners, but across the whole agency. We're addressing transportation fuels, aviation fuels, even using bio as a way of decarbonizing at a land scale. So we're—my own opinions are we're very uniquely situated based on our past capability, core competency, but also future opportunities.

Mr. KEAN. And the multiagency partnerships you just talked about that are in concordance and as we approach our national priorities such as during the COVID–19 crisis, how is the DOE's National Virtual Biotechnology Laboratory (NVBL) serve as the mechanism to provide a number of agencies like the FDA (Food and Drug Administration), the CDC (Centers for Disease Control and Prevention), DOD, with access to DOE research capabilities?

Dr. KUNG. Thank you for that question. NVBL is really the pride and joy of the Office of Science that we stood up when the crisis of COVID–19 hit. This is really an excellent model that in a very short period of time we were able to marshal all the resources, expertise from all 17 of DOE's national laboratories and really capitalize on the expertise, for example, in materials, in chemistry, in biology, and also high-performance computing to be able to address some of the key challenges. For example, by using materials, we actually are addressing supply chains from respirators to fibers that go into the KN95, N95 masks. But also using our light sources, we're actually able to decipher the very detailed structure of the virus so we can then design countermeasure such as antiviral drugs and vaccines.

But lastly, our high-performance computer has been so powerful, they actually can do the epidemiologic modeling to inform policymakers in terms of emergency response or also whether to close schools or bars. I think that is really an excellent example of interagency partnership, working across different agency, pooling the resources capability together in the moment of national crisis, so we're very proud of that example.

Mr. KEAN. OK. Thank you. Dr. Jones, given the challenge from China and from other adversaries, should the NSF be partnering with strategic allies on science and technology research? And if so, what policies are necessary to facilitate those partnerships?

Dr. JONES. Great, thank you very much for that question. So science is a global endeavor, and so we do look to be part of the global research environment. Submitted in our testimony, for example, would be the LHC, Large Hadron Collider activity where DOE and NSF partner in a very——

Mr. STRONG. Thank you. The gentleman's time——

Dr. JONES [continuing]. Very important international——

Mr. STRONG [continuing]. Is expired. I'm sorry. The gentleman's time has expired. The Chair——

Mr. KEAN. And if I—can you follow up—send that response in writing, please?

Dr. JONES. Yes.

Mr. KEAN. Thank you.

Dr. JONES. Yes.

[The written response of Dr. Jones follows:]

The NSF is focusing on international partnerships with likeminded countries based on the principles of transparency, reciprocity, merit-based competition, and openness to the extent possible. NSF together with NIH represented the United States on the G7 Security and Integrity of the Global Research Ecosystem group. Through this effort, the G7 developed research security and integrity principles and best practices. NSF also participated in the OECD Global Science Forum effort on research security and integrity to develop international approaches to research security and integrity. NSF begins its international partnerships by developing agreements with the international partner that outlines the principles by which the collaboration will occur, meaning outlining clearly what each partner is contributing, how data will be shared and distributed, and the roles and responsibilities of each partner. These principles are then reinforced in the management plan for the international collaboration program. To ensure that NSF appropriately reviews proposed projects for national security implications, NSF has announced in its draft 2024 policy guidance that it is developing a risk rubric where proposals will be returned without review if there is a high national security risk according to the rubric.

Mr. KEAN. Thank you, Chairman. I yield back.

Mr. STRONG. Thank you, sir.

The Chair now recognizes Mr. Tonko of New York for five minutes.

Mr. TONKO. Thank you to both Chair Lucas and Ranking Member Lofgren for hosting this important discussion. And thank you to the witnesses. You're a distinguished panel, and it's great to hear from you.

The U.S. R&D ecosystem is directly responsible for the security and prosperity that Americans enjoy today. When leveraged correctly, the most incredible scientific discoveries and technological innovations emerge directly out of our Federal research agencies. This is especially important as international competition grows and the climate crisis intensifies. What we do today will determine whether we are still leaders on the global stage tomorrow.

So I recognize the essential role that DOE plays in this and sought to tap into its unique technical expertise with my *Micro Act,* a bill that was included in the *CHIPS and Science* package last Congress. With over a half a billion dollars in new investments, the *Micro Act* will leverage DOE's world-renowned national labs and their partners in industry and academia to tackle foundational challenges in the microelectronics R&D effort.

So with that being stated, Dr. Kung, can you talk about DOE's role in the broader microelectronics R&D enterprise?

Dr. KUNG. Thank you so much for that question. DOE actually has a long history of supporting microelectronics, both as a consumer because some of our world-leading supercomputers are actually based on the cutting-edge microelectronics. But we're also an engine of innovation contributing to the innovation of microelectronics. For example, the most advanced EUV (extreme ultraviolet lithography) technology that we're currently using to produce the smallest gauge of the microelectronic is developed—was developed by a joint partnership among several DOE laboratories. So we feel like we are a essential contributor to the extremely exciting but also challenging situation with the microelectronics in terms of the leading edge in technology development but also in addressing the supply chain.

And we also believe that microelectronics is such an area that is really requiring a whole-of-the-government approach because different agencies were actually bringing different pieces of expertise and capabilities together. And I really appreciate the *CHIPS and Science Act* that passed and authorized the Department on being able to further contribute to the cutting edge of microelectronics, being the—for example, the microelectronics center being authorized in the *Micro Act.* We believe this is the right type of model for us to really co-design from the very bottom of materials all the way to application, hardware, and the whole infrastructure be able to design the next generation of microelectronics. So thank you for that question.

Mr. TONKO. Oh, thank you. And, Dr. Jones, in your testimony, you talk about the importance of long-lasting partnerships with industry to meet the challenges of today and tomorrow. Can you explain to us more about the TIP Directorate and the potential programs and partnerships with private companies to develop the transformative solutions to semiconductor manufacturing challenges?

Dr. JONES. Great, thank you so much for that question. And we're very grateful for the support of the National Science Foundation in establishing the Technology Innovation Partnership Directorate. It's actually the first directorate created in 31 years. And so we're very, very grateful for the support of Congress to establish the new directorate.

Translational innovation is actually part of the DNA within NSF. It always has been. But with this new directorate, we will be able to partner with entities like other Federal agencies but also industry to translate fundamental basic research at a much faster pace and at a much larger scale than what we have done before. So our new directorate has already been very successful at forming new partnerships with industry, such as our Intel partnership and Micron partnership, looking at semiconductor workforce issues, as well as leading the way with our Engineering directorate on our FuSe (Future of Semiconductors) solicitation, again, looking at semiconductors where we're partnering with four industry partners already, Ericsson, Samsung, Intel, Micron as well. And so we're very, very proud of the equities that we'll be able to do through this new directorate to further partner with industry.

This directorate also houses our SBIR (Small Business Innovation Research) and STTR (Small Business Technology Transfer) programs where we're able to support small businesses and those businesses then grow into larger businesses, but also partner with larger entities. In addition, this new directorate is starting a new program, the Regional Innovation Engine program, which——

Mr. STRONG. The gentleman's time has expired. Thank you, Dr. Jones.

Mr. TONKO. Mr. Chair, I had a question for Mr. Reuter, and I'll give that to the Committee in writing about aviation systems, so thank you.

Mr. STRONG. Thank you, Mr. Tonko.

The Chair recognizes himself for five minutes.

Dr. Kung, Mr. Reuter, Dr. Morgan, Dr. Jones, I want to thank each of you for coming before us today. It's been very informative.

As mentioned, NASA and the Department of Energy have held formal research partnerships for over six decades. Additionally, NASA has long history of collaboration with DOD's Defense Advanced Research Projects Agency, or more affectionately known as DARPA. Mr. Reuter, how does the most recent partnership announcement between NASA and DARPA leverage the space nuclear development that NASA and DOE has been conducting in recent years?

Mr. REUTER. Yes, yes, thank you, Congressman. What I would say is we've got a great opportunity now to advance nuclear systems in space and really revolutionize the way we travel around space and the way we operate on foreign lands. And we've been—over the last several years had a lot of joint activities with DOE in terms of developing the reactors, the fuel elements and stuff that went through that can enable these type missions at the very high efficiency that we demand. In fact, we had some starts and stops with this. We had to change technology paths and stuff, but we've gotten to the point where we're actually confident in this. So for us then, it's become a time now, let's go demonstrate this thing.

And the fortunate thing we had is—because we try to work across all agencies—DARPA has a very similar objective, a little bit different than the requirements and objectives that we have but close enough that we could work it out together. And so what we're doing is building off those—the technologies that we've been developing over the years and applying it to a joint development, primarily between us and DARPA, for the next—for a flight demonstration. Now, DOE will still be along with that. There's still key roles for that, their critical expertise as we go forward.

Mr. STRONG. Thank you. It's my understanding that the Fiscal Year 2023 President budget was the first time a line item was included for these developments. Would you say, Mr. Reuter, that for NASA to be successful in the Moon-to-Mars mission and for DOD and DARPA to be successful in cislunar space that continued support and growth for space nuclear is necessary?

Mr. REUTER. Yes, absolutely. I think space nuclear systems are fundamental to us achieving the objectives for Moon to Mars.

Mr. STRONG. Thank you. How would this partnership accelerate development of human transport to Mars?

Mr. REUTER. Well, what we're doing—looking at this, I view this as kind of an experimental vehicle if you will. It's the first step. You got to take a big step, and getting something that's actually flying and operating in a relatively short timeframe over the next few years is something that can get—put us on a path and then the next step will be just achieve the actual requirements and go on toward other distant—Mars and beyond.

Mr. STRONG. Thank you. I'll reclaim my time. And the Chair recognizes Ms. Salinas of Oregon.

Ms. SALINAS. Thank you, Mr. Chair. And thank you to the panelists. I apologize for not being here for your oral testimony, but I did review your written testimony.

Dr. Kung, billions of dollars are spent each year in the United States on agriculture, food research and development, but a lot of this is focused on food product manufacturing, crop protection, and food safety, all worthy and valuable. But relatively little is spent on climate mitigation and breakthrough technologies that really have the potential to radically change the impact of our food systems. What forms of innovation policies are needed to deploy future agricultural technologies to decarbonize the sector?

Dr. KUNG. Thank you so much for that question. Actually, that is one of our major priorities and emphasis is really utilizing our biotechnologies and expertise to decarbonize the agriculture is one of the aspects that we are looking into. I have just mentioned that the Executive order on biotechnology and biomanufacturing was just released September 2022. Multiple agencies are coming together in terms of furthering the societal goals for climate change solutions. There are four aspects. There are four kind of bold goals. One is to address the need to develop more carbon-neutral transportation stationary fuels. The second is to use biotechnology to produce chemicals materials from renewable biomass. And the third is climate-focused agriculture systems and plants. And the fourth is the carbon dioxide removal really from the landscape scale of removing carbon dioxide out from the agriculture sector. So we are laser focused on these very important issues and look forward to providing additional information as the plan comes together.

Ms. SALINAS. Thank you. And I'm going to dive a little bit deeper. Our Nation's centralized freshwater infrastructure is deteriorating due to climate change and other factors. Water, food, and energy form a nexus at the heart of sustainable development with agriculture as the largest consumer of the world's freshwater resources. And this really speaks and goes to the complexity at the energy water nexus and demand for a Federal coordinated approach. How does DOE partner with USDA to decarbonize the ag sector with a focus on that nexus between food, energy, and water?

Dr. KUNG. I am not the right expert to address the question. I do understand that the Department has a very active energy-water-food nexus activity. So if it's OK, we'll get back with you based on the experts from the Department.

Ms. SALINAS. Thank you. And then just, again, following up a little bit in kind of the same agriculture question and maybe a little bit more general and higher level. How should our Federal Government ensure that an integrated and sustainable management of water, food, and energy is balanced with the needs of people, nature, and the economy?

Dr. KUNG. Again, I think I would defer to the experts in the Department to answer. I do agree that's a very important question and important issue.

Ms. SALINAS. Thank you. OK. And then turning to—since I do have a couple minutes left—to DOE's Bioenergy Research Centers. What do you see as the central role of the BRCs within the spectrum of bioenergy technology and development? And how is this research vital to the mission of DOE?

Dr. KUNG. In the—I really liked the way that you're framing this, the spectrum. So on the BRC, which is funded by the Office of Science side, we're very mindful. We're focusing on the lower Technology Readiness Level, really addressing the knowledge gaps that are really preventing us to really deriving the maximum benefit from renewable biomass. And that knowledge really need to be able—we need to be able to translate any of the innovation to the technology progress so they can then develop that commercial technologies.

I mentioned earlier about the BRC partnership with USDA. This is really an excellent way of really combining the biotrays that we're trying to engineer and insert that function into the plants was the USDA, where they're coming from, the agriculture, the land and the water usage. So this is really an excellent example—I gave earlier a pennycress example, as—but I think there are multiple example not only from Office of Science but also from the Technology Office. We will be happy to provide additional information to you.

Ms. SALINAS. Thank you so much, and I yield back.

Mr. STRONG. Thank you, Ms. Salinas.

The Chair recognizes Mr. Mullin of California. Mr. Mullin, you're recognized for five minutes.

Mr. MULLIN. Thank you, Mr. Chair. Thank you all for your testimony.

I'm from the San Francisco peninsula. California has been experiencing a long drought cycle, interrupted by a very wet winter. Even as we speak, we're bracing for an apparently relatively warm atmospheric river. We're concerned about snow melt and flooding and so forth. So we're sort of living the extremes when it comes to climate. And, fortunately, FEMA (Federal Emergency Management Agency) has been engaged.

So my question is with Dr. Morgan. And just can you describe how you partner with the agencies not represented here like FEMA, like HUD (Department of Housing and Urban Development)? You know, we have these communities that are—their infrastructure is simply not equipped to deal with the volume of water that we're seeing, and just how you share your models so groups like—entities like FEMA can get ready for these megastorms and abnormal events that can affect our communities and just what kind of collaboration and coordination with the other entities so we can get ready and brace appropriately for what might come?

Dr. MORGAN. Yes, thank you for your question. And I think I'm going to ensure that a more complete response is given to you in some questions for the record. But as we anticipate significant weather events, Weather Service offices located all around the country, we've been focusing—let me back up, NOAA has been focusing on impact decision support services. And what this means is forecasters at individual forecast offices are prepared to go to emergency management centers within States' Federal Emergency Management to relay the information and the likely impacts of high-impact weather events are going to have on communities all across the country. So I imagine that there are currently meteorologists in the Monterey forecast office and other ones, Reno area as well, that are looking at the upcoming event with this relatively warm atmospheric river and the likelihood of significant snow melt, which may lead to flooding, and they're beginning to prepare folks for that—for this inevitability or this likelihood—excuse me—of significant flooding. So we have meteorologists that are basically deployed within particular emergency management offices to basically convey this information. But we also make use of social media. We make use of, you know, all ways of contact to make sure that our communities are well aware of upcoming significant weather events.

Mr. MULLIN. I appreciate that, sir, and thank you for that. That is reassuring. And I look forward to getting more information about that ongoing coordination because this will be a—clearly an ongoing challenge for all of us. So thank you, sir.

Dr. MORGAN. Sure.

Mr. MULLIN. And I yield back.

Mr. STRONG. Thank you, Mr. Mullin.

I want to thank each of the witnesses for their valuable testimony and for the Members for their questions. The record will remain open for two weeks for additional comments and written questions from Members.

With no further questions, this meeting is adjourned.

[Whereupon, at 12:40 p.m., the Committee was adjourned.]

Appendix I

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Harriet Kung

U. S. House of Representatives Committee on Science, Space, and Technology
March 8, 2023 Hearing
Innovation Through Collaboration: The Department of Energy's Role in the U.S. Research Ecosystem
Questions for the Record Submitted to Dr. Harriet Kung, Deputy Director for Science Programs in the Office of Science

QUESTIONS FROM REPRESENTATIVE BILL POSEY

Q1. With China controlling more and more of the global supply chain of critical minerals and materials, does the Dept. of Energy consider this a serious threat to the national security of our nation?

A1. Geographic concentration of supply chain capabilities represents a key vulnerability for several critical minerals and materials important to energy. This is a consistent finding from the reports issued in response to Executive Order 14017.[1,2] Onshoring and friendshoring critical minerals and materials advances our national security interests consistent with E.O. 14017. In tandem with its sister agencies, DOE seeks to invest in critical and emerging technologies that would reduce dependence on foreign supply chains. DOE's Critical Minerals and Materials Strategy is based on mitigation approaches that include:

- Diversify and expand supply to ensure materials are available,
- Develop alternatives to reduce reliance on critical materials where possible,
- Efficient use and manufacture of material to minimize waste generation, and
- Circular economy approaches to extend the lifetime of materials and partially offset the need to extract virgin materials.[3]

DOE signed a Memorandum of Agreement with the Department of Defense and Department of State to develop a critical minerals stockpile for minerals which enable clean energy technologies in February 2022 as part of Mandate 26 under the International Energy Agency Critical Minerals Working Party.

Q1. With China controlling more and more of the global supply chain of critical minerals and materials, does the Dept. of Energy consider this a serious threat to the national security of our nation?

[1] https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf
[2] https://www.energy.gov/policy/securing-americas-clean-energy-supply-chain
[3] https://www.energy.gov/critical-minerals-materials

U. S. House of Representatives Committee on Science, Space, and Technology
March 8, 2023 Hearing
Innovation Through Collaboration: The Department of Energy's Role in the U.S. Research Ecosystem
Questions for the Record Submitted to Dr. Harriet Kung, Deputy Director for Science Programs in the Office of Science

Q2. What is the Dept. of Energy's Office of Science's policy and commitment to establish a domestic supply of these minerals?

A2. DOE's Critical Materials Research, Development, Demonstration, and Commercialization Application (RDD&CA) Program spans basic science to applied research and development, to deployment and commercialization (https://www.energy.gov/critical-minerals-materials). This Program is coordinated by a team representing 17 DOE Offices, including the Office of Science, that are committed to implementing DOE's Critical Minerals and Materials Vision to:

- Build resilient, affordable, diverse, sustainable, and secure domestic critical mineral and materials supply chains;
- Support the clean energy transition and decarbonization of the energy, manufacturing, and transportation economies; and
- Promote safe, sustainable, economic, and environmentally just solutions to meet current and future needs.

The Office of Science (SC), primarily through the Basic Energy Sciences (BES) program, supports basic research to advance the understanding of fundamental properties of a variety of critical minerals and materials, with the goals of developing methodologies to enhance their extraction and processing, reduce their use, and discover substitutes. Close coordination across the Department, as described above, ensures that advances in basic science are translated to applied research and technology development and that the evolving technology landscape is considered in the priority directions for the SC portfolio. SC's continued support for this fundamental research provides the foundation for robust and reliable domestic supply chains for key energy technologies and helps to reduce our reliance on foreign sources.

Q3. How much has the Dept. of Energy spent on critical minerals research in the last ten years?

U. S. House of Representatives Committee on Science, Space, and Technology
March 8, 2023 Hearing
Innovation Through Collaboration: The Department of Energy's Role in the U.S. Research Ecosystem
Questions for the Record Submitted to Dr. Harriet Kung, Deputy Director for Science Programs in the Office of Science

A3. Following the publication of DOE's Critical Materials Strategy in 2010, DOE has invested in basic research and applied research and development related to critical minerals and materials, expanding those efforts to include pilot and demonstration efforts in 2020. This includes the Critical Materials Institute, an Energy Innovation Hub which was launched in 2013 and led by Ames National Laboratory. The Institute represents a $220 million investment over the last ten years. The table below represents the Critical Minerals and Materials Budget Crosscut in recent years. Investments from FY 2019 to FY 2023 total more than $1 billion, and DOE was directed to spend no less than $266 million on critical minerals and materials in FY 2023. Beyond these annual appropriations, the Bipartisan Infrastructure Law (BIL) has significantly expanded DOE's investments to include large demonstration and deployment activities, with over $8 billion of critical minerals and materials related provisions.

For example, DOE's Office of Manufacturing and Energy Supply Chains announced selections totaling $2.8 billion through BIL 40207 to support new, retrofitted, and expanded commercial-scale domestic facilities to produce battery materials, processing, and battery recycling and manufacturing demonstrations.[4]

Critical Minerals and Materials

Funding by Appropriation and Program Control ($K)[5,6,7]

	FY19 Enacted	FY20 Enacted	FY21 Enacted	FY22 Enacted	FY23 Enacted	FY24 Request
Advanced Research Projects Agency – Energy (ARPA-E)			13,653	66,125	TBD	TBD

[4] https://www.energy.gov/mesc/bipartisan-infrastructure-law-battery-materials-processing-and-battery-manufacturing-recycling
[5] https://www.energy.gov/sites/default/files/2023-03/doe-fy2024-budget-volume-2-crosscutting-v3.pdf
[6] https://www.energy.gov/sites/default/files/2022-05/doe-fy2023-budget-volume-2-crosscutting.pdf
[7] https://www.energy.gov/cfo/articles/fy-2021-budget-justification

U. S. House of Representatives Committee on Science, Space, and Technology
March 8, 2023 Hearing
Innovation Through Collaboration: The Department of Energy's Role in the U.S. Research Ecosystem
Questions for the Record Submitted to Dr. Harriet Kung, Deputy Director for Science Programs in the Office of Science

ARPA-E Projects*			13,653	66,125	TBD	TBD
Energy Efficiency and Renewable Energy	49,282	104,200	104,000	112,523	157,900	206,087
Advanced Manufacturing Office (AMO)			45,000	47,000	26,000	-
Advanced Materials and Manufacturing Technologies Office (AMO successor office)			-	-	-	50,000
Geothermal Technologies			4,000	50	3,000	2,787
Hydrogen and Fuel Cell Technologies			25,000	30,000	30,000	22,000
Solar Energy Technologies			-	-	16,000	8,000
Vehicle Technologies			30,000	34,000	73,700	96,500
Wind Energy Technologies			0	1,473	9,200	26,800

U. S. House of Representatives Committee on Science, Space, and Technology
March 8, 2023 Hearing
Innovation Through Collaboration: The Department of Energy's Role in the U.S. Research Ecosystem
Questions for the Record Submitted to Dr. Harriet Kung, Deputy Director for Science Programs in the Office of Science

Fossil Energy and Carbon Management	18,000	23,000	23,000	23,000	44,000	41,000
Mineral Sustainability			23,000	23,000	44,000	41,000
Nuclear Energy	-	-	59,500	61,500	136,500	131,500
Fuel Cycle Research and Development			58,500	60,500	136,500	131,000
Nuclear Energy Enabling Technologies			-	1,000	-	-
Office of Technology Transitions			100	100	-	-
Science	20,000	20,000	17,000	25,000	25,000	25,000
Basic Energy Sciences			17,000	25,000	25,000	25,000
Total	**87,282**	**147,200**	**217,253**	**209,623**	**363,400**	**403,587**

*ARPA-E funding is determined annually based on programs developed through office and stakeholder priorities. Therefore, funding for FY 2023 and FY 2024 is not available currently.

Q4. How many commercial critical minerals and materials production facilities have resulted from these expenditures?

A4. DOE's investments have resulted in several pilot plants and planned commercial facilities that are validating innovation technologies to recover, recycle, and refine critical materials.

- The Office of Manufacturing and Energy Supply Chains (MESC) announced selections of 21 projects that support new, retrofitted, and expanded commercial-scale domestic facilities to produce battery materials, processing, and battery recycling and manufacturing demonstrations.[8] These projects are projected to result, by 2030, in the production of up to 50,000 metric tons of lithium precursors, 75,000 metric tons of nickel precursors, 110,000 metric tons of graphite, 8,000 metric tons of silicon material, and 40,000 tons of battery critical materials-containing black mass via recycling to feed domestic battery critical material demand.

- The Office of Fossil Energy and Carbon Management (FECM) and MESC announced selections for front-end engineering design studies for the Rare Earth Element Demonstration Facility.[9]
- The Critical Minerals Institute has generated several innovative technologies to recover critical materials from mine tailings and electronic waste that are currently being validated through pilot plants or commercialized in partnership with industry.[10,11,12,13]
- The Office of Energy Efficiency and Renewable Energy (EERE) awarded two projects in 2021 focused on demonstrating improved industrial methods to produce refined lithium and rare earth elements to support U.S. manufacturing of clean energy technologies.[14]

---

[8] https://www.energy.gov/mesc/bipartisan-infrastructure-law-battery-materials-processing-and-battery-manufacturing-recycling
[9] https://www.energy.gov/articles/biden-harris-administration-invests-16-million-build-americas-first-kind-critical-minerals
[10] https://www.riotinto.com/en/news/releases/2021/Rio-Tinto-achieves-battery-grade-lithium-production-at-Boron-plant
[11] https://www.energy.gov/sites/default/files/2022-07/h2-mach-21-lister.pdf
[12] https://www.ameslab.gov/news/green-rare-earth-recycling-goes-commercial-in-the-us
[13] https://builtin.com/dallas-fort-worth/momentum-technologies-secures-20m-121621
[14] https://www.energy.gov/eere/ammto/advanced-manufacturing-office-fy20-critical-materials-foa-selections

U. S. House of Representatives Committee on Science, Space, and Technology
March 8, 2023 Hearing
Innovation Through Collaboration: The Department of Energy's Role in the U.S. Research Ecosystem
Questions for the Record Submitted to Dr. Harriet Kung, Deputy Director for Science Programs in the Office of Science

- FECM's investments in rare earth element and other critical minerals recovery from coal-based sources have resulted in four pilot projects to scale-up these processes.[15]
- Advanced Research Projects Agency-Energy's (ARPA-E) SCALEUP Program will commercialize critical material-free permanent magnets, leveraging past investments by DOD and ARPA-E.[16]

In addition to these research investments, the Loan Programs Office provides financing to help deploy a range of critical materials supply chain projects. Recently announced projects include a $102.1 million loan to a natural graphite processing plant in Vidalia, Louisiana, in 2022 and several conditional commitments across the supply chain in 2023, including a $2 billion conditional commitment for a closed-loop lithium-ion battery manufacturing facility in McCarran, Nevada; a $375 million loan for a battery recycling facility in Rochester, New York; and a loan of up to $700 million for a lithium processing facility in Esmeralda County, Nevada.

Q5. How can the Dept. of Energy ensure its research funds are used in a way that promotes American companies?

A5. Through DOE's competitive process, DOE restricts awards to critical minerals and materials projects to domestic entities, absent a waiver. DOE routinely encourages or incentivizes partnership with industry to facilitate accelerated technology transfer and adoption.

---

[15] https://edx.netl.doe.gov/ree-cm/
[16] https://arpa-e.energy.gov/technologies/scaleup/scaleup-2021/niron-magnetics

U. S. House of Representatives Committee on Science, Space, and Technology
March 8, 2023 Hearing
Innovation Through Collaboration: The Department of Energy's Role in the U.S. Research Ecosystem
Questions for the Record Submitted to Dr. Harriet Kung, Deputy Director for Science Programs in the Office of Science

QUESTION FROM REPRESENTATIVE JEFF JACKSON

Q1. The Center for Hybrid Approaches in Solar Energy to Liquid Fuels (CHASE), led by researchers at UNC-Chapel Hill, started in 2020 with funding from DOE's Office of Science. CHASE's research, inspired by photosynthesis, is helping figure out how to produce fuels from sunlight. Now more than 100 researchers at six institutions, including NC State University, are now working with CHASE in the development of this fundamental research. Could you elaborate on the importance of DOE's continued investment in fundamental research like that being done at CHASE?

A1. Fuels produced from sunlight, also called solar fuels, are made from common substances like water and carbon dioxide using the energy of sunlight to form liquid fuels. Solar fuels could provide an abundant supply of sustainable, storable, and portable energy. They could diversify our fuel supply and increase the sustainability of our overall energy system. Solar fuels could also be used with existing fuel infrastructure for a huge range of applications, thus minimizing costs for implementation. While the production of electricity from sunlight is well established, efficient production of liquid fuels from sunlight is still at an early stage that is not yet technically or economically viable for commercial use.

The Center for Hybrid Approaches in Solar Energy to Liquid Fuels, or CHASE, is one of two multi-institutional, multi-disciplinary research teams funded under DOE's long-standing Fuels from Sunlight Hub program. Both CHASE and the second award, the Liquid Sunlight Alliance, focus on highly collaborative research to overcome key scientific barriers for production of liquid solar fuels. The two Hub awards take on complementary research topics that have proven challenging for traditional funding modalities (i.e., single investigator and small teams) and for which success could be transformative to science and technology. This research will establish scientific foundations for scalable technologies that convert carbon dioxide into renewable liquid fuels using solar energy as the only added energy input. This type of collaborative fundamental science effort—the hallmark of DOE's Energy Innovation Hub program—

addresses both longstanding and emerging scientific barriers that prevent or slow down progress in the development of technology for liquid solar fuels production. In general, DOE's investments in large, multi-disciplinary, multi-institutional research centers, coupled with those from the Department's complimentary portfolio of single investigator and small team research activities, are essential to accelerating the pace of progress in clean energy technology by providing the scientific discoveries and enabling research tools for U.S. companies, including those spun out of DOE investments in basic science, to drive rapid innovation and development of new commercial products.

Responses by Mr. James L. Reuter

Questions for the Record

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"Innovation Through Collaboration: The Department of Energy's Role in the U.S. Research Ecosystem"

Mr. James L Reuter, Associate Administrator for the Space Technology Mission Directorate, the National Aeronautics and Space Administration

Question submitted by Rep. Brian Babin, Committee on Science, Space, and Technology

1. Will you please share your thoughts on the attached document and elaborate on NASA's efforts to develop the full range of SNPP applications?

NASA agrees that the ability to develop and use space nuclear power and propulsion (SNPP) systems safely, securely, and cost-effectively in partnership with U.S. industry provides valuable capabilities in support of maintaining and advancing United States space exploration goals. NASA believes the funding sought in NASA's FY24 budget request is essential to build upon and continue recent technology advancements and progress.

NASA envisions SNPP systems continuing to offer power and potentially also providing transportation capabilities for sustainable human exploration and space science missions across the solar system. These systems permit operations under extreme environments where solar and chemical systems are inadequate.

Over the last decade, NASA has invested in SNPP system development, including radioisotope and fission systems, in cooperation with U.S. industry. These investments are showing progress toward solving significant technology challenges leading to higher temperature fuel chemistries and reactor designs that are smaller and lighter while using low enriched uranium. NASA's focus on advancing low enriched uranium reactor technologies has expanded engagement with industry and led to new and innovative reactor design approaches. Advancing engineering solutions for each of these areas is critical to reducing the risk to deploying future SNPP systems.

NASA continues to coordinate and work with other government agencies, such as on Department of Energy's small, modular reactor programs, Defense Advanced Research Projects Agency's (DARPA) DRACO flight demonstration program, the Air Force JETSON Program, and the Office of the Secretary of Defense's Pele project. NASA recently entered into an Interagency Agreement with DARPA to partner on the DRACO nuclear thermal propulsion demonstration with a goal of accelerating nuclear propulsion development efforts. NASA also is a key participant on inter-agency activities focusing on space nuclear regulatory policies with the goal of clarifying pathways for government and commercial applications. In all these activities, NASA partners closely with private industry across the nation.

Appendix II

ADDITIONAL MATERIAL FOR THE RECORD

G:\CMTE\SC\18\SPACE\DOE_NASA.XML

[DISCUSSION DRAFT]

118th CONGRESS
1st Session

H. R. ____

To provide for Department of Energy and National Aeronautics and Space Administration research and development coordination, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

M__. ________ introduced the following bill; which was referred to the Committee on ______________

A BILL

To provide for Department of Energy and National Aeronautics and Space Administration research and development coordination, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "[To Be Supplied] Act".

SEC. 2. DEPARTMENT OF ENERGY AND NATIONAL AERONAUTICS AND SPACE ADMINISTRATION RESEARCH AND DEVELOPMENT COORDINATION.

(a) IN GENERAL.—The Secretary of Energy (in this section referred to as the "Secretary") and the Administrator of the National Aeronautics and Space Administration (in this section referred to as the "Administrator") shall carry out cross-cutting and collaborative research and development activities focused on the joint advancement of Department of Energy and National Aeronautics and Space Administration mission requirements and priorities.

(b) MEMORANDUM OF UNDERSTANDING.—The Secretary and the Administrator shall coordinate the activities under subsection (a) through the establishment of a memorandum of understanding, or other appropriate interagency agreement. Such memorandum or agreement, as the case may be, shall require the use of a competitive, merit-reviewed process, which considers applications from Federal agencies, National Laboratories, institutions of higher education, non-profit institutions, and other appropriate entities.

(c) COORDINATION.—In carrying out the activities under subsection (a), the Secretary and the Administrator may—

(1) conduct collaborative research in a variety of focus areas, such as—

(A) propulsion systems and components, including nuclear thermal and nuclear electric, for the Moon and Mars, including radioisotope power systems, thermoelectric generators, advanced nuclear fuels, and heater units;

(B) modeling and simulation, machine learning, data assimilation, large scale data analytics, and predictive analysis in order to optimize algorithms for mission-related purposes;

(C) fundamental high energy physics, including regarding dark energy and dark matter, in collaboration with the program authorized under section 305 of the Department of Energy Research and Innovation Act (42 U.S.C. 18643);

(D) fundamental earth and environmental sciences, including in collaboration with the program authorized under section 306 of the Department of Energy Research and Innovation Act (42 U.S.C. 18644);

(E) radiation health effects, including in collaboration with the program authorized under section 306 of the Department of Energy

Research and Innovation Act (42 U.S.C. 18644);

(F) quantum information sciences, including quantum computing and quantum network infrastructure, including in collaboration with the programs authorized under sections 403 and 404 of the National Quantum Initiative Act (15 U.S.C. 8853 and 8854);

(G) nanotechnology;

(H) scientific observations of the early universe from the Moon;

(I) planetary defense from potentially hazardous asteroids and near-Earth objects;

(J) sensor and satellite development;

(K) space situational awareness; and

(L) fundamental heliophysics;

(2) develop methods to accommodate large voluntary data sets on space and aeronautical information on high-performance computing systems with variable quality and scale;

(3) promote collaboration, open community-based development, and data and information sharing between Federal agencies, National Laboratories, institutions of higher education, nonprofit institutions, and other appropriate entities by pro-

viding the necessary access and secure data and information transfer capabilities; and

(4) support research infrastructure as the Secretary and Administrator determine necessary.

(d) AGREEMENTS.—In carrying out the activities under subsection (a), the Secretary and the Administrator are authorized to—

(1) carry out reimbursable agreements between the Department of Energy, the National Aeronautics and Space Administration, and other entities in order to maximize the effectiveness of research and development; and

(2) collaborate with other Federal agencies as appropriate.

(e) REPORT.—Not later than two years after the date of the enactment of this section, the Secretary and the Administrator shall submit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Energy and Natural Resources and the Committee on Commerce, Science, and Transportation of the Senate, a report detailing the following:

(1) Interagency coordination between each Federal agency involved in the research and development activities carried out under this section.

(2) Potential opportunities to expand the technical capabilities of the Department of Energy and the National Aeronautics and Space Administration.

(3) Collaborative research achievements.

(4) Areas of future mutually beneficial successes.

(5) Continuation of coordination activities between the Department of Energy and the National Aeronautics and Space Administration.

(f) RESEARCH SECURITY.—The activities authorized under this section shall be applied in a manner consistent with subtitle D of title VI of the Research and Development, Competition, and Innovation Act (enacted as division B of the CHIPS Act of 2022 (Public Law 117–167; 42 U.S.C. 19231 et seq.)).

[DISCUSSION DRAFT]

118TH CONGRESS
1ST SESSION

H. R. ______

To direct the Department of Energy and the National Oceanic and Atmospheric Administration to conduct collaborative research in order to advance numerical weather and climate prediction in the United States, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

M__. ____________ introduced the following bill; which was referred to the Committee on ______________________________

A BILL

To direct the Department of Energy and the National Oceanic and Atmospheric Administration to conduct collaborative research in order to advance numerical weather and climate prediction in the United States, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Advanced Weather Model Computing Development Act".

SEC. 2. DEFINITIONS.

In this Act:

(1) DEPARTMENT.—The term "Department" means the Department of Energy.

(2) NATIONAL LABORATORY.—The term "National Laboratory" has the meaning given such term in section 2 of the Energy Policy Act of 2005 (42 U.S.C. 15801).

(3) SECRETARY.—The term "Secretary" means the Secretary of Energy.

(4) ADMINISTRATOR.—The term "Administrator" means the Administrator of the National Oceanic and Atmospheric Administration.

SEC. 3. DEPARTMENT OF ENERGY AND NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION RESEARCH AND DEVELOPMENT COORDINATION.

(a) IN GENERAL.—The Secretary and Administrator shall carry out collaborative research and development activities in artificial intelligence and high performance computing, focused on the advancement of climate models and operational numerical weather prediction skill to support National Oceanic and Atmospheric Administration mission requirements and the advancement of Department computational and networking capabilities to analyze, model, simulate, and predict complex phenomena.

(b) MEMORANDUM OF UNDERSTANDING.—The Secretary and Administrator shall carry out the activities under subsection (a) through the establishment of a memorandum of understanding, or other appropriate interagency agreement. Such memorandum or agreement, as the case may be, shall require the use of a competitive, merit-reviewed process, which considers applications from Federal agencies, National Laboratories, institutions of higher education, nonprofit institutions, and other appropriate entities.

(c) ACTIVITIES.—In carrying out the activities under subsection (a), the Secretary and Administrator may—

(1) conduct collaborative research in modeling and simulation, machine learning, data assimilation, large scale data analytics, and predictive analysis in order to optimize algorithms for climate modeling and numerical weather prediction;

(2) explore options for performance portability of the optimized weather model codes between the operational computing systems of the National Oceanic and Atmospheric Administration and the Department's high performance computers;

(3) develop methods to accommodate large data sets on weather and climate information with variable quality and scale;

(4) collaborate on new approaches and maximize the use of algorithms developed through artificial intelligence, machine learning, data analytics, natural language processing, modeling and simulation, with a focus on new algorithms suitable for high performance computing systems and numerical weather prediction or climate models;

(5) to the maximum extent practicable, and in compliance with national security policies, promote collaboration, open community-based development, and data sharing between Federal agencies, National Laboratories, institutions of higher education, nonprofit institutions, and other appropriate entities by providing the necessary access and secure data transfer capabilities; and

(6) support scientific computing infrastructure as the Secretary and Administrator determine appropriate.

(d) COORDINATION.—In carrying out the activities under subsection (a), the Secretary and Administrator are authorized to—

(1) carry out reimbursable agreements between the Department, the National Oceanic and Atmospheric Administration, and other entities in order to

maximize the effectiveness of research and development to improve numerical weather prediction; and

(2) collaborate with other Federal agencies as appropriate.

(e) REPORT.—Not later than two years after the date of the enactment of this Act, the Secretary and Administrator shall submit to the Committee on Science, Space, and Technology of the House of Representatives, and the Committee on Commerce, Science, and Transportation and the Committee on Energy and Natural Resources of the Senate, a report detailing the following:

(1) Interagency coordination between each Federal agency involved in the research and development activities carried out under this section.

(2) Potential opportunities to expand the technical capabilities of the Department and the National Oceanic and Atmospheric Administration.

(3) Collaborative research achievements.

(4) Areas of future mutually beneficial gains by such activities.

(5) Continuation of coordination between the Department and the National Oceanic and Atmospheric Administration.

SEC. 4. CLIMATE AND WEATHER PREDICTION ON HIGH PERFORMANCE COMPUTERS INITIATIVE.

(a) IN GENERAL.—The Secretary and Administrator shall carry out an initiative to run advanced model code, including climate and operational weather models, on the Department high performance computers in order to conduct proof of concept scenarios and comparison to current issued forecasts and models. The Secretary and Administrator shall carry out such initiative through a competitive, merit-reviewed process, and consider applications from Federal agencies, National Laboratories, institutions of higher education, nonprofit institutions, and other appropriate entities.

(b) COMPONENTS.—In carrying out the initiative under subsection (a), the Secretary and Administrator shall prevent duplication and coordinate research efforts in artificial intelligence, high performance computing, modeling and simulation, machine learning, and data assimilation across the Department, and may—

(1) run real-time weather forecast scenarios to conduct comparative research on National Weather Service issued forecasts to forecasts issued through the use of operational models run on high performance computers;

(2) share relevant modeling system and applications innovations developed through such initiative,

including Unified Forecast System-based applications, through community-based activities; and

(3) leverage related weather and climate efforts and data from the National Science and Technology Council and the Interagency Council for Advancing Meteorological Services.

(c) REPORT.—Not later than two years after the date of the enactment of this Act, the Secretary and Administrator shall submit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation and the Committee on Energy and Natural Resources of the Senate a report evaluating the following:

(1) The effectiveness of the initiative under subsection (a), including applied research discoveries and operational weather prediction improvements achieved.

(2) Potential opportunities to expand the technical capabilities of the Department and the National Oceanic and Atmospheric Administration through the development of artificial intelligence and data analytics technologies.

(d) SUNSET.—The authority under this section shall terminate five years after the date of the enactment of this section.

SEC. 5. RESEARCH SECURITY.

The activities authorized under this Act shall be applied in a manner consistent with subtitle D of title VI of the Research and Development, Competition, and Innovation Act (enacted as division B of the CHIPS Act of 2022 (Public Law 117–167; 42 U.S.C. 19231 et seq.)).

[DISCUSSION DRAFT]

118TH CONGRESS
1ST SESSION

H. R. ____

To provide for Department of Energy and Department of Agriculture joint research and development activities, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

M__. ________ introduced the following bill; which was referred to the Committee on ________________

A BILL

To provide for Department of Energy and Department of Agriculture joint research and development activities, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "[To Be Supplied] Act".

SEC. 2. DEPARTMENT OF ENERGY AND DEPARTMENT OF AGRICULTURE JOINT RESEARCH AND DEVELOPMENT ACTIVITIES.

(a) IN GENERAL.—The Secretary of Energy and the Secretary of Agriculture (in this section referred to as the "Secretaries") shall carry out cross-cutting and collaborative research and development activities focused on the joint advancement of Department of Energy and Department of Agriculture mission requirements and priorities.

(b) MEMORANDUM OF UNDERSTANDING.—The Secretaries shall carry out and coordinate the activities under subsection (a) through the establishment of a memorandum of understanding, or other appropriate interagency agreement. Such memorandum or agreement shall require the use of a competitive, merit-reviewed process, which considers applications from Federal agencies, National Laboratories, institutions of higher education, nonprofit institutions, and other appropriate entities.

(c) COORDINATION.—In carrying out the activities under subsection (a), the Secretaries may—

(1) conduct collaborative research over a variety of focus areas, such as—

(A) modeling and simulation, machine learning, artificial intelligence, data assimilation, large scale data analytics, and predictive analysis in order to optimize algorithms for purposes related to agriculture and energy, such as life cycle analysis of agricultural or energy systems;

(B) fundamental agricultural, biological, computational, and environmental science and engineering, including advanced crop science, crop protection, and breeding, including in collaboration with the program authorized under section 306 of the Department of Energy Research and Innovation Act (42 U.S.C. 18644);

(C) integrated natural resources and the energy-water nexus, including in collaboration with the program authorized under section 1010 of the Energy Act of 2020 (enacted as division Z of the Consolidated Appropriations Act, 2021 (42 U.S.C. 16183));

(D) advanced biomass, biobased products, and biofuels, including in collaboration with the activities authorized under section 9008(b) of the Farm Security and Rural Investment Act of 2002 (7 U.S.C. 8108(b));

(E) diverse feedstocks for economically and environmentally sustainable fuels, including aviation and naval fuels;

(F) colocation of agricultural resources and activities and ecosystem services with diverse energy technologies and resources, such as geothermal energy, nuclear energy, solar energy, wind energy, natural gas, hydropower, and energy storage;

(G) colocation of agricultural resources and activities with carbon storage and utilization technologies;

(H) invasive species management to further the work done by the Federal Interagency Committee for the Management of Noxious and Exotic Weeds;

(I) long-term and high-risk technological barriers in the development of transformative science and technology solutions in the agriculture and energy sectors, including in collaboration with the program authorized under section 5012 of the America COMPETES Act (42 U.S.C. 16538);

(J) grid modernization and grid security; and

(K) rural technology development, including manufacturing, precision agriculture technologies, and mechanization and automation technologies;

(2) develop methods to accommodate large voluntary standardized and integrated data sets on agricultural, environmental, supply chain, and economic information with variable accuracy and scale;

(3) promote collaboration, open community-based development, and data and information sharing between Federal agencies, National Laboratories, institutions of higher education, nonprofit institutions, industry partners, and other appropriate entities by providing reliable access to secure data and information that are in compliance with Federal rules and regulations; and

(4) support research infrastructure and workforce development as the Secretary and Administrator determine necessary

(d) AGREEMENTS.—In carrying out the activities under subsection (a), the Secretaries are authorized to—

(1) carry out reimbursable agreements between the Department of Energy, the Department of Agriculture, and other entities in order to maximize the effectiveness of research and development; and

(2) collaborate with other Federal agencies as appropriate.

(e) REPORT.—Not later than two years after the date of the enactment of this Act, the Secretaries shall submit to the Committee on Science, Space, and Technology and the Committee on Agriculture of the House of Representatives, and the Committee on Energy and Natural Resources and the Committee on Agriculture, Nutrition, and Forestry of the Senate, a report detailing the following:

(1) Interagency coordination between each Federal agency involved in the research and development activities carried out under this section.

(2) Potential opportunities to expand the technical capabilities of the Department of Energy and the Department of Agriculture.

(3) Collaborative research achievements.

(4) Areas of future mutually beneficial successes.

(5) Continuation of coordination activities between the Department of Energy and the Department of Agriculture.

(f) RESEARCH SECURITY.—The activities authorized under this section shall be applied in a manner consistent with subtitle D of title VI of the Research and Development, Competition, and Innovation Act (enacted as division B of the CHIPS Act of 2022 (Public Law 117–167; 42 U.S.C. 19231 et seq.)).

LETTER SUBMITTED BY SPACE NUCLEAR POWER AND PROPULSION INDUSTRY

March 8, 2023

Representative Frank Lucas Chair Committee on Science, Space, and Technology 2318 Rayburn House Office Washington, DC 20515	Representative Zoe Lofgren Ranking Member Committee on Science, Space, and Technology 2320 Rayburn House Office Washington, DC 20515

Dear Chair Lucas and Ranking Member Lofgren,

As the leading innovative companies within the commercial space nuclear power and propulsion (SNPP) industry, we write in support of NASA's efforts to develop the full range of SNPP applications essential to achieving America's space exploration goals.

More specifically, we encourage the Committee on Science, Space, and Technology to provide multi-year budget authorization for Nuclear Thermal Propulsion (NTP), Nuclear Electric Propulsion (NEP), and Fission Surface Power (FSP) within the NASA Authorization bill for FY2024 and beyond. We also support continued funding for NASA's Radioisotope Power Systems Program (RPS) and partnerships with the U.S. commercial sector focused on innovation for fission, fusion, and radioisotope technologies.

It is our belief that a whole-of-government approach and the alignment around nuclear fuels development and reactor requirements is key to leveraging the industry investments that will reduce the overall cost and development timeframe for SNPP systems. To meet that approach, NASA should continue to align its Space Nuclear Technologies portfolio with other relevant Federal departments and agencies, such as the Department of Defense and the Department of Energy, to leverage investments that will enable NASA and its commercial partners to enable a regular cadence of truly sustainable missions to the surface of the Moon and Mars and ensuring U.S. leadership in space exploration.

Consistent government support is not only necessary for the development of these complex applications, but it also sends a powerful signal to the private markets to stimulate competition, innovation, and investment. In addition to supporting the achievement of our most ambitious space exploration goals, this approach also creates and sustains thousands of STEM and advanced manufacturing jobs across the United States, an increasing number of them in privately funded, small and medium-sized companies.

To fully leverage these commercial investments, NASA needs to align its SNPP efforts with the associated technologies the American commercial space nuclear power and propulsion industry is developing at a rapid pace. Without clarity around available funding for future development, recent progress by industry in SNPP is at risk of stalling, inadvertently delaying NASA's exploration timelines and potentially curtailing private investments that are being made in anticipation of knowing that NASA intends to be an early customer for commercially developed SNPP systems.

Dedicated funding, with an outyear profile, and a clear roadmap will ensure that NASA's Space Nuclear Technologies portfolio aligns key technology development and commercial investments. This funding and directional clarity can provide the incentive for continued and additional innovation and investment in the commercial SNPP sector. Strengthening our domestic space industrial base at the precise moment when global competition in the realm of space technologies is intensifying will provide NASA with a diverse set of commercial partners with whom to continue pursuing America's long-term goals in cislunar space, around and on the Moon, and on to Mars.

We thank you for your consideration and please do not hesitate to contact us if we can provide further assistance or additional information.

Sincerely,

AVALANCHE

USNC
ULTRA•SAFE•NUCLEAR

zeno