THE DEPARTMENT OF ENERGY'S OFFICE OF SCIENCE: EXPLORING THE NEXT FRONTIERS IN ENERGY RESEARCH AND SCIENTIFIC DISCOVERY

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

OF THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED SIXTEENTH CONGRESS

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January 15, 2020

THE DEPARTMENT OF ENERGY'S OFFICE OF SCIENCE: EXPLORING THE NEXT FRONTIERS IN ENERGY RESEARCH AND SCIENTIFIC DISCOVERY

WEDNESDAY, JANUARY 15, 2020

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

The Subcommittee met, pursuant to notice, at 2:01 p.m., in room 2318 of the Rayburn House Office Building, Hon. Lizzie Fletcher [Chairwoman of the Subcommittee] presiding.

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY
U.S. HOUSE OF REPRESENTATIVES
HEARING CHARTER

The Department of Energy's Office of Science: Exploring the Next Frontiers in Energy Research and Scientific Discovery
Wednesday, January 15, 2020
2:00PM EST
2318 Rayburn House Office Building, Washington, D.C. 20015

PURPOSE

The purpose of this hearing is to examine the current research and development activities and facilities supported by the U.S. Department of Energy's Office of Science, and to consider potential future directions for its various programs.

WITNESS

- **Dr. Chris Fall**, Director, Office of Science, U.S. Department of Energy

BACKGROUND

The U.S. Department of Energy's Office of Science is the lead federal agency supporting scientific research for energy applications and the nation's largest supporter of research in the physical sciences, supporting over 22,000 investigators at over 300 U.S. academic institutions and the DOE laboratories. The Office of Science portfolio has two principal thrusts: direct support of scientific research and support of the development, construction, and operation of unique, open-access scientific user facilities. These missions are primarily pursued by six research program offices: Advanced Scientific Computing Research, Basic Energy Sciences, Biological and Environmental Research, Fusion Energy Sciences, High Energy Physics, and Nuclear Physics. It also supports education initiatives through its Workforce Development for Teachers and Scientists program and general infrastructure projects for research facilities.

In carrying out these activities, the Office of Science stewards 10 of the 17 DOE laboratories. The laboratories execute long-term government missions and develop unique, often multidisciplinary, scientific instruments and resources beyond the scope of academic and industrial institutions. Key among the assets provided by the National Lab System are user facilities, which are used by over 32,000 researchers per year from universities, national laboratories, industry, and international partners.[1]

Office of Science Budget

FY 2019 Enacted:	$6.58 billion
FY 2020 Enacted:	$7.00 billion
Difference:	+$420 million (+6.38%)

Advanced Scientific Computing Research (ASCR)

ASCR's mission is "to discover, develop, and deploy computational and networking capabilities to analyze, model, and simulate complex phenomena important to the Department of Energy."[2] ASCR supports research in both applied mathematics and computer science focused in areas relevant to high-end computing systems and stewards several of the largest computational facilities in the world. In addition, ASCR supports research in advanced networking capabilities to enable national and international research collaborations.

Notable ASCR facilities include the National Energy Research Scientific Computing Center (NERSC), which delivers high-end capacity computing services for the research community, currently supporting over 5,000 users; the Argonne Leadership Computing Facility (ALCF), which supports more than 800 active users and over 120 active projects; and the Oak Ridge Leadership Computing Facility, which supports Frontier, currently the fastest computer system in the world.[3]

Budget

FY 2019 Enacted:	$935.5 million
FY 2020 Enacted:	$980 million
Difference:	+$44.5 million (+4.76%)

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[1] Department of Energy FY 2020 Congressional Budget Request. https://www.energy.gov/cfo/downloads/fy-2020-budget-justification

[2] Office of Science. Department of Energy. https://science.osti.gov/ascr/About

[3] Advanced Scientific Computing Research. DOE. https://www.energy.gov/science/ascr/advanced-scientific-computing-research

Basic Energy Sciences (BES)

BES supports research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels. The research disciplines that the BES program supports – condensed matter and materials physics, chemistry, geosciences, and biosciences – are those that lead to the creation of new materials and design new chemical processes. These disciplines touch virtually every aspect of energy resources, production, conversion, transmission, storage, efficiency, and waste mitigation.

Due to the breadth of its mission, BES is one of the nation's largest sponsors of research in the natural sciences and funds research at more than 170 research institutions in the U.S. In the process, BES supports many user facilities, including several massive light source and neutron source facilities, which enable materials characterization through x-ray and particle scattering, as well as five Nanoscale Science Research Centers. BES also stewards two Energy Innovation Hubs and 46 Energy Frontier Research Centers (EFRCs). Energy Innovation Hubs are integrated research centers (~$25 million annual budget per Hub) that combine research with engineering to accelerate scientific discovery in critical energy issue areas. BES specifically stewards the Fuels from Sunlight Hub, which focuses on advancing nonbiological processes to directly convert sunlight to liquid fuels, and a Batteries and Energy Storage Hub. EFRCs are integrated, multi-investigator centers (~$3-5 million annual budget per Center) that conduct research focused on one or more energy research "grand challenges" identified by the Basic Energy Sciences Advisory Committee.

Budget

FY 2019 Enacted:	$2.166 billion
FY 2020 Enacted:	$2.213 billion
Difference:	+$47 million (+2.17%)

Biological and Environmental Research (BER)

BER, by integrating molecular-level biological science with advanced computational and experimental approaches, seeks to gain a predictive understanding of living systems, from microbes and microbial communities to plants and other organisms. This knowledge serves as the basis for the redesign of microbes and plants for sustainable biofuel production, improved carbon storage, and contaminant remediation. As part of this work, BER supports four bioenergy research centers. BER also supports research that advances our understanding of the roles of Earth's biogeochemical systems (the atmosphere, land, oceans, sea ice, and subsurface), which includes developing advanced computational climate models. Additionally, in accordance with the Department of Energy Research and Innovation Act (P.L. 115-246) signed into law in September 2018, BER is required to re-establish a low-dose radiation research program to enhance the scientific knowledge of, and reduce uncertainties associated with, the effects of exposure to low-dose radiation to inform improved risk-management methods.[4]

Budget

FY 2019 Enacted:	$705 million
FY 2020 Enacted:	$750 million
Difference:	+$45 million (+6.38%)

Fusion Energy Sciences (FES)

FES is the lead federal program that supports research in the science and engineering required to confine plasmas for the purposes of generating net fusion energy. The program is responsible for building, operating, and improving several major fusion research facilities, including U.S. contributions to the ITER project (described below). It is also the lead program that stewards research in plasma science, which has applications in a broad range of areas from microchip processing to astrophysics. Additionally, in accordance with the Department of Energy Research and Innovation Act (P.L. 115-246) signed into law in September 2018, FES is required to re-establish an alternative and enabling concepts program; establish an inertial fusion R&D program which will, among other activities, leverage expertise and research facilities supported by DOE's weapons stockpile stewardship program for potential energy applications[5]; advance the development of fusion-relevant materials; improve coordination with the Department's Advanced Research Projects Agency – Energy (ARPA-E); and develop a 10-year strategic plan to establish R&D priorities under "not fewer than 3 realistic budget scenarios."[6]

ITER[7] (pronounced "eater") is a major international research project with the goal of demonstrating the scientific and technological feasibility of energy from nuclear fusion. The project is being designed and built by the members of the ITER Organization (IO): the European Union (EU), India, Japan, China, Korea, Russia, and the U.S. The device is under construction at Cadarache in southeastern France with the EU serving as the host party, and it is currently scheduled to begin preliminary operations by 2025. ITER is expected to generate fusion power that is at least 10 times greater than the external power delivered to heat its plasma by 2035. The

[4] https://www.congress.gov/bill/115th-congress/house-bill/589
[5] See National Research Council. 2013. *An Assessment of the Prospects for Inertial Fusion Energy*. Washington, DC: The National Academies Press. https://doi.org/10.17226/18289
[6] https://www.congress.gov/bill/115th-congress/house-bill/589
[7] ITER was originally an acronym for "International Thermonuclear Experimental Reactor," but that full title is no longer officially in use, and the project's leaders now note that *iter* also means "the way" in Latin.

project is designed to explore and test expectations of plasma behavior when the nuclear fusion process itself provides the primary heat source to sustain its high temperatures.

Budget

FY 2019 Enacted:	$564 million
FY 2020 Enacted:	$671 million
Difference:	+$107 million (+18.97%)

High Energy Physics (HEP)

HEP supports research to advance our understanding of the fundamental building blocks of matter and energy as well as the nature of space and time and the interactions between them. HEP explores fundamental scientific frontiers ranging from the origins and behavior of the universe to the importance of the discovery of the Higgs Boson, which had been predicted to largely explain the origin of mass in matter.

It does this through support for proton and electron accelerator-based physics (using accelerators to create and analyze particles); non-accelerator based physics (examining phenomena such as dark matter, dark energy, neutrinos, and primordial matter, often in partnership with NASA and/or NSF); theoretical physics (providing the mathematical framework for understanding and extending knowledge about high energy physics); and R&D to develop the next generation of accelerator and detector technologies.

In 2017, HEP initiated construction of the Long-Baseline Neutrino Facility/Deep Underground Neutrino Experiment (LBNF/DUNE) at Fermilab in Illinois and the Sanford Underground Research Facility (SURF) in South Dakota, which is designed to be the premiere facility in the world that will examine the properties of neutrinos. Neutrinos are fundamental to understanding physics beyond the long-established "Standard Model" of particle physics and can help scientists determine how the universe continues to evolve.

Budget

FY 2019 Enacted:	$980 million
FY 2020 Enacted:	$1.045 billion
Difference:	+$65 million (+6.63%)

Nuclear Physics (NP)

The mission of NP is to discover, explore, and understand all forms of nuclear matter. Nuclear matter consists of any number of clustered protons and neutrons which makes up the nuclei of atoms, but exactly how they fit together and interact to create different types of matter in the universe is still largely not understood. To try to answer the many remaining questions in this field, NP supports experimental and theoretical research – along with the development and operation of specially designed particle accelerators and other advanced technologies – to create, detect, and describe the different forms of nuclear matter that can exist in the universe, including those that are no longer found naturally.

Specifically, NP supports research into the interaction of quarks and gluons that make up the nucleus; why the universe is made up of matter rather than antimatter (which is also relevant to HEP as described above); new and predicted matter including matter and phenomena that existed during the universe's infancy; how protons and neutrons are bound into stable nuclei versus rare and unstable nuclei; the evolution of the cosmos, and the theoretical underpinning needed to support the interpretation of data obtained from all other NP research in order to advance hypotheses and stimulate experimental investigations.

On January 9th, 2020, DOE announced that Brookhaven National Laboratory in New York, in partnership with the Thomas Jefferson National Accelerator Facility in Virginia, will be the site for construction of a major new NP facility called the Electron Ion Collider (EIC). The EIC is designed to be the premiere facility in the world that "will smash electrons into protons and heavier atomic nuclei in an effort to penetrate the mysteries of the 'strong force' that binds the atomic nucleus together."[8]

In addition, NP supports the production and development of techniques to make isotopes that are in short supply for medical, national security, environmental, and other research applications.

Budget

FY 2019 Enacted:	$690 million
FY 2020 Enacted:	$713 million
Difference:	+$23 million (+3.33%)

[8] https://www.energy.gov/articles/us-department-energy-selects-brookhaven-national-laboratory-host-major-new-nuclear-physics

Chairwoman FLETCHER. This hearing will come to order. Without objection, the Chair is authorized to declare a recess at any time. Good afternoon, and welcome to our first Energy Subcommittee hearing of 2020 entitled, "The Department of Energy's Office of Science: Exploring the Next Frontiers in Energy Research and Scientific Discovery." I'm glad to be here today as the new Chair of the Energy Subcommittee, and I'm looking forward to leading us through an important and busy year of hearings and legislative action to help provide clean, reliable, and secure energy resources and services for every American, and for the world.

We're here today to discuss the role of the Office of Science at the Department of Energy (DOE) in fulfilling this mission. The Office of Science is the Nation's premiere Federal agency that supports research in the physical sciences for energy and other applications. It oversees 10 of DOE's 17 national labs, and it houses 6 program offices, focused on everything from advanced computing and material science to biological and nuclear physics research. It is also the home of DOE's work on climate modeling.

The Office of Science plays a critical role in our fight against climate change. It is uniquely positioned to help us reach our shared goals of developing energy that is clean, sustainable, reliable, and affordable. This is no small task. We need everyone working together to achieve this goal, and to do so as quickly as possible. That's why it is essential that we invest our shared resources in this research, and that we identify and enable the critical research that we need to invest in.

In order to develop effective solutions, we need to start with the science. The Office of Science supports a wide range of research efforts to ask the right questions and find the best answers, and the Office of Science has an important role to play in the advancement of the physical sciences as well. In the past year, scientists and researchers supported by this Office have contributed to the development of nanoscale cancer treatments that provide targeted drug delivery, a Dark Energy Survey that will help answer fundamental questions about why our universe is expanding, and algae that can capture and store carbon dioxide, and those are just a few examples of the various efforts supported by the Office each and every year.

Collaboration on these issues is critical. It is what I have witnessed on this Committee time and again, and I've seen the Office of Science do this successfully. Working with researchers at Rice University in Houston has led to a breakthrough way to use imperfections in lithium-ion batteries, which had typically been expected to degrade battery performance, to make this important technology perform better instead. This is just one of many exciting research collaborations between the Office of Science and the companies and research institutions that call Houston home. I'm glad Dr. Fall is here today, and look forward to hearing more about the recent developments at the Office of Science, and ways that we can all work together to help it achieve its mission.

[The prepared statement of Chairwoman Fletcher follows:]

Good afternoon, and welcome to our first Energy Subcommittee hearing of 2020.

I am glad to be here today as the new Chairwoman of the Energy Subcommittee and am looking forward to leading us through an important and busy year of hearings and legislative action to help provide clean, reliable, and secure energy resources and services for every American—and for the world.

We are here today to discuss the role of the Office of Science at the Department of Energy in fulfilling this mission. The Office of Science is the nation's premier federal agency that supports research in the physical sciences for energy and other applications. It oversees ten of DOE's seventeen national labs, and it houses six program offices focused on everything from advanced computing and materials science to biological and nuclear physics research. It is also the home of DOE's work on climate modeling.

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And the Office of Science has an important role to play in the advancement of the physical sciences as well. In the past year, scientists and researchers supported by this office have contributed to the development of nanoscale cancer treatments that provide targeted drug delivery, a Dark Energy Survey that will help answer fundamental questions about why our universe is expanding, and algae that can capture and store carbon dioxide. And those are just a few examples of the various efforts supported by this Office each and every year.

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I am glad Dr. Fall is here today and look forward to hearing more about recent developments at the Office of Science, and ways that we can work together to help it achieve its mission.

With that, I yield back.

Chairwoman FLETCHER. I will now recognize Ranking Member Weber for an opening statement.

Mr. WEBER. Thank you, Madam Chairwoman, and congratulations, I think, on getting appointed to this Committee. You may have second thoughts about it after a while, but we're glad you're here. We appreciate you hosting this hearing, and thank you, Dr. Fall, for being here this afternoon. I'm excited to hear about the critical work being performed at the Department of Energy, DOE's, Office of Science. As we know, DOE is the largest Federal sponsor of basic research in the physical sciences. This Committee's jurisdiction includes all of DOE's civilian research, including almost $13 billion, with a B, in research, development, demonstration, and commercial application programs, as well as the Department's 17 national labs, which amounts to about one third of DOE's total budget. As Ranking Member of the Energy Subcommittee, I take great pride in this responsibility, and I believe that one of the most important pieces, if not the most important piece, of our portfolio is the DOE Office of Science. That's why I'm a little surprised, quite frankly, that this Congress this is the first hearing we've had held on this agency, especially since the Office of Science is a $7 billion, with a B, dollar program that represents actually more than half of this Subcommittee's jurisdiction.

Instead, last year we had many hearings on advanced renewable energy technologies, from solar and wind, to sustainable transportation, to geothermal and hydropower. Now, while I'm very supportive of these technologies, I think we can all agree that there's one key weakness that they have in common, one that industry will never address. In order for these technologies to truly provide reliable and affordable grid scale electricity across these United States, they will require access to next generation energy storage materials and technologies. To meet this need, strong and strategic support for basic research in material science and computing through the Office of Science is absolutely critical. And that's just one example of the importance of this agency's work.

In the past few decades, research conducted through the Office of Science has led to monumental discoveries in material science in computing, in fundamental physics, and biological sciences, and has enabled the development of innovative energy technology. Each DOE lab has made invaluable contributions to U.S. scientific progress, and they have repeatedly demonstrated that basic science research is the most effective way to encourage that innovation. Additionally, the unique open access user facilities at these Office of Science labs provides our Nation's researchers with the most cutting-edge tools of modern science, like advanced light sources, particle accelerators, and the two fastest supercomputers in the entire world. Each year thousands of researchers from academia, other Federal agencies, and U.S. industry partners, from Fortune 500 companies, to even small businesses, rely on those DOE facilities to perform new scientific research and develop those new technologies.

Thanks to the Office of Science and its decades of excellent work, the United States is the world leader in basic science research and technological development. But even as we speak, other countries, for example China, are making significant investments in science and threatening our global leadership. The Department's continued investment in basic and early-stage research is vital, absolutely vital, to the maintenance of our technological edge. By investing wisely in this research, the Department can achieve its goal of scientific discovery and technological breakthrough for our future generations.

DOE must also invest in facility upgrades, and basic infrastructure that attracts and retains the best scientists in the world right here at home. I look forward to hearing from Dr. Fall about his plans to address these issues. I also look forward to hearing from Dr. Fall about DOE's ongoing implementation of several key pieces of bipartisan Science Committee legislation that was signed into law last Congress, in fact, including the *DOE Research and Innovation Act*, and the *National Quantum Initiative Act*. When basic research is the priority of Federal support, everyone has the opportunity to access these fundamental knowledge that can lead to the development of those future energy technologies.

I'd like to take a moment to thank my friends across the aisle for holding this hearing. I'm pleased to see, especially with our new Chairwoman, that we're starting off the new year on the right foot by focusing on this key aspect of our jurisdiction. I'm going to thank Dr. Fall for being here today, and, a point of personal privilege, if I may, Madam Chair, it turns out that there's a bit of sadness here today because we are losing one Ms. Emily Domenech, who is sitting behind me. She has been with our part of the Committee for a long time. She keeps us on the straight and narrow, and that's a full-time job. So let's give her a hand. Can we recognize her help? And with that, Madam Chair, she's red, and I yield back.

[The prepared statement of Mr. Weber follows:]

Thank you, Chairwoman Fletcher, for hosting this hearing, and thank you Dr. Fall for being here this afternoon. I am excited to hear about the critical work being performed at the Department of Energy's (DOE) Office of Science.

DOE is the largest Federal sponsor of basic research in the physical sciences. This Committee's jurisdiction includes all of DOE's civilian research, including almost $13 billion in research, development, demonstration, and commercial application programs, as well as the Department's 17 national labs. This amount totals one-third of the DOE's budget.

As Ranking Member of the Energy Subcommittee I take great pride in this responsibility. And I believe that one of the most important pieces, if not the most important piece, of our portfolio is the DOE Office of Science.

That is why I am a little surprised that this Congress, this is the first hearing we have held on this agency. Especially since the Office of Science is a $7 billion dollar program that represents more than half of this Subcommittee's jurisdiction.

Instead, last year, we had many hearings on advanced renewable energy technologies from solar and wind, to sustainable transportation, geothermal and hydropower.

And while I am very supportive of these technologies, I think we can all agree that there is one key weakness they all have in common. One that industry will never address.

In order for these technologies to truly provide reliable and affordable grid-scale electricity across the United States, they will require access to next generation energy storage materials and technologies. To meet this need, strong and strategic support for basic research in materials science and computing through the Office of Science is critical.

This is just one example of the importance of this agency's work. In the past few decades, research conducted through the Office of Science has led to monumental discoveries in materials science, computing, fundamental physics, and biological sciences, and has enabled the development of innovative energy technology.Each DOE lab has made invaluable contributions to U.S. scientific progress. And they have repeatedly demonstrated that basic science research is the most effective way to encourage innovation.

Additionally, the unique, open-access user facilities at these Office of Science labs provide our nation's researchers with the most cutting-edge tools of modern science, like advanced light sources, particle accelerators, and the two fastest supercomputers in the world. Each year, thousands of researchers from academia, other Federal agencies, and U.S. industry partners, from Fortune 500 companies to small businesses, rely on DOE facilities to perform new scientific research and develop new technologies.

Thanks to the Office of Science and its decades of excellent work, the United States is the world leader in basic science research and technological development.

But even as we speak, other countries, like China, are making significant investments in science and threatening our global leadership.

The Department's continued investment in basic and early-stage research to vital to the maintenance of our technology edge.

By investing wisely in this research, the Department can achieve its goal of scientific discovery and technological breakthroughs for future generations. DOE must also invest in the facility upgrades and basic infrastructure that attracts and retains the best scientists in the world here at home. I look forward to hearing from Dr. Fall about his plans to address these issues.

I also look forward to hearing from Dr. Fall about DOE's ongoing implementation of several key pieces of bipartisan Science Committee legislation that was signed into law last Congress—including the *DOE Research and Innovation Act*, and the *National Quantum Initiative Act*.

When basic research is the priority of federal support, everyone has the opportunity to access the fundamental knowledge that can lead to the development of future energy technologies.

I'd like to take a moment to thank my friends across the aisle for holding this hearing. I am pleased to see that we are starting off the New Year on the right foot by focusing on this key aspect of our jurisdiction. Thank you again Dr. Fall for taking the time to be here today.

Chairwoman FLETCHER. Thank you, Mr. Weber. And I would now like to recognize Mr. Lucas for an opening statement.

Mr. LUCAS. Thank you, Madam Chair, and today we welcome Dr. Chris Fall, the Director of the Department of Energy's Office of Science to discuss the program's priorities for Fiscal Year 2020 and beyond. Before he joined the Office of Science in 2019, Dr. Fall served as the Acting Director of the Advanced Research Project Agencies—Energy, ARPA-E, near and dear to many of our hearts. These are two DOE programs where I'm pleased to say the Science Committee has found a lot of bipartisan agreement over the years. I look forward to carrying on that tradition this Congress, and I would like to thank Dr. Fall for his work.

DOE is a world leader in technology development and scientific innovation. Through the Office of Science, the Department funds robust research programs across the scientific disciplines, from material science and mathematical modeling, to fusion energy science, and the study of neutrinos. Discoveries made through the Office of Science are the force behind the development of next generation energy technologies. They are the cornerstone of our clean energy future. If we are serious about the climate issues we discussed this morning, then we should equally be serious about our support for this agency and bold investments in basic research. The Science Committee has jurisdiction over all of the Office of Science research and development activities, and its 10 DOE national laboratories, which total $7 billion in annual spending at DOE. This afternoon our discussion with Dr. Fall will focus on the programs within this critical jurisdiction.

This Committee has consistently supported robust funding for the Office of Science. In particular, its basic energy sciences, high energy physics, advanced scientific computing research, and fusion energy sciences programs have long received bipartisan support from this Committee. For example, Committee Members on both sides of the aisle have steadily supported full funding for the U.S. contributions to ITER, a high-priority fusion energy experiment funded through the Office of Science. I was pleased to see the Fiscal Year 2020 appropriations package included enough funding to maintain our participation in this world-leading international research collaboration. Fusion is the next generation scientific frontier, and with the potential to produce near limitless zero emission power for centuries.

Another one of our great areas of bipartisan agreement is the Advanced Scientific Computer Research (ASCR) Program, one of the Science Office's top priority programs. ASCR supports the Department's goal of completing the world's first exascale computing system. Exascale systems will perform one billion calculations per second, and developing one is critical to enabling scientific discovery, strengthening national security, and promoting U.S. industrial competitiveness thanks to DOE's targeted investments. The United States now hosts the top two fastest supercomputers in the world: Summit at Oak Ridge National Laboratory, and Sierra at Lawrence Livermore National Laboratory; and the Department is on track to reach exascale by 2021.

As other countries, like China, race to develop exascale systems of their own, DOE's continued strong support of advanced computing is essential to the maintenance of U.S. leadership in this field. In order to support innovation in next-generation science, DOE must also invest in research infrastructure and cross-cutting research initiatives with other Federal agencies. This includes Office of Science initiatives in critical research areas like quantum information science and artificial intelligence, as well as key investments in our Nation's light resources and neutron resources.

I want to thank Chairwoman Fletcher for holding this hearing, and Dr. Fall for his testimony today. I look forward to a productive and valuable discussion. Our twin goals of addressing today's climate challenges with affordable, reliable clean energy solutions, and ensuring that the United States remains a world leader in science and energy technology for years to come, while we continue our shared commitment to prioritize basic research supported by this critical agency. And with that, Madam Chair, I yield back.

[The prepared statement of Mr. Lucas follows:]

Today we welcome Dr. Chris Fall, the Director of the Department of Energy's Office of Science to discuss the program's priorities for fiscal year 2020 and beyond.

Before he joined the Office of Science in 2019, Dr. Fall served as Acting Director of the Advanced Research Projects Agency—Energy (ARPA-E). These are two DOE programs where, I am pleased to say, the Science Committee has found a lot of bipartisan agreement over the years. I look forward to carrying on that tradition this Congress and I would like to thank Dr. Fall for his work.

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For example, Committee members on both sides of the aisle have steadily supported full funding for U.S. contributions to the ITER project, a high priority fusion energy experiment funded through the Office of Science. I was pleased to see that the fiscal year 2020 appropriations package included enough funding to maintain our participation in this worldleading international research collaboration. Fusion is the next great scientific frontier—with the potential to produce near-limitless, zero emission power for centuries.

Another one of our great areas of bipartisan agreement is for the Advanced Scientific Computing Research (ASCR) program, one of the Office of Science's top priority programs. ASCR supports the Department's goal of completing of the world's first exascale computing system.

Exascale systems will perform one billion, billion calculations per second and developing one is critical to enabling scientific discovery, strengthening national security, and promoting U.S. industrial competitiveness. Thanks to DOE's targeted investments, the United States now hosts the top two fastest supercomputers in the world—Summit at Oak Ridge National Laboratory, and Sierra at Lawrence Livermore National Laboratory. And the Department is on track to reach exascale by 2021. As other countries like China race to develop exascale systems of their own, DOE's continued strong support of advanced computing is essential to maintain U.S. leadership in this field.

In order to support innovation in next-generation science, DOE must also invest in research infrastructure and cross-cutting research initiatives with other Federal agencies.

This includes Office of Science initiatives in critical research areas like quantum information science and artificial intelligence, as well as key investments in our nation's light sources and neutron sources.

I want to thank Chairwoman Fletcher for holding this hearing and Dr. Fall for his testimony today. I look forward to a productive and valuable discussion. Our twin goals of addressing today's climate challenges with affordable and reliable clean energy solutions, and ensuring that the United States remains a world leader in science and energy technology for years to come, require that we continue our shared commitment to prioritize basic research supported by this critical agency.

Chairwoman FLETCHER. Thank you very much, Mr. Lucas, for that opening statement. If there are other Members who would like to submit additional opening statements, your statements will be added to the record at this point.

[The prepared statement of Chairwoman Johnson follows:]

Thank you Chairwoman Fletcher for holding this hearing today, and I would also like to thank Dr. Fall for being here.

The Department of Energy's Office of Science is actually the largest supporter of research in the physical sciences in the country, and it operates more than 30 national scientific user facilities whose applications go well beyond energy innovation. Our nation's top researchers from industry, academia, and other federal agencies use these facilities to examine everything from new materials that will better meet our military's needs, to new pharmaceuticals that will better treat disease, to even examining the fundamental building blocks of the universe. I believe that this stewardship of unique scientific research, including the nation's major national user facilities, is an important role that I hope the Department will continue to make one of its highest priorities.

Now, while this Office supports many critical research programs and facilities, I would like to take this opportunity to briefly talk about your role in fostering fusion energy research and, specifically, the ITER international fusion project. I was pleased that back in 2018, the President signed into law the *Department of Energy Research and Innovation Act*, which I was proud to sponsor with the Committee's Chairman at the time, Mr. Smith. That law requires the Office of Science Director to, among other things, establish an innovative concepts program as well as an inertial fusion energy program to further pursue breakthrough ideas that, thus far, had no real home in the Department's research portfolio. I hope that you are already taking steps to finally address this important legislative direction as soon as possible.

I am also quite happy that the President just signed into law a substantial increase in support for the ITER international fusion project, which I and Ranking Member Lucas strongly advocated for. It is crucial that we honor our commitment to this project, and ensure that we are providing the funds that the Department of Energy itself determined would be necessary to maintain its construction schedule and minimize its total cost to U.S. taxpayers. The completion and operation of ITER will make major contributions to what we know of fusion energy today. And if successful, this project could be a huge game changer in the energy future of not only our nation, but for humanity as a whole. I hope that the Department's next budget request finally reflects the support that this project requires and certainly deserves.

Thank you, and with that I yield back the balance of my time.

At this time I would like to introduce our witness. Of course, we got a nice preview. As Ranking Member Lucas mentioned, Dr. Fall is the Director of the Department of Energy's Office of Science, the lead Federal agency supporting scientific research for energy applications, and the Nation's largest supporter of research in the physical sciences. Prior to his current role, he served as senior advisor to DOE's Undersecretary for Energy, and as acting director of DOE'S Advanced Research Project Agency for Energy, better known as ARPA-E. Before coming to DOE he worked in various roles at the Office of Naval Research, and at the White House Office of Science and Technology Policy. Dr. Fall began his career in academia, serving as a faculty member at the University of Illinois, Chicago, in the Bioengineering and Anatomy and Cell Biology Departments.

Dr. Fall, you will have 5 minutes for your spoken testimony. Your written testimony will be included in the record of the hearing. When you've completed your spoken testimony, we'll move on to questions. Each Member will have 5 minutes to ask questions, and we look forward to hearing from you, and then having an exchange, so your testimony can begin.

TESTIMONY OF DR. CHRIS FALL, DIRECTOR, OFFICE OF SCIENCE, U.S. DEPARTMENT OF ENERGY

Dr. FALL. Chairwoman Fletcher, Ranking Member Weber, and Members of the Committee, thank you for the privilege of being here today on behalf of Secretary Brouillette to discuss the remarkable work being done by the Office of Science at the U.S. Department of Energy. I've been Director of the Office since my swearing in at the end of May, and together with the researchers we support at our laboratories and universities, and in the private sector, we're working both to discover the secrets of the physical world, and to bring scientific discovery to bear on critical needs for energy security, economic competitiveness, and national security.

I'm lucky to come to the Department of Energy at a special time of opportunity for American science. The House and the Senate clearly are aware of the intense landscape of international competition in research and development, and the critical importance of maintaining U.S. leadership in science. With your support, the Office of Science funds tens of thousands of scientists, students, and technical and administrative staff. We continue to build some of the most amazing scientific instruments and open access user facilities in the world, and to upgrade those that we already have. The Office of Science is currently beginning work on the Deep Underground Neutrino Experiment a mile underground in South Dakota, and astronauts in December just extended the life of the Alpha-Magnetic Spectrometer orbiting 200 miles above ground, attached to the International Space Station. We're upgrading both the Advanced Photon Source at Argonne National Laboratory, and the Advanced Light Source at Berkeley, and we're building not one, but three game-changing exascale supercomputers, in conjunction with the National Nuclear Security Administration.

Just last week we announced the launch of a new effort to build a game-changing Electron Ion Collider for nuclear physics, and, while robustly supporting the traditional physical science mission of the Office of Science, we're in the process of launching and expanding a number of exciting new initiatives, including building the Quantum Information Science Centers as part of the National Quantum Initiative authorized by Congress, incorporating artificial intelligence and machine learning into many of the things that we do across the Department, advancing biotechnology to grow the bioeconomy and to enhance biosecurity, and other research to promote the growth of industries of the future now being supported by the Administration. We collaborate with the best scientists from around the world in our laboratories and in theirs, and at the same time we're paying close attention to emerging threats like misappropriation of intellectual property, and dual use technology, and we're taking the necessary steps to help mitigate those threats.

As we strive to push back the frontiers of science, we're mindful of the need to be the best possible stewards of the Department's labs and user facilities. Most of the 10 Office of Science laboratories date to the cold war or earlier. In our planning, and in our budget requests, we're asking to renew and refurbish the physical infrastructure of these laboratories in order to sustain them for the future. It simply would be irresponsible to build something like a new accelerator or light source on a foundation of crumbling and unreliable electricity, water, and other critical infrastructure. So as we build new capabilities, we must continue to maintain and modernize our laboratories' basic infrastructure. I hope that you and your staffers will appreciate this balance that we are trying to achieve as you evaluate our budget requests.

I'd like to mention in closing that the 2019 Nobel Prize in Chemistry was awarded to John Goodenough, Stanley Whittingham, and Akira Yoshino for the development of lithium-ion batteries, a technology I think we can all agree has essentially changed our way of life. Both Goodenough and Whittingham are long-time DOE-supported researchers. For the Department of Energy's science enterprise, identifying and supporting incredible talent like these researchers is just one part of the commitment we have to push back the boundaries of what's possible. And as amazing as winning even a single Nobel Prize is, the Department has supported over 100 Nobel Prizes. Because of the investment the American people make in robust support for basic research, because of the scope and scale of our laboratory system and the universities we partner with, and the remarkable scientists and staff we attract, the amazing happens each and every day.

So thank you, Madam Chair, for the opportunity to share the DOE leadership team's pride in the people and programs of our Office of Science and our laboratories. We are in awe every day of their dedication and their accomplishments, and I'm deeply honored to be their Director. And with that, I'd like to try to answer any questions that you might have.

[The prepared statement of Dr. Fall follows:]

Testimony of Hon. Chris Fall

Director, Office of Science

U.S. Department of Energy

Before the Committee on Space, Science, and Technology

Subcommittee on Energy

U.S. House of Representatives

January 15, 2020

Chairwoman Fletcher, Ranking Member Weber, and Members of the Committee:

Thank you for the privilege of being here today to discuss the great work being done in the Office of Science at the U.S. Department of Energy. I've been the Director of the Office of Science since my swearing in at the end of May 2019. Together with the researchers we support at our laboratories, at American universities, and in the private sector, we're working both to discover the secrets of the physical world and to bring scientific discovery to bear on critical needs for energy security, economic competitiveness, and national security.

I came to DOE at a special time of opportunity for American science. The House and Senate clearly are aware of the intense international competition in research and development (R&D), and the critical importance of maintaining U.S. leadership in science. The Office of Science continues to fund tens of thousands of scientists, students, and technical and administrative staff. We continue to build some of the most amazing scientific instruments and open access user facilities in the world, and to upgrade those that we already have. The Office of Science is currently beginning work on the Deep Underground Neutrino Experiment, a mile underground in South Dakota, and astronauts just extended the life of the alpha magnetic spectrometer orbiting 200 miles above ground in space. We are upgrading both the Advanced Photon Source at Argonne National Laboratory and the Advanced Light Source at Lawrence Berkeley National Laboratory. And we are building not one but three game-changing exascale supercomputers in conjunction with the National Nuclear Security Administration. Just last week we announced the launch of a new effort to build a game-changing electron ion collider for Nuclear Physics.

While robustly supporting the traditional physical science mission of the Office of Science, we are in the process of launching and expanding a number of exciting new initiatives, including:

- Building the new Quantum Information Sciences Centers as part of the National Quantum Initiative;
- Incorporating artificial intelligence and machine learning into many of the things we do across the Department;

- Developing the knowledge and technologies that will enable advanced biotechnologies and enhance biosecurity;
- and other research to promote the growth of other industries of the future being supported by the Administration.

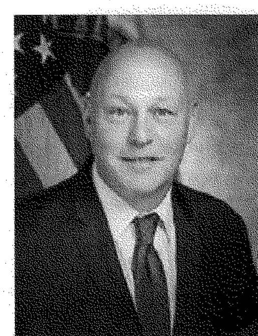
We collaborate with the best scientists from around the world at our laboratories and in our 27 scientific user facilities, as well as in other labs and facilities around the world. At the same time, we are paying attention to emerging threats like the misappropriation of technology and where appropriate, we are taking necessary steps to help mitigate threats.

As we strive to push back the frontiers of science, we are mindful of the need to conduct the best possible stewardship of the Department's labs and major user facilities we provide. Most of the 10 Office of Science laboratories date to the cold war or earlier. I have made it clear to my team that, in our planning and our budget requests, we need to make sure we renew and refurbish the physical infrastructure of these laboratories in order to sustain them for the future. It simply is irresponsible to build something like a new accelerator or light source on a foundation of crumbling and unreliable electricity, water, and other critical infrastructure. As we build new capabilities, we must continue to maintain and modernize our laboratories' basic infrastructure. I hope that you, and your staffers, will appreciate what we are trying to do as you evaluate our budget requests.

I'm going to mention in closing that the 2019 Nobel Prize in Chemistry was awarded to John B. Goodenough, M. Stanley Whittingham, and Akira Yoshino for the development of lithium-ion batteries. Both Goodenough and Whittingham are longtime DOE supported researchers. I mention this almost in passing because as amazing as winning a Nobel prize is, the Department has supported over one hundred Nobel prizes. For the Department of Energy's science enterprise, it's part of the everyday commitment to push the boundaries of what is thought to be possible. Because of the investment the American people make in robust support for basic research, because of the scope and scale of our laboratory system and the universities we partner with, and the remarkable talent we attract, the amazing happens each and every day.

So, thank you Mr. Chairman for the opportunity to share my pride in the people and programs of DOE's Office of Science. I am in awe every day of their accomplishments and deeply honored to be their Director. I am happy to answer any additional questions you may have.

Dr. Christopher Fall
Director, Office of Science
U.S. Department of Energy



Dr. Chris Fall serves as Director of the Department of Energy's Office of Science, the lead federal agency supporting fundamental scientific research for energy and the nation's largest supporter of basic research in the physical sciences. He oversees the Office's two principal thrusts: direct support of scientific research, and development, construction, and operation of unique, open-access scientific user facilities that are made available to external researchers. The Office of Science also is responsible for stewardship of 10 of the Department's 17 national laboratories.

Before joining the Office of Science, Dr. Fall served as a Senior Advisor to the Undersecretary for Energy and as Acting Director of DOE's Advanced Research Projects Agency-Energy (ARPA-E). Dr. Fall came to DOE from the Office of Naval Research (ONR), where he served for more than seven years in a variety of roles including Acting Chief Scientist and Lead for the Research Directorate, Deputy Director of Research, Director of the International Liaison Office, and the ONR Innovation Fellow. While on loan from ONR, Dr. Fall served for three years in the White House Office of Science and Technology Policy as Assistant Director for Defense Programs and then as Acting Lead for the National Security and International Affairs Division. Before government service, Dr. Fall was a faculty member at the University of Illinois at Chicago in the Bioengineering and Anatomy and Cell Biology departments. His research program included the study of resilience of energy production in neurons, and the measurement and modeling of coupling between cellular energy production and cellular signaling systems. He completed postdoctoral fellowships at the University of California at Davis Institute for Theoretical Dynamics and the New York University Center for Neural Science.

Dr. Fall earned a Ph.D. in Neuroscience and a B.S. in Mechanical Engineering from the University of Virginia. He also holds an MBA from Northwestern University's Kellogg School of Management.

Chairwoman FLETCHER. Thank you so much, Dr. Fall. We will begin our first round of questions. I will start, recognizing myself for 5 minutes.

And I thank you for the update, and congratulations to the entire team. I think we are all impressed by the incredible work that's being done, and I want to touch on two things you just talked about in your testimony. First, you mentioned competitiveness in the current environment, and we know that the Office of Science's national labs have several world-class user facilities, including five light sources, two neutron sources, an array of particle accelerators, the fastest supercomputer in the world, Summit, which is located at Oak Ridge National Lab. In terms of the technological capabilities, power capacity, and access, how do these facilities compare with competitors around the world, and how do our investments in these facilities contribute to the U.S.' global leadership in scientific research?

Dr. FALL. Well, thanks for the question. I'd say they compare very favorably. Most obviously, supercomputing is the most famous, where we're sort of strikingly ahead at the moment, but it's a "horse race," and so it's not a place where you can let up, you know, your guard. We're developing new technologies, particularly important are accelerator technologies, and these are also fundamentally dual use. So while we're pushing forward the frontiers of science, and the capabilities of these machines, we're also developing technologies that are relevant to national security, as are other countries around the world. We mentioned China earlier. They are very keen to compete with us not just to have capabilities, but to attract scientists from around the world, which is what these world class facilities do. So I'd say we're in a reasonably good place, but it is a "horse race." Europe, the United States, China, Japan, it's not so differentiated when it comes to those key technologies.

Chairwoman FLETCHER. Thank you, that's helpful. I think the other topic I definitely want to touch on, in the context of this "horse race," and this competitive international environment, there also is an emphasis on international collaboration, and in your testimony you mention the global nature of the research conducted at the Office of Science, and threats of misappropriation of technology that that raises with the international collaboration. Kind of relating to that topic, I think one of the things that's going on simultaneously is that the Administration's been taking steps to restrict U.S. researchers from participating in some foreign talent recruitment programs as well.

So I think what would be helpful to us is to understand what actions the Office of Science has taken in response to that directive, and also how you can balance the need, or how you are balancing the need, for protecting against potential misappropriation, while at the same time participating in the collaborative international efforts that benefit the American research enterprise. Can you just talk a little bit about that to us?

Dr. FALL. Sure. Well, let me start by saying for the Department of Energy, it's not just the Office of Science. This has been—the effort to deal with misappropriation of technology, and foreign talent programs, and other sorts of behavior we characterize as not in the best scientific and technological values around the world. We're following the same guidance from originally the Deputy Secretary, now Secretary Brouillette. Yes, we've made it clear that if you are a member of a foreign talent recruitment program, particularly related to countries at risk, you will not be employed by the Department of Energy. It's sort of that simple and that complicated.

Now, at our laboratories we've announced publicly that we've developed a technology risk matrix of key technologies, and their relevance to economic and national security, and so we use that to evaluate how likely we are to collaborate with a number of foreign partners, particularly those for countries at risk. That's now a part of our laboratory structure as well—whether or not we will collaborate in certain technology areas, and that's where we are right now.

And what we're doing at this point is pausing a little bit to see what the effect is because, at the end of the day, I think we all understand that China is a science and technology juggernaut, and in the long term we're not going to be able to just close the doors and shut the windows. We're going to have to find a way to modify behavior and work together in some areas with the Chinese. So we're looking for a response, and we're also pausing to allow the interagency to take a breath, figure out what we've all done, and together—what's more important than the Department of Energy putting out a new policy about this, that, or the other aspect of this, it's that we do all of this together with the other agencies, like the National Science Foundation (NSF), Department of Defense, and others who fund research. So largely looking inward at our laboratories and our employees, not yet imposing policies on the extramural community that we fund at universities and so forth.

Chairwoman FLETCHER. Thank you, that's very helpful. And I just have a little bit of time left. I did also notice in your testimony that you mentioned the hope of renewing and refurbishing some of the facilities, so that comment was not lost, and part of my last question that maybe you can just touch on throughout the hearing is the ways that we in Congress can help advance these policy and other initiatives from this Committee, the things we can do to be helpful to you would be very useful to us.

So I've now gone over my 5 minutes, and I will recognize Mr. Weber for his 5 minutes of questions.

Mr. WEBER. Thank you, ma'am. Dr. Fall, last week I was pleased to see that DOE announced the selection of Brookhaven National Laboratory as the site for the construction of the electron ion collider, an essential new nuclear physics research facility. As I mentioned in my opening statement, I feel strongly that these types of DOE national laboratory user facilities provide American industry and researchers with the tools they need to maintain our leadership in science, and develop new materials and technologies. But some of these facilities, like the advanced photon source at Argonne National Lab, and the advanced light source at Lawrence Berkeley National Lab, are in need of those critical infrastructure upgrades we talked about. We want them to remain the best in the world. These are upgrades we pushed for with bipartisan infrastructural legislation that passed the house last Congress.

In your prepared testimony you mentioned that the Office of Science is currently working to upgrade both of these facilities. Can you give us a status update on both of those projects, and then what new opportunities they might afford American researchers, please, sir?

Dr. FALL. Yes. I want to be careful to—I'll circle back with particular details of dates and so forth, but we've certainly, for both of those, entered into what we call, in DOE jargon, CD–3A, which is advance procurement for the kinds of long lead time things that we need to buy for these facilities. The magnets, for example, take a long time to build and source, and other materials like that.

So the projects have gone through our stage gates, and are on track, and on budget, and we feel both of those are in good shape. And I do just want to differentiate, as you did, the projects, which are in great shape, from the underlying labs, which we still have some work to do on, in terms of the infrastructure, like electricity, in the case of these synchrotrons, light sources, that need to be reliable. As you may have heard, Berkeley National Laboratory, because of the fires in California, had to shut down twice, at a significant cost to the taxpayer, because you don't just turn off the lights at these laboratories, and as far as the current leadership is aware, it had never shut down before. So twice in the space of just a couple of months, so the reliability of multiple power sources, that sort of thing, is kind of important.

Mr. WEBER. And new opportunities it might afford American researchers?

Dr. FALL. Absolutely. Every time we—so there's the science, and then there is the technology, and the engineering that goes into building these amazing machines, and that is—absolutely, you know, diffuses out from the laboratory complex, and has wider applicability. Magnetic—I'll just say something you may know already, that magnetic resonance imaging came out of the magnets for these facilities, right? I mean, the original magnet technology led to the development of magnetic resonance imaging that has changed our lives, and so all sorts of opportunities.

Mr. WEBER. All right. We never know when that next great discovery is just right around the corner, so this is pretty exciting stuff. Dr. Fall, last week the DOE announced the launch of the Energy Storage Grand Challenge, a comprehensive program that builds on the Administration's Advanced Energy Storage Initiative to accelerate the development, commercialization, and the utilization of next generation energy storage, the technologies that will sustain American global leadership in that particular area. As director of this Office of Science, what will you do to support and help make sure we maintain these initiatives?

Dr. FALL. Thank you for the question. It is a huge opportunity. As we know, there's phenomenally good penetration of renewables in our country: Wind, solar, others. The Achilles heel is grid-scale storage, and so that's why not just the Office of Science, but the Secretary has directed the whole of the Department of Energy—this grand challenge is a whole Department initiative, including at NNSA (National Nuclear Security Administration), partially. They have less of a role, but the Applied Offices, and of course the Office of Science, where we do the fundamental work on batteries, characterizing batteries, for one, basic material science that feeds into the applied side for batteries and other modalities as well. So we're participating fully. Again, it's a whole of department effort at a very high level. This has the personal attention of the Secretary.

Mr. WEBER. Real quick, in the time I have left, in your opinion, what basic research programs in the Office of Science are the most essential to development of that next generation energy storage technology?

Dr. FALL. Typically energy technologies in general are a material science problem. Critical materials and material science, that's what leads to a lot of advances in all sorts of advanced energy technologies.

Mr. WEBER. OK. I thank you, sir, and, Madam Chair, I yield back.

Chairwoman FLETCHER. Thank you, Mr. Weber. I'll now recognize Mr. Lipinski for 5 minutes.

Mr. LIPINSKI. Thank you. I'd like to thank the Chairwoman for holding this hearing today, and thank you Dr. Fall for being here today. As Director of DOE's Office of Science, you're responsible for overseeing the Department's Advanced Scientific Computing Research Program. I think it's more important now than ever that the Nation's leadership in high performance computing is maintained because of national security, economic prosperity, and innovation that are critical to our country. And I'm proud that the first exascale computer in the Nation, Aurora, will be built at Argonne National Lab, which is in my district, but I'm concerned that we're in a tight global race through the completion of the first exascale computer in the world. I mean, it could be the first one in the world if we got there before China does.

So I'd like to ask if you can give an update on the Aurora project, and discuss the potential for exascale computing, and the ramifications if we fall behind in this race. And I just want to say I know Ranking Member Lucas has been there—also had mentioned exascale computing in his opening.

Dr. FALL. Well, thanks for the question, sir. I think we're in pretty good shape with the program. I will tell you we're spending every penny that you apply to this program to move as quickly as we can. I think we will get there first with the machines, but there's so much more to high performance computing than just the machines, and I just want to brag a little bit that we're covering all of those bases in a way that we believe that our competitors are not, and that includes the high speed Internet, interconnects between the generation of data and the computation on the data, our ESNet. That includes completely, at the same time we're building these exascale machines, reworking and modernizing the software stack that goes into those machines.

And that's a top down, sort of once in a generation reworking of this to move it from what amounts to cottage industry scientific computing to using the best software development tools, and cross-disciplinary libraries for computation, and that sort of thing. So there's a lot more to it than just the machines. We still think we're going to get there first on the machines. And, again, we're spending every dollar that you appropriate——

Mr. LIPINSKI. So are you saying you need more? More money?

Dr. FALL. I can't—no, I wouldn't say that. I'd say we're just right where we want to be. But we're spending every dollar that you give us.

Mr. LIPINSKI. No, go ahead, say you need more money. I'd be happy to hear you say it. So Aurora and other DOE supercomputers are just part of the Department's work in artificial intelligence (AI), and I know that the Administration has taken steps to improve coordination on AI, but I believe that these coordination efforts could be improved.

Earlier this year I introduced the *Growing Artificial Intelligence through Research Act*, which, in part, ensures that there is a central coordinating entity. So, Dr. Fall, can you describe how the Office of Science, particularly the Advanced Scientific Computing Research Program coordinates with the Department's Office of Artificial Intelligence and Technology?

Dr. FALL. Sure, and maybe I could offer just a little more beyond that. So the AITO, as it's called, Artificial Intelligence Technology Office, is simply a coordination entity, so it doesn't run programs, it's not appropriated to run programs. The programmatic decisions on what to spend money on, on hardware, on software, and so forth, happen in the Office of Science. They happen in the laboratories and programs under the Undersecretary for Energy, and also in the National Nuclear Security Administration, but there's a lot of things that we don't need to do three different, four different, X different times. Develop the technology once, try a new hardware example once, and the AITO's job is to make sure that we are being as efficient as we can, and also, you know, getting out of our parochial focus on science, and looking out to the remarkable blossoming of AI across the commercial sector, and make sure we're buying what we can buy, instead of having to grow it ourselves or build it ourselves. So this Office does play a really important role, and we're completely synced up with it.

Mr. LIPINSKI. And how would your AI efforts benefit from additional coordination with other Federal agencies?

Dr. FALL. Well, we're there also. So I guess that's what I could've gone into there. So this is a place where the White House is doing an exemplary job of coordinating across the Federal Government. There are at least two, that I can think of, AI-focused bodies, one at a higher, you know, level, and then a more working level. They meet regularly. I participate in those. We are connected, because of them, with the JAIC Program in the Department of Defense, and with other major, you know, many agencies are now working on this. So I'd say the coordination is actually pretty—this is a good news story across the government, coordination, and a sense of purpose about the need to actually win at this game. And it is very important.

Mr. LIPINSKI. And if I can't return for another round, I'll give you a question about the National Quantum Initiative for the record, though so I yield back.

Dr. FALL. Thank you.

Chairwoman FLETCHER. Thank you, Mr. Lipinski. I'll now recognize Mr. Lucas for 5 minutes.

Mr. LUCAS. Thank you, Madam Chair. Dr. Fall, as you know, bipartisan Science Committee legislation H.R. 4091, the *ARPA-E Re-*

authorization Act of 2019, authorizes key reforms of the Department of Energy's ARPA-E program regarding research scope, program evaluation requirements, and efforts to avoid duplication. And, being the next questioner after Mr. Lipinski, it's only appropriate that I ask you, as current Director of the Office of Science, and the former Acting Director of ARPA-E, can you please describe, using specific examples, if you can, the level of intentional complementary research performed between the Office of Science Programs and ARPA-E funded programs?

Dr. FALL. Yes, and I could probably offer you, after the fact, more of a laundry list of the opportunities, but let me just give you one. Earlier today——

Mr. LUCAS. And this leads us over into discussion about how you facilitate and——

Dr. FALL. Right.

Mr. LUCAS [continuing]. Make that happen. If you would?

Dr. FALL. I can do that as well. We talked about fusion energy a little while ago. There's an example where just now we are working with ARPA-E to put together a joint funding announcement. There's one concrete example. The benefit to the Office of Science of working with ARPA-E is this sort of special forces nature of ARPA-E, that they can move quickly, attack a problem with a lot of focus, and with energy derived from bringing people in from the outside to run those programs, and so we're always happy, if not to co-fund, then to co-scope. So when we're working up a funding opportunity in the Office of Science, just as a routine matter, be involving program officers, and even contracting officers because of the way they know how to do business in a different way, into our process. This is what we did with the quantum initiative that we just launched last week. This was a cross-agency effort that included ARPA-E to, what are we missing here in terms of the ability to move quickly?

Before Secretary Brouillette became Secretary, as Deputy Secretary he started something called the RTIC, Research and Technology Investment Committee, at the Under Secretary level so NNSA, Energy, Science, and the Deputy Secretary, and ARPA-E, for just his high-level coordination function, and that's going very well. The working group under that does topical deep dives, like advanced energy storage, like artificial intelligence, and so forth, and reports up to the Under Secretary level to assure that we are doing all the cross-fertilization that we can find opportunity for. And so that's relatively new, you may or may not have heard of that already.

Mr. LUCAS. Dr. Fall, as I mentioned in my opening statement, I'm pleased to see that the fiscal 2020 appropriations numbers have adequately provided for U.S.' contributions to the ITER Program, the world leading international research collaboration into fusion energy that's received strong and continued bipartisan support from this Committee. As Director of the Office of Science, what will you do in FY and beyond to help ensure that U.S. ITER programs receive the resources that it needs?

Dr. FALL. Well, we will follow the law. You've appropriated the money, and it will go——

Mr. LUCAS. Thank you, first. That's a very important point.

Dr. FALL. Yes. Of course we'll follow the law. We're also working very hard, frankly, to stimulate our domestic fusion, including fusion energy startup community that, at the end of the day, will feed into ITER, and projects that go beyond ITER. We recognize the intent of Congress, and we will follow the law.

If I can just offer a little awareness—I don't know if it was intentional, but I think it bears understanding that we did receive an increase of $110 million in order to fund ITER, but received an overall increase for fusion energy for only about $107 million, and so the obvious consequences, we're making some choices there. And I understand budget negotiations are complicated, but we'd like to see, if I may—always great to have super support. We'd like to also support the domestic, you know, be able to say that we're doing something in a relatively balanced way, in terms of increasing support. If money goes to ITER, we'd also love for money to go to the domestic side as well.

Mr. LUCAS. Absolutely, Doctor. And, as you well know, as authorizers, part of our process is to help, in a polite way, educate the appropriators about common goals we all have together. With that, thank you, Dr. Fall, yield back the balance of my time, Madam Chair.

Chairwoman FLETCHER. Thank you very much, Mr. Lucas. And I would just like to note, Dr. Fall, that for the upcoming year, one approach you could take that would be particularly helpful would be if you submit a budget request for both of those items, and that would be very helpful to us. And now I would like to recognize Mr. McNerney for 5 minutes.

Mr. MCNERNEY. Well, thank the Chair, and I thank you, Dr. Fall. I think you have one of the most interesting and fun jobs in government. Little bit of jealousy here. But in your written testimony you noted that your agency is, "in the process of launching and expanding a number of new initiatives, including incorporating artificial intelligence and machine learning into many of the new things we do across the Department," sort of following up on earlier questions. I know that the DOE has recently established an AI and Technology Office, which was already discussed. Can you speak to some of the DOE's plans for leveraging its existing computing infrastructure to develop AI and keep our leadership in that area?

Dr. FALL. Well, I would say, yes, sir, existing and planned. All of these new exascale machines have artificial intelligence in mind, so we're designing the processing ability from the ground up to be able to handle traditional and artificial intelligence problems. And we're also, as we contemplate the construction and installation of these new supercomputers, thinking of a sort of plug-in test bed model. So I don't think there is technology available yet to scale to some of the new computing architectures that really fulfill the promise of AI, but small machines can be plugged into the large machines to test that capability, for example.

So this is being done in an extremely thoughtful way, I can say. Again, both the hardware question for AI, the software question, and the use cases. So there's just a whole variety of use cases across the Department of Energy, and one that I'm particularly excited about, because I'm responsible for these 10 laboratories, is, you know, it's no secret that Amazon, and Google, and companies like that use AI to improve their bottom line, right? They make more money by extracting data and understanding it. We think that we can use AI for operations in the Department of Energy as well. So think about acquisition, human resources, the use of, you know, spending we do on energy, lights, and so forth, that we can turn those tools on the operation of our laboratories, and even the Department as part of this cross-agency AI push, and get efficiency using AI, in addition to the science and technology mission. So that's pretty exciting, I think.

Mr. MCNERNEY. Well, if you do that, then I hope you sort of develop products that can be used in the private sector as well. So, for the world to meet meaningful emission reductions in the next few decades, we'll need to invest in negative emission technology. I was pleased to see that in Fiscal Year 2020, the Energy and Water Appropriations Report directed funding to be used for crosscutting initiatives between the Office of Science, Biological Environmental Research, and Basic Energy Sciences program. Can you elaborate on specific plans and research in this area and the Office of Science?

Dr. FALL. I can tell you that we just discussed it this morning. We have specific plans to do it, we don't know exactly what those plans are yet. You know, it—just come out of the budget cycle. But the question that we have, and we haven't made a decision, is whether to increase funding of existing hubs and mechanisms that we already have in place that do some of this work, or to go down different avenues, or both. We just have to make some choices. But we're on it, and I assure you that the money will be spent as directed.

Mr. MCNERNEY. Yes. Do flow batteries have promise?

Dr. FALL. That's something that ARPA-E invests more in. We do, you know, we could help with the basic chemistry there, but both the basic chemistry and the engineering of those things—that's not my area of expertise, and so I'd like to get back to you on that. But on the negative emissions, I do want to acknowledge your direction to work with the Office of Fossil Energy on negative emissions, and we're having those conversations already, so the direction is being followed.

Mr. MCNERNEY. So following up on Mr. Lucas' questioning, I'm enthusiastic about fusion power, the prospects of fusion power. What are the different types of fusion power that are moving forward in your Department?

Dr. FALL. Well, the two big ones are, obviously, inertial and magnetic confinement, and that's been the case for some time. One interesting opportunity that our ARPA-E organization has explored is that middle ground. You know, and that middle ground is being sort of attacked by this amazing growth of a community of startup companies in this country, thinking that these intermediate technologies—you don't need to build something as big as ITER, or as big as NIF (National Ignition Facility), in order to get to a successful place in fusion energy. And we're very interested in continuing to support this community, you know, both through traditional science and technology funding, but also through new mechanisms, using our labs as resources that these companies can access, potentially even moving toward what NASA (National Aeronautics and

Space Administration) calls their COTS (Commercial Orbital Transportation Services) model for, you know, *Space Act* sorts of authorities to put together public/private partnerships to grow industries. There's a lot of opportunity here, sir, and we're extremely excited about this, you know, both the participation in basic research, and in demonstration projects like ITER, but also in this intermediate startup space.

Mr. MCNERNEY. Well, you know, there used to be the joke that it's 50 years away. I don't think that's the case anymore, is it? I mean, we have real prospects now, right?

Dr. FALL. Well, I don't want to do math in public, but it still is a ways off, but we're certainly moving quickly toward that goal.

Mr. MCNERNEY. Thank you. I yield.

Chairwoman FLETCHER. Thank you, Mr. McNerney. I'll now recognize Dr. Baird for 5 minutes.

Mr. BAIRD. Thank you, Madam Chair. And, Dr. Fall, in your prepared testimony, you state that one of the Office of Science's goals is to enhance the U.S. biosecurity. So I come from an agricultural background, and I represent a district that is deeply rooted in agriculture, so could you share what might be being done in the biosecurity, and that agricultural industry?

Dr. FALL. Well, less in agriculture, because that's the mission of the Department of, you know, we're sort of constrained a little bit by the rules and the laws about what we can work on, but the enabling technology is something that we've been doing stretching back to our participation in the Human Genome Project. So we know how to sequence genes, we know how to understand what genes do in cells. We're very interested to leverage one of our superpowers in the Department of Energy, and that's convergence. That's putting together biology with physics, and mathematics, and computing to understand biology in a fundamentally new way, and explore the opportunities of engineering biology for health, for products, for agriculture, but also, you know, when you can change biology, there's a threat involved, and so understanding what the threat space is, and being prepared to defend against that is something that we can do at the Department of Energy in a sort of unique way.

Mr. BAIRD. Thank you. Also, you gave us some indication about the implementation of DOE's policies to prevent foreign infiltration, specifically in DOE's basic research space and at the national labs. Could you elaborate on that, or at least give us some idea how we're preventing foreign infiltration into our basic research?

Dr. FALL. Well, I did mention that we have a policy about the foreign talent recruitment program, so this is, you know, this is a way of recruiting, you know, basically appropriating technology from other countries. That's a no for us. At the same time, we are, you know, massively increasing our ability to understand who is at our laboratories. You know, who's at our laboratories, where are they from, what are they asking to do there, and have a filter for that. That's really important, while recognizing that science is a fundamentally international activity, and we lose by saying no to everybody. So it's a tough problem.

So the Foreign Talent Program's relatively easy. The understanding who's in and who's out of our laboratories is also relatively straightforward. Then we have to make the decision about, you know, who to let in, and who not to let in. Fundamental to all of this is enforcing policies that we've actually had in place, as have other agencies for quite a long time, and that's disclosure. You know, if you're going to come and either work for us or work with us, we ask you to tell us who's funding you, where are you from, what are your affiliations? And, you know, the first step is to require a disclosure.

Second step is to ask, well, is the disclosure truthful? That's a, you know, whole separate line of business. But just that act of saying, in order to work with us, you need to tell us who you are, and what you're all about, is important. And, surprisingly, over the decades, agencies, not just ours, but I think all of us have gotten a little bit lax about enforcing the requirements that always came with grant applications and, you know, applications to come visit, and so forth. So that's a really important part, the disclosure part.

Mr. BAIRD. I can appreciate that is a real challenge, because you don't want to be so restrictive that we can't advance, you know, scientific advancement, but at the same time you'd like to have others share in the cost of getting that done, not just American taxpayers. So I thank you for your comments, and I appreciate you being here today, and I yield back.

Dr. FALL. Thank you.

Chairwoman FLETCHER. Thank you, Dr. Baird. I'd now like to recognize Mr. Foster for 5 minutes.

Mr. FOSTER. Well, thank you, Chairwoman Fletcher, Ranking Member Weber, and Dr. Fall for joining us today. First off, I'd like to congratulate you on the siting decision on the EIC at Brookhaven. You know, these siting decisions are really tough, and Congress often does not make them easier, but as someone who's sort of a connoisseur of technical design reports, and also, probably even more importantly, the physics capability documents that really are the important ones to look at on these—when you have competing proposals. I can tell you, at least from my opinion, you made the right decision technically, and for the physics, from these. And your timing was also excellent because the National Labs Caucus was already planning a visit to Brookhaven at the end of this month, which you're very welcome to come to, if you can make it there, or send somebody to join multiple Members of Congress.

Now, as you know, Argonne National Lab in my district is working very hard on supercomputing, as well as artificial intelligence. Last November sort of snuck under a lot of people's radar screens, but Argonne tested in a commercial partnership with Cerebras, a giant wafer scale—the fastest AI engine in the world. And this is a commercial partnership that is, you know, it's great. It's the wave of the future in AI, with so much commercial money going into it. But, you know, the main program at Argonne is Aurora, which we hope will be the first exascale computer on Earth, certainly will be in our country.

But I'm a little less sanguine about the probability that the Chinese won't beat us in this, and, you know, at least some of that's due to the fact that Congress delivered a little less money than Brookhaven had requested in this year. There's a shortfall there. But one of the ways that you have available to partly make up this shortfall is with the $71 million for AI and machine learning—for a number of Office of Science programs. I was wondering, have you come up with a plan for how to allocate that money, and is it likely that that may be useful for helping some of the shortfall in the Aurora effort?

Dr. FALL. Well, I'd be reticent to commit to moving money from one to the other, because then we get the other side complaining.

Mr. FOSTER. But there is certainly opportunity there.

Dr. FALL. But we haven't decided how to spend all the dollars in terms of exactly where they're going, but we kind of know what we're going to spend it on. There's just a ton—as you know, from your background, just a ton of opportunity, from enhancing the ability of these machines to do calculations in a new way to, at the front end, sort of pre-computing, pre-calculating, pre-sorting the mass of data that comes out of the science machines, right, all along the way. Never mind, you know, running something like an accelerator using AI as an assistant, if you will.

So across everything we're doing in the Office I talked about AI for operations at the laboratories. That's, I think, novel and innovative for a Federal agency, but what's clear is the opportunity for us across the basic sciences—that's why we're spending so much money on it. It's not by accident. So I want to be cautious about committing to moving money around. You can use——

Mr. FOSTER. Yes, it's obvious that these are combined hardware/software efforts, and then there is some degree of fungibility once the money hits the laboratory. And if you build the hardware, and don't have the software in place, the algorithms, the scientific participation, you don't get nearly as much out of that hardware. Another thing that came up, actually, in response to the previous questions involving biology, is one of the real areas of growth recently is in so-called cell-free technologies, you know, where you take advantage of the enzymatic pathways that nature provides, but you don't have these annoying cells around that proceed to evolve and do other things to wreck your culture. I was just wondering if that's something where you think there may be a natural area of participation for the Office of Science.

Dr. FALL. Well, absolutely, because what that allows is science at scale, which is what we do. It's the high through-put paradigm. When you can do cell-free systems in multi-well plates, using robotics to do the mixtures and so forth, that's where you get a whole lot of information very quickly, and that's the kind of thing that the Department of Energy does is big science, big machines, integrated data, and so forth. So I would say yes.

Mr. FOSTER. So I'd just encourage you to have a look at that, because it's a new field, and it sort of falls between the cracks in some ways. And then finally, on quantum, there are three broad buckets. There is building quantum computers with technology at hand, there's quantum instrumentation and sensing, which is often separate thing, and then there's developing fundamental sciences, new materials, and devices in support of quantum. And, to make it even more complicated, you have the military off on the side, you have significant efforts, commercial. So how do you make sure that the Office of Science is focusing on what you can uniquely do best there?

Dr. FALL. And I would also add—I think you mentioned, but I'm not sure, quantum communication, exactly, which is also a low hanging fruit. So, yes, we're the Nation's experts in material science. Quantum is another place, like advanced energy, it's all about materials at this point, and also systems engineering, when you start to think about the cooling required, and so forth. So we are being very cautious.

I think that some of the direction that we're going to go in will shake out of the process by which we choose these quantum centers that we've just announced. We're expecting a whole lot of input. Not just innovative science programs, but innovative collaboration models and so forth, and so I think there's a lot of opportunity there. And I don't want to get ahead of my skis in public here, but I think you're going to hear more very soon about quantum networking and communications on a larger scale. And so we're moving as quickly as you allow us to with the resources you provide——

Mr. FOSTER. Thank you. My time is up, and I'll have to yield back.

Chairwoman FLETCHER. Thank you very much. I'll now recognize Mr. Cloud for 5 minutes.

Mr. CLOUD. Thank you, Madam Chair. Dr. Fall, we appreciate you being here. You mentioned that China is a technological juggernaut, and it occurs to me that this isn't because of necessarily major breakthroughs that they've made, but rather our naivete toward them over the last few decades, and the fact that they're stealing technology from us and others. You mentioned some things that we're doing, in the sense of being careful about who we're allowing to work at the labs and such, but could you speak to what else DOE is doing to better secure the Office of Science Research against, for example, cyber theft?

Dr. FALL. Well, yes, let me start by saying much of what we do in terms of results is public science anyway. You know, we publish the work because we're a basic science organization. Many, but not all, of our laboratories, because they're funded by multiple sources, also have national security missions, and we sit in a department that has perhaps the most sensitive national security mission in the country, with the strategic deterrent and those weapons. We know how to do security, and we live in an environment—it's funny that I often complain about how most Americans don't understand the role that the Department of Energy plays in science. They don't know that we have labs, they don't know that we do all this work, and that's because we spent the first 70 years of our existence not telling anybody what we do, right? So we understand security. I think, part of the problem is actually advertising the amazing things that we do.

Secretary Perry, before he left, stood up CESER, Cybersecurity, Energy Security, and Emergency Response division, and a whole new Assistant Secretary in the Department of Energy just focused on cybersecurity, and that's cybersecurity of the grid, cybersecurity of the lab, cybersecurity of operations. We're attacking the problem. We understand that it's a problem always, and—but we do come from a posture of understanding security problems. It's not a naivete——

Mr. CLOUD. Right. I get the picture, I always have, with regards to China and funding, I mean, we spent I think $7 billion last year from Congress, and it's the picture of this bucket that we're pouring into, but there's a hole in the bottom going into a bucket that China's sitting there, you know? And so when we think about how to expand our capacity, it's not just more funding as it is, sometimes, I think, closing that hole a little bit so more stays in our bucket.

We know China's sending foreign actors to universities, for example. Some of our research dollars are going to universities, and working with that. Of course, that's not every student there, but certainly there are foreign actors. Is there anything that we're doing in regards to making sure that research funding that's being funded by taxpayer dollars isn't going to fund the China government initiatives?

Dr. FALL. Yes, sir. We're not rolling out any policies at this point, but we are having—a little bit earlier I mentioned that we are participating with the inter-agency—we want to make sure that any steps that we do take regarding extramural research to universities and other organizations is done in coordination with all the agencies so that we do it the same way. For all sorts of reasons, it's not going to work for the Department of Energy to have sort of rules, and NSF another set, and so forth. We recognize the problem, and we are actively discussing alternatives. It will probably take some authorizing, you know, changes to authorization and so forth, because there are rules about how you, you know, open access here to funding and so forth.

Mr. CLOUD. Right. OK. Shifting gears a little bit, could you compare/contrast where we are in China when it comes to AI, and then specifically what the DOE's doing to apply advancements in AI toward how we manage our electric grid?

Dr. FALL. Yes. I would defer Part B, which is the electric grid, to the Assistant Secretary for Electricity—but I can tell you that we're working closely together. The Office of Science provides the basic AI technology, the machines and so forth, and, frankly, the connections out to industry and academia. They're leveraging it. I'm not current on exactly what they're doing, but I know it is a complete priority. The Office of Electricity and Cybersecurity, and Emergency Response Assistant Secretary is for protecting the grid, which is largely an Internet of Things. I mean, it's absolutely a threat. Part A was, I'm sorry, China and——

Mr. CLOUD. Compare our capacity to China when it comes to AI.

Dr. FALL. You know, this is another place where it's a footrace with no clear—I would say no clear—it's hard to say who's ahead in AI, frankly, and I think most experts would agree AI is a little bit still of a boutique industry. There are more researchers in China working on AI than there are in this country. And also, one of the key enablers of AI is data, and we all know you don't need to have a poor social score to understand that China is amassing a lot of data on people, and things, and processes, and putting it together for use in a way that we don't in this country on principle. And so there is an advantage there for them in terms of AI, but, of course, the consequences are things that we prefer not to entertain, like personal social scores.

Mr. CLOUD. Thank you. I yield back.

Chairwoman FLETCHER. Thank you, Mr. Cloud. I'll now recognize Mr. Lamb for 5 minutes.

Mr. LAMB. Thank you, Madam Chair. Dr. Fall, thank you for joining us today, and for all your service to the country. In 2018, the *Department of Energy Research and Innovation Act* was signed into law, and I believe it required the re-establishment of a low dose radiation research program, the idea being that a lot of the basic scientific data underpinning radiation limits and requirements had a lot to do with survivors of the atomic attacks. It might not have been as directly relevant to, for example, the plant workers at the nuclear plant in my district who experienced low levels over a long period of time, so with the goal being just accuracy as far as what we know about where those measurements and what those regulations need to be for the health of the workers, but also the competitiveness of the industry.

I think again in FY 2020, we directed the establishment of another low dose radiation research plan, or same one, just funding for it. Just asking for an update on progress in that area. Does that sound familiar to you?

Dr. FALL. Yes, sir, of course. And I'm going to be really careful with the words, because I think it was established, not re-established, and that's germane because our position is that there are some new opportunities here, technologies that we didn't have originally, things like computational, things like cell-free and other mechanisms so we're actively—we understand we've been directed to do this. We understand that we're directed to spend a certain amount of money, I believe it's $5 million this year. We're going to do that.

We are in active conversations with the National Cancer Institute at NIH (National Institutes of Health), who has similar problems, if you think about the causes of cancer, and the impact of imaging, like x-rays and so forth, so they want to understand this as well. So we're working with them, as well as an inter-agency group under the Office of Science and Technology Policy, who's getting together and saying, "hey, here are our options here. It doesn't make sense to do five different things. Let's get together on a low-dose program." So we are following the guidance, we think, in a way that makes sense, and I'm happy to get you more detail on that. I do know that we haven't made any particular funding decisions on people or places yet, but happy to keep you up on the details.

Mr. LAMB. Great. Just making sure it's underway. Thank you.

Dr. FALL. Absolutely it is, yes, sir.

Mr. LAMB. And then I wanted to ask about fusion, and some of my colleagues did as well. And I had the chance last summer to visit the project up at MIT, which is really just an impressive and fascinating piece of work, and they're doing pretty well now with private-sector funding. And one of the things that I came to understand in the history of that project was the importance of Federal funding, you know, throughout so many years of their history, particularly on the research on the magnets, and now they're not really receiving Federal funding for that project anymore. And so first question is just of in line with what you said earlier about the $110 million and the $107 million, are you concerned that too much of our Federal share of fusion research, or all of it, is going to ITER, basically, in the sense that we're kind of putting all of our eggs in one basket, as opposed to cultivating some fusion research here at home at the same time?

Dr. FALL. Well, I wouldn't go that far, because obviously it's a $670-something million dollar program, fusion, plasma sciences, and so forth, and some part of that is going to fusion, $240-something, I believe. I'm more worried about the balance. I'm worried about sustaining both. If we're going to participate in ITER, we also should be paying attention to nurturing these folks. We have a lot of great ideas, and, of course, there is an enduring question, if there's going to be a demonstration project in this country, should there be one here? Sorry, in the world, should there be one also here? I can offer that there's probably, you know, we love all of our programs equally. I think I can offer that our Undersecretary for Science, there's no program that's more important to him than getting fusion on a right path, and so we're paying an awful lot of attention to this.

Mr. LAMB. Perfect. And if I could just ask you, right before my time runs out, there was this National Academies' report at the end of 2018 that kind of talked about doing demonstration here at home, but particularly emphasizing the advances in high temperature magnets in kind of a smaller, faster, more efficient approach. Is that promising? Is that something you think the government should be investing in, and will we need to give new authority to make that possible.

Dr. FALL. Right, high-temperature superconducting magnets. Yes, and then—well, I don't want to say we should go forward. What we are going to do, what we've already done, is contacted the National Academies, it was the Burning Plasma Report, and asked them to do a follow-on discussion. They recommended doing a demonstration plan, but with no guidance beyond that. We'd like them to explore that in detail, tell us the options, tell us what they think it would cost us to do that. We've already started the conversations with that to get more information. It's certainly something we should understand, and then we weigh, you know, the costs and benefits of doing it here versus other places.

Mr. LAMB. Excellent. Thank you very much. Madam Chair, I yield back.

Chairwoman FLETCHER. Thank you, Mr. Lamb. I'll now recognize Mr. Casten for 5 minutes.

Mr. CASTEN. Thank you, Madam Chair. Thank you so much, Dr. Fall. I think I'm the only thing between you and the end of the evening. Really appreciate you coming out. I have the good fortune to have a district that just to my west is Fermi Lab, and just to my south is Argonne, and have had the pleasure of touring both, and meeting with a lot of your scientists multiple times, and I appreciate having the opportunity to nerd out so close to home, so I appreciate that.

I want to talk specifically about climate change, and what we're doing for it, which is, in many cases, a deployment problem. We under-deploy lots of proven technologies, but there's a hugely significant role that the national labs play, and in particular there's some really interesting work going on at Argonne around energy storage, and I've been involved in the *Promoting Grid Storage Act* to increase funding, and I don't know if it's sufficient, frankly, but, you know, but at core we have more than enough clean, zero cost energy to run the country, but it isn't where the loads are, and it's not always running at the time that the loads are there. And either we need to figure out how to build a lot more transmission than we've figured out politically how to build, or how to deploy a whole lot of storage around the grid at an efficiency level that's much higher.

So could you, you know, I think we gave you a $420 million increase in your budget last year, which I look forward to hearing how you're going to use, but tell me, if you would, where you see the gaps in energy storage, and, if you'd like, transmission, from a science perspective, what we are doing, and what we should be doing more of to try to bridge those gaps.

Dr. FALL. Well, thank you for the question. Someone was asking earlier about cybersecurity for the grid, and the intersection of AI with the grid. I would say also what hasn't been mentioned here today is the opportunity that automating the grid provides for squeezing more out of it. So, you know, using AI, using Internet enabled, using, you know, computational technology to understand energy flow on the grid lets us do more with less generation, for example.

But, that said, this is why the advanced—we talked a little bit, excuse me, earlier about the Energy Storage Grand Challenge. I think that we feel in the Department that we're on a great track, and moving rapidly, mainly due to market forces, frankly, on the deployment of renewables. But the "Achilles' heel" for more renewables, you have to have storage. You've got to have the load, you know, available, as you said. Reliable electricity is really important, and so storage is the most important piece. And I would say, of all of this, of storage and renewables and so forth, something we do in the Office of Science, in terms of materials science, something that ARPA-E does a lot more of, something that EERE, Energy Efficiency Renewable Energy, does a lot more of, in terms of closer-end technologies. I don't know if I've—happy to go back and forth here——

Mr. CASTEN. Yes, and I'd love to continue to conversation. There's no right answer to the question. I just know that if we're going to get to 100-percent renewables, we've got to solve that storage problem, in terms of the technology and the deployment. With the time I've got left I want to talk about the science of climate change. It strikes me that we have two significant gaps. There's one gap that we talk about ad infinitum, which is true, that climate models are uncertain, and they get tighter and tighter, and there's better and better computational power, and I've never met a scientist who didn't want a bigger computer. And that's fine. As against that, we have really limited tools to understand what the impact is of the policy. So, you know, we had, you know, hearings this morning that, you know, one of our witnesses was talking about changes in agricultural policy, trying to get a good understanding of, OK, if we want to get to this goal of parts per million in the atmosphere, how much can this agricultural policy change, on a permanent basis, accomplish? These are scientific questions.

So you can take either or both, but what do you think we could be doing better both to have better predictive models of what is going to happen under various scenarios, and on the other side, better models to understand for a given policy change, or behavioral change, what's the impact going forward? Because that's going to affect the amount of flow into the system.

Dr. FALL. Right. Well, I'll pass on the second, because that's not my area of expertise, and I'll maybe talk about the computational side. We made a big deal today about these exascale computers. I talked a little bit about the software stack that goes into that, and one of the things that we are doing under the BER division is completely rebuilding these Earth systems models. At the end of the day it turns out that size matters, and what do I mean by that? The scale at which you do these computations, actually, you have to go small. You have to use an exascale supercomputer in order to capture the nuances in these Earth system models, and so that's what we're buying with these exascale machines, exactly what you said, better precision on the computation. And it's not just a wish list for scientists. You have to do that in order to be able to predict the weather. You know, the better you do, the smaller spatial and temporal scale you compute on for these predictions, the longer your prediction is valid. That's for weather, that's for Earth systems, that's for all of these things. And so I think we're moving in a great direction. This is a huge effort in this division of ours, to fundamentally, from the ground up, rebuild—with the inter-agency. It's not just the Department of Energy. It's working with NOAA (National Oceanic and Atmospheric Administration), and these other agencies who have a dog in this fight to rebuild the Earth systems modeling. I don't know if that's helpful.

Mr. CASTEN. Thank you. I yield back.

Chairwoman FLETCHER. Thank you, Mr. Casten. Dr. Fall, we are almost finished, but because you gave us some really interesting things to think about, I'm going to just——

Dr. FALL. Where did I make a mistake?

Chairwoman FLETCHER [continuing]. An additional round of——

Mr. WEBER. When you showed up.

Chairwoman FLETCHER [continuing]. Just a question, so for any remaining Committee Members, if you have an additional question, I'm going to open it up for that. I wanted to follow up on your question and answer with Mr. Lamb, and just follow up a little bit on the ITER question, because my understanding is, since his appointment as Director General of the ITER International Fusion Project 5 years ago, Dr. Bigot and his team have made remarkable progress in improving the management of what may well be the most complex scientific project in the world.

As you know, the U.S. played a leading role in pushing for major personnel and management changes that have gotten the project back on track, but the last three budget requests for ITER have been a fraction of the DOE-approved estimates for what it will take to minimize the project's total cost to U.S. taxpayers, and to maintain the current schedule. So my question is, do you agree that the DOE's most recent budget requests for ITER have been a fraction of what it will take to minimize the project's total cost to U.S. taxpayers, and to maintain the current schedule, and if so, how will you address that going forward?

Dr. FALL. OK.

Chairwoman FLETCHER. Easy question.

Dr. FALL. Well, first of all, let me say that Bernard Bigot is an international hero. He absolutely has turned around the ITER Organization, absolutely brought a remarkable difference to the management of the project, and things are going in a much better direction. And it is true that the budget request that we made is less than what we've, frankly, committed to in the international agreement that we're a part of. I'm not willing to go beyond that, in terms of motivation. That's between you all and the President at some point. What I will commit to, as always, is, you know, you tell us what we're going to do, and we will do that. We will follow the rules, the law, and spend the money that you instruct us to do.

Chairwoman FLETCHER. Thank you very much for that, and I do appreciate your answer in explaining to us where we are, and I know that this Committee has been particularly interested, and Chairwoman Johnson, in particular, has worked hard to ensure that the funding is appropriated, and that that goes through the process. So thank you for clarifying that for us. That was my one question, so now I'm going to turn it over to and recognize Mr. Weber for a question.

Mr. WEBER. Thank you, ma'am. Dr. Fall, earlier in your testimony about infrastructure, and the need to upgrade the basic infrastructure of the National Labs, and we talked about we couldn't attract the world's best talent if we didn't do that. One of the questions I didn't get to ask was, have you see that state of our national labs, the basic infrastructure state needing repair? Have you noticed, seen, or heard, has that impact or had a high impact on the workforce retention out in community, out in industry? Are you aware of any of that? Has that had an impact on workforce retention?

Dr. FALL. In our laboratories, yes. At the end of the day, you know, in a tight labor market, where there are a lot of choices, these things start to matter a lot. The one thing that brings folks to our laboratories is the mission, but at some point, you know, if they get paid less, and they also show up to a leaky building with old computers and all that kind of stuff, it starts to take a toll. It's important to provide modern, effective workplaces to technical people.

Mr. WEBER. So that's obviously impacted the labs. When people leave the labs, do you have a sense or know where they go, and the quicker they come in and out, has it impacted the workforce? In other words, if we could retain them longer, and get them trained up, and get them really solid, would that help industry? Do you have any sense of that at all?

Dr. FALL. It would help industry side. Guess I'm not following your question exactly, but we're—let me just take one step back and say my personal opinion is we've got these three legs of the stool. We've got industry, we've got academia, and we've got our national labs, and I'm very comfortable with robust flow between those sectors. The problem we actually have is we make it hard for people to leave and come back, and this is what people want to do.

So if we could lower the barriers, I think we'd all be in a better place, industry, and the Labs, and——

Mr. WEBER. Well, that really is my question, because they can go to the Labs, great training grounds—a lot of good work in, take that expertise, go out in an industry. And then do really good stuff for industry, but if we're not kind of a training ground, if we're not—where they're applying that—I just didn't know if you were getting any sense from industry around, look, we're just not getting as many qualified people as we used to be because they come in, they don't stay that long, they go somewhere else pretty quick.

Dr. FALL. In the Labs. I mean, this is a, you know, again, tight labor market, lots of choices, lot more money in other places. That impacts us particularly in things like AI, computer science, and so forth. Hard to find too many places with particle colliders or synchrotrons. You know, if that's your thing in life——

Mr. WEBER. It's not on every corner. Although I've seen some streets in Texas that there is a lot of colliders on the corners. Thank you so much. I yield back.

Chairwoman FLETCHER. Thank you, Mr. Weber, and thank you for the comic relief. It's always appreciated. And, with that, I do want to bring the hearing to a close. But before we bring the hearing to a close, Dr. Fall, I really want to thank you for coming and testifying, and answering our questions today. The record will remain open for 2 weeks for additional statements from Members, additional questions the Committee may want to ask. But I thank you very much for being here, and now the hearing is adjourned.

Dr. FALL. Thank you. My complete pleasure.

[Whereupon, at 3:25 p.m., the Subcommittee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Chris Fall

House Committee on Science, Space, and Technology

"The Department of Energy's Office of Science: Building World-Class Research Tools and Programs for a Brighter Future"

January 15, 2020 Hearing

Dr. Chris Fall, Director, Office of Science, U.S. Department of Energy

QUESTIONS SUBMITTED BY REPRESENTATIVE EDDIE BERNICE JOHNSON, CHAIRWOMAN, COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Federal Advisory Committees

Q1. Last year, the President issued an Executive Order to all federal agencies to significantly reduce their number of Federal Advisory Committees, commonly referred to as FACAs. The National Science Foundation determined that each of its FACAs were essential for the proper stewardship of its highly technical research programs, and thus sought and received an exemption to this Order. But my understanding is that the Office of Science sought no such exemption, and was required by the Department to make recommendations regarding the elimination of several of its FACAs.

Q1a. Is this correct? If so, then why do you believe that some of the Office of Science's FACAs are no longer of value to guide its advanced research activities?

A1a. The Department of Energy (DOE or Department) cannot speak to the actions taken by the National Science Foundation (NSF) regarding its response to Executive Order (E.O.) 13875. SC's advisory committees have been instrumental in identifying new scientific directions for its communities and building the consensus around new research directions. SC remains committed to engaging our diverse scientific communities to ensure the portfolio of research and tools we maintain is world-leading, and that the U.S. maintains its position of eminence in the global scientific community. The Department continues to work with OMB on implementation of the E.O.

Q1b. What is the status of this effort? Have any determinations on which, if any, Office of Science FACAs will be eliminated, and is there a timeline for an announcement?

A1b. DOE is conducting a thorough review of all eligible advisory committees and continues to work with OMB on implementation of the Executive Order. During this period of deliberation, each of the six chartered FACAs that are aligned with one of SC's six core science programs will remain active and will continue to deliver advice to SC in support of program-related strategic planning and program evaluation.

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Energy Innovation Hubs

Q2. The Office of Science has stewarded two major Energy Innovation Hubs – the Joint Center for Energy Storage Research based at Argonne National Lab and the Joint Center for Artificial Photosynthesis at Lawrence Berkeley Lab and CalTech.

Q2a. What is the Office of Science doing to ensure that the important work carried out by these Hubs is well-coordinated with the relevant technology development programs supported by DOE's Office of Electricity and the Office of Energy Efficiency and Renewable Energy?

A2a. The Office of Science (SC) communicates formally and informally with OE and EERE regarding the Hubs. OE and EERE personnel participate in JCESR's annual reviews, and SC and JCESR researchers participate in OE and EERE program reviews. This promotes full and mutual understanding of upcoming science discoveries and technology-driven needs in energy storage research at a program level. At a management level, DOE's Research Technology and Investment Committee (RTIC) Subcommittee on Energy Storage coordinates energy storage research across DOE, including JCESR. Regarding JCAP, SC and EERE program managers hold scheduled coordination meetings to inform each other of research directions and funding opportunities, including areas related to JCAP research. They also interact informally (in-person, email, or phone) to discuss current research results from JCAP that may be ready for transition to a technology office program.

Q2b. Are there any examples you can provide of breakthroughs supported by these Hubs that are then further advanced toward a potential commercial application by these applied R&D programs?

A2b. Yes, for both Hubs. JCESR research on sulfur-based long-duration storage led to a spinoff company that is being funded by ARPA-E, and this chemistry is under consideration by OE. Research advanced by JCESR and others on lithium-sulfur vehicle battery chemistries formed the basis of the "Battery500" award by EERE. Aspects of JCAP's basic research on hydrogen production have transitioned to EERE through its HydroGEN Energy Materials Network (EMN) consortium, which aims to develop renewable sources of hydrogen; JCAP

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contributes expertise and methodologies related to the photoelectrochemical generation of hydrogen from water splitting.

Fusion Energy
ITER International Fusion Project

Q3. My understanding is that since his appointment as Director General of the ITER international fusion project about 5 years ago, Dr. Bigot and his team have made remarkable progress in improving the management of what may well be the most complex scientific project in the world. As you know, the U.S. played a leading role in pushing for the major personnel and management changes that have gotten this project back on track. Yet the last three budget requests for ITER have been a fraction of the DOE-approved estimates for what it will take to minimize the project's total cost to U.S. taxpayers and to maintain its current schedule. So I have a few questions I'd like to ask to help us all better understand the need for and the current status of this project.

Q3a. Do you agree that ITER's current leadership has done an excellent job in addressing the project's past management challenges, and are you confident in their ability to maintain this progress?

A3a. The ITER Director-General has moved aggressively to correct past management failures at ITER. Progress is evident both in the construction occurring on site and in the alignment of ITER management and staff to efficiently address project issues. My staff informs me that meetings of the ITER Council, which is the ITER governing board, have taken on the appropriate role of project oversight, and that ITER Members are pleased with the progress that the project has made during the past four years. The Director-General has recently implemented a reorganization that will facilitate the transition from construction to assembly and installation of the ITER facility. I believe that this change in management structure will help ensure continued progress at the ITER site.

Q3b. Could you provide us with a brief summary of the unique insights that the ITER international fusion project will provide for the development of a viable fusion reactor?

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A3b. The ITER facility is an experimental research reactor that is optimized to demonstrate the scientific and technical feasibility of fusion power. It is designed to be the first-ever fusion device to gain access to the unexplored frontier of the burning plasma regime, and therefore could deliver scientific and technical discoveries needed on the path toward a commercially viable fusion reactor. Construction and operation of the ITER facility, if successful, would provide understanding in fusion nuclear science and engineering science topics such as fusion fuel processing, blanket design, and tritium breeding; fusion safety, remote handling, and waste management; plasma heating and current drive systems; and the technologies for a self-sustained burning plasma. These insights would be paired with ongoing progress in materials, advanced reactor components, innovative diagnostics, high performance computing, and fusion plasma control systems, among other areas, to facilitate progress towards a commercially viable fusion reactor.

Q3(b.1). Is there a reasonable path to a commercial fusion power plant that does not include building and operating a burning plasma experiment?

A3(b.1). The National Academies report "A Strategic Plan for U.S. Burning Plasma Research" (2019) stated that any strategy to develop magnetic fusion energy requires study of a burning plasma. The Department will take this National Academies report under advisement in formulating our fusion strategy.

Q4. A report released by the National Academies last year highlighted the myriad benefits the project provides to the U.S. fusion research community's scientific expertise and our industrial capacity, and it warns of frankly dire consequences to the ability of the U.S. to ever establish a domestically-based commercial fusion industry if we pulled out of the project at this point.

Q4a. After three years in office, is the Administration still considering withdrawing from ITER, and if so, why would that make sense now given everything we've done to right the ship?

A4a. The past missteps and performance of ITER prior to 2015 raised concerns among the ITER Members. We have taken note of the excellent leadership of Director-General Bigot since then as well as the more recent performance of the project. As with all major projects, we are continually assessing performance.

Q4b. Do you agree that DOE's most recent budget requests for ITER have been a fraction of what it will take to minimize the project's total cost to U.S. taxpayers and to maintain its current schedule? If so, then how will you address this problem going forward?

A4b. The Department balances the funding for the ITER project with funding of other important initiatives in the Office of Science.

Alternative approaches

Q5. Over the past few years, several promising alternative approaches to achieving a viable fusion reactor have emerged from small and mid-sized start-ups, as well as academia and our national labs. As you likely know given your prior tenure as Acting Director of ARPA-E, in 2016 that agency established a 3-year program to further explore the potential for some of these concepts, particularly an approach called "magnetized target fusion". But, like all ARPA-E initiatives, this effort and its recently announced follow-on program are temporary, and do not have the breadth or resources to support the full range of emerging alternatives that currently receive no federal support.

Q5a. What is the Department doing to ensure that the full range of viable options to achieve commercial fusion energy are sufficiently vetted and, where appropriate, actively pursued?

A5a. One way that the Department is encouraging development of the commercial fusion sector is through the new "Innovation Network for Fusion Energy" (INFUSE), a pilot program for private-public partnerships that will provide access to technical capabilities at the DOE national laboratories. We will also work to ensure that research findings from facilities such as ITER are made available generally, which will be useful to U.S. private entities pursuing commercial development of fusion energy. Future support for the development of alternative approaches to fusion energy by the Office will also depend on the prioritized recommendations emerging from the community and FESAC long-range planning activity, currently under way.

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Q6. I understand that the Office of Science recently launched an initiative called the Innovation Network for Fusion Energy, or INFUSE for short, which provides funds to help private sector companies' partner with DOE labs to advance new fusion energy concepts. This is modeled on a similar initiative established by DOE's Nuclear Energy office.

Q6a. What is the budget for INFUSE in comparison to the fusion budget overall? Do you expect that it will be included in the Administration's request for FY21, and do you expect it to grow?

A6a. The Department obligated approximately $1.7M in FY 2019 for the INFUSE program. The FY 2020 Enacted Budget includes $4M for INFUSE. The FY 2021 President's Budget Request includes $4M for INFUSE.

Q6b. Is it your view that INFUSE will essentially serve as the Office's sole program to support alternative and innovative fusion concepts?

A6b. INFUSE continues to be the main source of support in the Office of Science for private sector efforts on alternative fusion concepts. Future support for the development of alternative approaches to fusion energy by the Office will depend on the prioritized recommendations emerging from the community and FESAC long-range planning activity, currently under way.

Q6c. How do you plan to support the development of alternative approaches to fusion energy that do not originate in the private sector, but rather from the academic or national lab research communities?

A6c. Academic and national lab research communities can form partnerships with private sector companies working on alternative approaches to fusion energy through the INFUSE program. Future support for the development of alternative approaches to fusion energy by the Office will depend on the prioritized recommendations emerging from the community and FESAC long-range planning activity, currently under way.

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Q7. The Fusion Industry Association has proposed establishing a new program modeled after NASA's Commercial Orbital Transportation Services program that would only provide federal funds to a private sector partner if specific milestones agreed upon by DOE and its industry partner are achieved. And as you likely know, the recent FY 2020 Appropriations Conference report directed DOE to develop a plan for such a program within 6 months.

Q7a. Is DOE currently considering this proposal? How soon can we expect to review this plan?

A7a. DOE is currently evaluating the potential of a cost-share program for fusion, modeled after NASA's COTS program. A report evaluating alternatives for such a plan will be submitted to the House and Senate Committees on Appropriations within 180 days from the date that the FY 2020 budget was enacted.

Q7b. What are your views on this model for federal support of advancing fusion energy concepts that are currently only supported by the private sector?

A7b. DOE is currently evaluating the potential of a cost-share program for fusion, modeled after NASA's COTS program. A report evaluating alternatives for such a plan will be submitted to the House and Senate Committees on Appropriations within 180 days from the date that the FY 2020 budget was enacted.

Inertial fusion energy

Q8. The Department of Energy Research and Innovation Act, which the President signed into law in September 2018, requires the Director of the Office of Science to establish a program to support research and development activities in inertial fusion for energy applications. Such a program would be consistent with the major recommendations of a 2013 National Academies report on this subject, which the Department still has yet to act upon, and it would likely leverage the expertise and capabilities of DOE's weapons stockpile stewardship program.

Q8a. Would you please provide us with an update on your implementation of this legislative requirement to establish an inertial fusion energy R&D program?

A8a. The Department, through the Office of Science, supports a vigorous research program on high-energy-density plasma science, which provides the scientific basis for inertial fusion energy (IFE) as well as an assessment of its requirements. This is consistent with the mission space of the Office of Science. In addition, several SBIR/STTR projects related to inertial fusion energy are being supported, and inertial fusion energy has been included as a responsive topic in several recent solicitations (SC/NNSA Joint Program in High Energy Density Science, SC Early Career Research, and the SC annual open solicitation).

Fusion energy vs. science

Q9. Unlike most other energy technology R&D efforts at DOE, fusion energy research is currently solely stewarded on an ongoing basis by the Office of Science.

Q9a. Is it your view that the Office of Science can support the full range of activities that will be required to develop fusion as an energy technology, rather than primarily focusing on the underlying science of fusion plasmas? If so, how, and if not, is it your view that a separate program in the Office of Nuclear Energy or elsewhere would need to be established?

A9a. The Fusion Energy Sciences (FES) program within the Office of Science supports several research activities in the area of fusion energy. Currently, ARPA-E also supports fusion energy research. Establishing a separate fusion energy program in the Office of Nuclear Energy or elsewhere does not appear to be necessary at the present time.

Academic Security

Q10. During your testimony you mentioned that DOE has developed and implemented a "technology risk matrix" at its national laboratories to inform decisions on whether or not to enter into an international collaboration on projects related to "key technologies" with relevance to U.S. economic and national security.

Q10a. Can you provide the list of foreign countries and key research areas and technologies that are included in the risk matrix?

A10a. DOE has established a countries of risk list. At this time, it is limited to China, Russia, Iran and North Korea. The research areas contained in the risk matrix are Quantum Information Sciences, High Performance Computing, Artificial Intelligence/Machine Learning, Biomanufacturing, Batteries, and Accelerator Sciences.

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Q10b. How did DOE determine which foreign countries, research areas, and technologies to include in its risk matrix?

A10b. DOE worked very closely with the scientific community of the national laboratory complex to create the risk matrix.

Q10c. When was this risk matrix implemented at DOE national labs?

A10c. DOE began implementation of the S&T risk matrix on December 11, 2019.

Q10d. Are there plans to incorporate this risk matrix into DOE's process for awarding extramural grants? If so, what is the timetable for that effort?

A10d. At this time, no decision has been made to extend the risk matrix to extramural grants.

Q10e. Through DOE's engagement in the Office of Science and Technology Policy Joint Committee on Research Environments, have there been discussions about implementing a similar risk matrix at other Federal science agencies?

A10e. JCORE has been briefed on the risk matrix and the approach DOE is taking in efforts of risk mitigation.

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QUESTIONS SUBMITTED BY REPRESENTATIVE HALEY STEVENS

Q1. As you know, my state of Michigan is home to the Office of Science-funded Facility for Rare Isotope Beams (FRIB). At over 90 percent complete, it is poised to be the world's most powerful radioactive beam facility.

Q1a. Would you provide an overview of DOE plans to well-instrument FRIB to realize its discovery potential and to achieve world-leading beam energy?

A1a. The FRIB facility was built with the understanding that the initial science program would be implemented with existing equipment, so scientific instrumentation was not included in the FRIB project scope. The Office of Nuclear Physics has made it a high priority to pursue the implementation of new scientific instrumentation to fully exploit FRIB capabilities. The Gamma-Ray Energy Tracking Array (GRETA) Major Item of Equipment will provide transformational improvements in efficiency and resolution well beyond that of the current generation of detector arrays and will be capable of reconstructing the position of the particle interaction with millimeter resolution. The High Rigidity Spectrometer (HRS) at FRIB will allow experiments with beams of rare isotopes at the maximum production rates for fragmentation or in-flight fission. This enhancement in experimental sensitivity provides access to critical isotopes not available otherwise. Smaller initiatives are also being pursued with grant research dollars and FRIB operating expenses. The intent is to continue developing next-generation scientific equipment for FRIB, also in cooperation with the National Science Foundation and international partners.

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QUESTIONS SUBMITTED BY REPRESENTATIVE CONOR LAMB

Q1. Dr. Fall, during the hearing, I asked you the below questions. Please provide answers in more detail for the record. You also stated during the hearing that you would be able to provide additional information on the low-dose radiation program in general. Please provide that information in your response. Thank you.

The Department of Energy Research and Innovation Act signed into law in September 2018 required you to re-establish a low-dose radiation research program to enhance the scientific knowledge of, and reduce uncertainties associated with, the effects of exposure to low-dose radiation. This research would be useful to inform industrial radiation limits. The limits we use today were created by using what we know from atomic bomb survivors, who received very high radiation doses in a short period of time and subsequently had higher associated health risks, and assuming similar adverse effects are possible with low-level exposures to radiation over a long time, as a nuclear power plant worker might experience. All this to say that this method created limits that are very conservatively calculated, and there is not currently enough science or research that would suggest this correlation is appropriate. It is imperative that this research is completed, because should the research show that the current limits are artificially conservative, nuclear power plant work would be more cost effective which ultimately would enable the nuclear power industry to be more competitive in general.

Q1a. I was pleased to see that the FY20 Energy and Water Appropriations Report included funding for the Office of Science's Biological and Environmental Research program (or BER) to develop a low-dose radiation research plan. Could you inform us of your progress thus far in this area?

A1a. In FY 2020 we are acting to spend the $5 million enacted appropriation on low dose radiation research. We are exploring ways to leverage the Department's existing partnerships with the National Cancer Institute (NCI) to explore the use of high-performance computing for cancer research and adapt this approach to address low dose radiation effects. The Office of Science has been working with the White House Office of Science and Technology Policy's (OSTP) on an interagency working group within the Physical Sciences Subcommittee (PSSC) of the National Science and Technology Committee (NSTC) to set up a coordination framework among multiple agencies with interests and/or active programs in low dose research. Both regulatory agencies such as the Nuclear Regulatory Commission (NRC) and agencies with existing radiation biology programs such as the National Aeronautics and Space Administration (NASA) are members of the interagency working group.

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Q1b. Given its history in stewarding this important field, do you think DOE is the right place to re-establish this program (versus, for example, the National Institutes of Health, or an outside of government, independent organization), and why?

A1b. Radiation is a known human carcinogen. Radiation protection regulations are intended to protect workers and the public from cancer. Low dose radiation research seeks to understand the origins of radiation-induced cancer in humans and to develop new or revised models for radiation protection. The scope of DOE's research mission does not include human cancer research. The primary agency investigating cancer in humans is the National Cancer Institute (NCI) of the National Institutes of Health (NIH). Other federal agencies also contribute to research in this area, and OSTP plays an important role in coordinating awareness across agencies. The unique capabilities of the Department's National Laboratories, including leadership computing and the light sources, would remain available for low dose radiation research in collaboration with other Federal agencies, including NIH/NCI.