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Introduction

Thank you, Chairwoman Johnson, Ranking Member Lucas, and distinguished Members of the Committee. It is with great pleasure that I join you today to represent the Department of Energy (DOE or the Department) at this hearing. As members of this Committee know, the DOE Office of Science (SC) is a cornerstone of the research ecosystem in the United States (U.S.). Through basic and use-inspired research and the development and operation of cutting-edge tools, SC delivers discoveries that are transforming our understanding of nature and enabling advances in areas of science and technology of critical importance to our economic and national security, including a just and equitable clean energy and climate change transition. SC is the largest Federal sponsor of basic research in the physical sciences and the lead in supporting fundamental scientific research for our energy future. Over decades, the investments and accomplishments in basic research and enabling research capabilities we've made have provided the foundation for countless new technologies that have benefited large and small businesses and launched new industries. These investments have contributed immensely to our Nation's economy, national security, and quality of life.

The core science programs in SC—Advanced Scientific Computing Research (ASCR), Biological and Environmental Research (BER), Basic Energy Sciences (BES), Fusion Energy Sciences (FES), High Energy Physics (HEP), and Nuclear Physics (NP)—along with the Offices of Isotope R&D and Production (IRP or DOE IP) and Accelerator R&D and Production (ARDAP) support research conducted at hundreds of universities and all 17 of DOE's National Laboratories, including the 10 for which SC has direct stewardship responsibility. SC supports different types of research programs—from single investigators and small teams to large, multi-disciplinary, multi-institutional collaborations. These programs probe fundamental questions to address nature's most compelling mysteries—from fundamental subatomic particles, atoms, and molecules that form the building blocks of our universe, to highly complex and dynamic systems, such as energy storage processes, microbial cells, and carbon cycling in the environment. The knowledge gleaned from this research provides the foundation for new discoveries and innovations that are essential to fulfilling the Department's missions.

We pursue breakthroughs in science through a global program that includes national and international partnerships that have enabled the U.S. to host world-leading facilities like the future Large Baseline Neutrino Facility and Deep Underground Neutrino Experiment (LBNF/DUNE), and for U.S. scientists to access the most advanced facilities located abroad. SC

has played an important role in the collaboration between the U.S. and the European Organization for Nuclear Research (CERN) at the Large Hadron Collider (LHC), the world's largest and highest-energy particle collider. This collaboration continues with the High Luminosity upgrade of the LHC accelerator and two large detectors, which will increase the particle collision rate and increase the reach for finding new physics.

The aforementioned advances in discovery science are enabled by investments in leading-edge capabilities and supporting infrastructure across the DOE national laboratories and the Nation. Many of the transformative scientific discoveries made by our research community are enabled by our stewardship of 28 scientific user facilities, which are available to all researchers based on the scientific merit of their proposed research. These tools include the world's most powerful computers, brightest X-ray light sources, most intense neutron sources, fastest information network, and specialized capabilities, such as nanofabrication and multiple modes of imaging, within centers for nanoscience and bio-characterization.

The expertise of the laboratory staff, and the research capabilities they help develop and operate, are invaluable assets that serve to advance the frontiers of fundamental scientific discovery, train the scientific and technical workforce in the U.S., and develop the tools and advanced instrumentation that keep our Nation at the forefront of innovation. The DOE National Laboratories are essential resources that the Nation turns to in emergencies. The complex is indispensable to the country's leadership in science and technology development to ensure our energy, economic, and national security.

In the sections below, I will discuss the Department's FY 2023 request for SC and describe our approach to ensuring we meet the needs of our community through both the research we fund and the support we provide for the development, construction, and operation of world-leading facilities.

Science Serving the Nation: The FY 2023 Office of Science Budget Request

The FY 2023 budget request for the DOE Office of Science (SC) balances competing priorities across the SC portfolio. The request supports forefront research to advance the frontiers of science, the construction and upgrade of world-leading scientific user facilities, and the operation and maintenance of these facilities. Each facet of this portfolio is essential to maintaining international competitiveness and advancing the energy, economic, and national security of the U.S. Every annual budget request is formulated with this portfolio approach to support our existing investments while simultaneously planning for future needs.

The FY 2023 request increases investments in Administration priorities including basic research on climate change and clean energy, artificial intelligence (AI) and machine learning (ML), and biopreparedness. SC's request for Reaching a New Energy Sciences Workforce (RENEW) initiative to expand targeted efforts to increase participation and retention of individuals from underrepresented groups in SC research activities is doubled relative to the FY 2022 appropriation. The FY 2023 request supports the launch of three new research initiatives: SC Energy Earthshots; Funding for Accelerated, Inclusive Research (FAIR); and Accelerate Innovations in Emerging Technologies (Accelerate). The Request also supports continued funding for priority areas including microelectronics, critical materials, quantum information

science (QIS), exascale computing, fundamental science to transform manufacturing, and accelerator science and technology. These initiatives position SC to address new research opportunities through more collaborative, cross-program efforts.

The FY 2023 request will allow the Department to continue to support the development of the next generation of scientific tools to maintain U.S. leadership in scientific discovery and technology development to support our Nation's economic competitiveness and national security. Long-term plans for facilities are informed by the scientific community though advisory committees and strategic planning reports. This community input informs budget requests as priorities are considered across the SC programs. The requested funding for FY 2023 would allow the Department to fund its highest priority facility construction and upgrades projects.

For decades, SC has been successful in the planning, execution, and operation of many scientific facilities, machines, and instruments. Since 2010, the execution of these projects has been conducted by the SC project management process, which implements a tailored approach to DOE Order 413.3B, "Program and Project Management for the Acquisition of Capital Assets." As part of this process, SC continues its over 40 year old practice of using independent project reviews to critically assess project status. This process allows SC to draw upon subject matter experts from throughout the DOE laboratory complex, domestic and international academia, and other government agencies to evaluate and determine each project's readiness to proceed to the next phase. The SC project portfolio currently consists of 65 projects that are at various phases and that span 8 programs. Since 2010, 52 projects have been completed, 94% of which were within budget and schedule.

Extending the Boundaries of Knowledge: Major Projects to Advance Discovery Science

Each project in the SC portfolio brings new capabilities to keep our Nation at the leading edge of discovery science. I would like to elaborate on the status of a few select projects and discuss how the FY 2023 budget request supports continued progress on these critical scientific investments.

Long-Baseline Neutrino Facility and Deep Underground Neutrino Experiment

When complete, LBNF/DUNE will be the centerpiece of a U.S.-hosted world-leading neutrino research facility that will use the world's most intense neutrino beam, created at Fermilab in Batavia, Illinois (Near Site), and large, sensitive underground detectors located 800 miles away at the Sanford Underground Research Facility in Lead, South Dakota (Far Site), to make transformative discoveries about the nature of our universe. The LBNF/DUNE construction project is a Federal, state, private, and international partnership developing and implementing particle accelerator and detector technology to enable world-leading research into the fundamental physics of neutrinos, which are simultaneously the most ubiquitous particles in the universe and among the most mysterious.

To optimize project execution, LBNF/DUNE has been reorganized into five subprojects to allow each element of the project to be baselined and executed when ready. The FY 2023 budget request of $176 million for LBNF/DUNE will allow the Far Site activities to remain on a technically limited schedule while maintaining planned activities for the Near Site. The current planned funding profile will allow for the project to complete fabrication in 2031, with neutrino

beam physics starting at the end of 2030 and atmospheric neutrino and supernova studies starting in 2029.

ITER

Fusion, the nuclear reaction that powers the stars and our Sun, is a potential source of inherently safe, non-carbon emitting, and virtually limitless energy. Harnessing fusion's power is the goal of the ITER research device, which is to be a key step between today's fusion energy research devices and tomorrow's fusion energy power plants. The ITER complex is a reactor-scale experimental research facility that is optimized to demonstrate the scientific and technical feasibility of fusion power. It will be the first-ever fusion device to gain access to the unexplored frontier of the burning plasma regime at reactor scale (greater than 500 megawatts), and therefore can deliver scientific and technical discoveries needed on the path toward a demonstration fusion reactor.

The international ITER Project brings together the financial and technical resources of the ITER Members. The U.S. Government, as an ITER Member, receives full access to the ITER design information and research data derived from its operation. The U.S. contributes about 9% of the total construction cost. The FY 2023 request for ITER construction is $240 million, which includes financial contributions for the operation of the ITER Organization during construction. The U.S. in-kind hardware contributions are 68% complete and the U.S. has finished two of the 12 planned in-kind hardware contributions. The overall project is currently 76% complete to achieving "First Plasma" and 61% complete to achieving the start of "Deuterium-Tritium Operations." The impacts of the COVID-19 pandemic on the project's schedule are still being evaluated.

The FY 2023 budget request maintains DOE's support for the U.S. contributions to the ITER project. The science that will be enabled by ITER, and the technology being developed to realize this machine, are critical parts of the Department's ambitious strategy for supporting progress on fusion research and demonstration over the next decade so that fusion power can contribute significantly, and to realizing fusion power as a significant contributor to our effort to reach net-zero emissions by mid-century.

Exascale Computing Initiative

The Exascale Computing Initiative (ECI), a partnership between SC and the National Nuclear Security Administration (NNSA), is developing and deploying three exascale-capable computing systems with an emphasis on sustained performance for relevant applications and analytic computing to support DOE missions. ECI includes: the Exascale Computing Project (ECP), focused on the research, development, and deployment of the exascale applications and software ecosystem; the exascale system procurements and deployment of Frontier at Oak Ridge National Laboratory (ORNL), Aurora at Argonne National Laboratory (ANL), and El Capitan at Lawrence Livermore National Laboratory; and additional investments by NNSA and SC Programs for their mission-specific work. The FY 2023 Request includes $227 million for SC's contribution to ECI, including $150 million to deploy and operate Aurora and testbeds in support of the ECP project teams.

Over the past six years, ECP has supported partnerships with vendors, the preparation of 21 science applications, and the development of an exascale software ecosystem that will effectively and efficiently execute on the planned exascale platforms. The Nation's first exascale platform, Frontier, was successfully delivered in 2021 and is currently being stabilized prior to acceptance testing. In late December 2021, Oak Ridge was able to run a test code that demonstrated Frontier's exascale capabilities while achieving excellent performance per watt, breaking the 20 megawatts per exaflop goal. In March 2022, an Independent Review Team found that ECP, which is scheduled to complete in early 2024, has a "well-defined lifecycle, processes, tools, and culture to deliver capabilities on schedule and on budget."

The ECI is poised to successfully deliver to the Nation's research community three exascale computers that will advance science and accelerate the pace of innovation. While not without its challenges, the success of ECI is a testament to the world-class expertise and best-in-class processes DOE has established to deliver world-leading scientific tools that meet, if not exceed, the original expectations of the community.

Linac Coherent Light Source-II

When complete, the Linac Coherent Light Source-II (LCLS-II) at SLAC National Accelerator Laboratory (SLAC) will solidify the LCLS complex as the world's leader in ultrafast x-ray science for decades to come. The original LCLS, commissioned in 2009, was the world's first hard x-ray free electron laser (XFEL) facility, producing a high-brightness x-ray beam with properties vastly exceeding those of existing synchrotron x-ray sources in three key areas: peak brightness, coherence, and ultrashort pulses. The upgrades to the LCLS consist of two projects – the LCLS-II project and the HE (high energy) project (referred to as LCLS-II-HE). The LCLS-II project adds to the existing capabilities of LCLS to provide unprecedented atomic-scale resolution, capturing the structure and dynamic processes that occur in chemistry and biology in quadrillionths of a second (femtoseconds) with unmatched coherence and brightness. The HE project upgrade to higher photon energies will provide a discovery-class user facility that will revolutionize pharmacology, structural biology, chemistry, and materials science, as well as emerging technologies for clean energy, energy storage and transport, microelectronics, quantum information science, advanced manufacturing, and novel materials.

Final funding for the LCLS-II project was requested in FY 2022, so no additional funding for this project is requested in FY 2023. The LCLS-II project is making excellent progress, with the construction phase now complete. It has constructed a superconducting linear electron accelerator, or linac, housed in the existing linac tunnel at SLAC, including new undulators to generate a high-repetition-rate (near 1 million per second) coherent x-ray beam covering an energy range of 200 to 5,000 electron volts. The repetition rate will be increased by at least a factor of 1,000 over LCLS to yield unprecedented high-average-brightness x-rays that will be unique worldwide. When operational, LCLS-II will surpass LCLS in its capabilities, including spectral tuning range and brightness, as well as its capacity for serving experiments.

LCLS-II is currently in the commissioning phase. The cryogenics plant is operating 24 hours a day, 7 days a week to cool down the superconducting linac to 2 degrees above absolute zero before the electrons are injected into the accelerator to generate the first x-rays ("first light"),

currently anticipated by the end of calendar year 2022. The project completion is anticipated not later than January 31, 2024, with potential completion as early as April 2023. In the FY 2023 request, $90M in funding is requested for the LCLS-II-HE project to support engineering, design, R&D, prototyping, long-lead procurements of construction items, and preparation for project baselining. As competing European and Asian XFEL facilities advance, the nearly complete LCLS-II project and the ongoing HE upgrade project will maintain American leadership in this field for decades.

Modernizing Critical Infrastructure for Science: The Science Laboratory Infrastructure Program

The FY 2023 SC budget request supports the Department's effort to pursue a robust portfolio of maintenance and modernization construction projects across the entire DOE laboratory complex. These projects are necessary for our continued innovation in the conduct of science itself to address modern problems, including the application of AI and automation to scientific discovery. The DOE National Laboratories were established from the 1940's to 1960's, with some approaching 80 years of service. The research facilities at these Laboratories—including general research laboratories, specialized research centers, accelerators, light sources, high-performance computers, and two nuclear reactors—are supported by general-purpose infrastructure and a vast network of utilities that form the backbone of each site.

The ten SC-stewarded laboratories alone comprise an infrastructure portfolio worth nearly $22 billion, consisting of more than 1,600 buildings accounting for 24 million gross square feet, roads, utilities, and other supporting infrastructure assets on more than 18,000 acres of land. Unfortunately, almost half of these buildings are rated as substandard or inadequate to meet mission needs. In addition, nearly two-thirds of support infrastructure, including utility systems, are also rated as substandard or inadequate. The result is unplanned outages, costly repairs, elevated safety risks, and inefficiencies that are occurring at increasing frequency. The FY 2023 SC budget request will continue to support our effort to alleviate these deficiencies through funding new and sustaining existing general purpose infrastructure, as well as fostering safe, efficient, reliable, and environmentally responsible operations that support and enable the scientific and technological innovation for which the DOE laboratories are known.

SC laboratories conduct rigorous and consistent analyses of the condition, utilization, mission readiness, and resilience of the facilities and infrastructure that are most critical to mission accomplishment. Together, SC and its laboratories use these assessments to develop comprehensive Campus Strategies as part of the annual laboratory planning process. To support the core capabilities and achieve our scientific vision, each laboratory's Campus Strategy identifies needed activities and infrastructure investments. SC leadership uses these Campus Strategies to determine the facilities and infrastructure needs and priorities.

Infrastructure needs and priorities for all laboratories are evaluated annually by SC's Science Laboratories Infrastructure (SLI) program. The SLI program supports investments that focus on laboratory core infrastructure and operations. Continuing investments in core infrastructure (e.g., utility systems, site-wide services, and general-purpose facilities) ensures that facilities and utilities are either upgraded or replaced as they approach end-of-life. SLI projects are evaluated on mission readiness, cost savings (including energy and water), environmental safety and health

issues, sustainability (including DOE net zero initiatives), resilience, and reliability. The SLI program maintains an active list of critical core infrastructure investment needs and works closely with the SC core science programs and the laboratories to prioritize projects that are critical for the mission. Priorities are evaluated continuously, and the highest priority projects are selected for funding upon entry into the corresponding execution year. For example, the SLI program is actively constructing the necessary future power requirements and reliability that will support the deployment of the Aurora exascale computer through the Electrical Capacity and Distribution Capability project at ANL. Likewise, the SLI program has recently initiated the Critical Utility Infrastructure Revitalization project at SLAC which will support the LCLS-II and LCLS-II-HE upgrade projects.

The SLI program funds line-item construction (LIC) projects and general plant projects (GPP) that improve SC's existing physical assets and installs new cutting-edge facilities that enable emerging science opportunities. Its current focus is on major utility systems in addition to general purpose laboratory facilities that are implemented with Line-Item Construction Projects and General Plant Projects. Modernizing infrastructure at the SC national laboratories, especially facilities and systems that are nearing the end of their useful life-cycle , will ensure that the critical needs of the future science initiatives and world class user facilities are met for decades to come while minimizing unwanted disruptions through resilience and reliability and ensuring safety and maintainability.

Over the past two decades, SLI has invested over $1.1 billion in infrastructure and successfully completed 16 line-item projects. Since FY 2016, SLI has invested over $200 million in general plant projects including approximately $133 million in electrical and utility improvements, $35 million in building improvements, and $32 million in safety and sustainability. Despite these investments, there is a backlog of more than $880 million of deferred maintenance across the 10 SC-stewarded labs. In order to drive down this backlog, SC is pursuing an aggressive funding strategy to support LIC projects and GPP so that more urgent action can be taken to address the Labs' infrastructure. Investing in projects to replace and modernize infrastructure at the Laboratory complex will reduce the deferred maintenance backlog. Additionally, supporting maintenance and infrastructure projects at the labs brings blue collar science, technology, and engineering jobs to our sites around the country.

Challenges: Addressing the Impacts of COVID-19 and Optimizing Operations of User Facilities

SC construction projects continue to be impacted by the COVID-19 pandemic due to increased costs of materials and labor and schedule delays due to supply chain shortages. These issues have introduced large uncertainties that are impacting project contingencies throughout the portfolio. We are continuing to fold these impacts into our project planning as we consider approaches for mitigation.

In the FY 2023 budget request, all of the scientific user facilities are funded at approximately 90% of optimum. SC strives to maintain a balanced portfolio that includes close to optimal funding for facilities. This leads to tough decisions and funding tradeoffs to support Administration and Departmental priorities. SC recognizes the need and is committed to

increasing support for operations of these world-class facilities to ensure they are fully utilized and available to keep the U.S. at the forefront of science and innovation.

These and other considerations for both construction projects and facility operations are an important part of the Department's continuing efforts to develop our future funding plans. Addressing these issues effectively will be essential to ensuring these investments are fully utilized to meet the Administration's goal of accelerating discovery and innovation through basic and use-inspired science.

Conclusion

Chairwoman Johnson, Ranking Member Lucas, and members of the Committee, thank you again for the opportunity to speak about the Department in its science mission. As reflected in the FY 2023 Request, SC will continue to invest in the most compelling foundational research, in providing advanced tools for scientific discovery and technology development, and in a laboratory complex that is unequivocally the world's most comprehensive collection of scientific and technical expertise.

We will continue to make necessary investments in the sectors of the future, and do so in partnership with our interagency colleagues, to advance science and technology that will dominate the 21st Century—including AI, QIS, microelectronics, and systems biology. We will continue to overcome the key scientific challenges needed to realize abundant, affordable, and clean energy technologies for the future, including fusion energy, to tackle the climate crisis, and to address the ongoing COVID-19 global pandemic and other emerging threats.

To engage these challenges, we will leverage cross-disciplinary teams of experts with diverse perspectives and backgrounds from universities and National Laboratories, and form partnerships with other Federal agencies and international institutions. This approach will allow us to address these critical issues by conducting science at scales not possible by individual researchers, individual institutions, or even individual countries.

We will continue to make investments in our core infrastructure. These investments are vital to fostering safe, efficient, reliable, and environmentally responsible operations for all of the SC missions. A robust funding profile that supports core infrastructure ensures we can continue to reduce the frequency of unplanned outages and costly repairs, and at the same time enhance safety and increase efficiency across the complex.

Finally, to ensure that we have the talent needed to meet these challenges, we will develop our future workforce with a strong commitment to the principles of diversity, equity, inclusion, and accessibility. This commitment extends to our National Laboratories, to the research and facilities we support in the scientific community, to our own staff, to the processes we use in pursuit of the mission, and to the investments we make in workforce development programs.

Thank you again for the opportunity to address this committee. I would be happy to take your questions.