

Statement of Under Secretary for Science and Energy Franklin Orr
U.S. Department of Energy
Before the
House Committee on Appropriations
Subcommittee on Energy and Water Development
March 2, 2016

Chairman Simpson, Ranking Member Kaptur, and Members of the Subcommittee, thank you for the opportunity to testify on the President's Fiscal Year 2017 Budget Request for the U.S. Department of Energy's (DOE's) science and energy programs. Before I begin I would like to thank you for your support of the Consolidated Appropriations Act, 2016, which we are now implementing.

The Office of Science's (SC) mission is twofold, to support and deliver scientific discoveries, and to build and operate major scientific tools and facilities. The goal is to enhance our understanding of nature and advance the energy, economic, and national security of the United States. SC is the Nation's largest Federal sponsor of basic research in the physical sciences and the lead Federal agency supporting fundamental scientific research for our Nation's energy future.

The President's Request for the Office of Science is \$5.672B, a 6.1% increase from the FY 2016 Enacted level of \$5.347B. The FY 2017 Budget Request contains important investments across our six major programs. The SC Request is part of the \$12.9B FY 2017 Budget Request for Science and Energy, \$2.8B above the FY 2016 Enacted level. The Science and Energy Request supports DOE's missions of enabling the transition to a clean energy future with low-cost, all-of-the-above energy technologies; supporting a secure, modern, and resilient energy infrastructure; and providing the scientific backbone for discovery and innovation for America's future prosperity.

The Request takes the first step in fulfilling the U.S. Government's pledge to Mission Innovation, an unprecedented global initiative across 20 nations to double public clean energy research and development (R&D) over the next five years, in conjunction with commitments for private investments led by a coalition of 28 private investors from ten countries. Together, these initiatives will drive innovation essential for economic growth enabled by affordable and reliable energy, for energy security, for U.S. competitiveness, and for a transition to a low carbon energy future. The Office of Science's FY 2017 Request supports \$100M in new Mission Innovation activities.

Our Nation stands at an important point in the transition to a low-carbon economy. I believe we'll look back on this period as one of significant acceleration in innovation that will have made a clean energy future possible. In just the last seven years, the deployment of clean energy

technologies has increased dramatically, in large part due to foundational basic research made possible through the world-leading capabilities of the scientific user facilities and National Laboratories stewarded by SC. To continue global momentum and accelerate clean energy technology development, the Department's FY2017 Budget Request aims to further accelerate SC's innovative work that puts this Nation at the front of the global clean energy race. It also builds on the work of the 2015 Quadrennial Technology Review (QTR) by investing in key scientific opportunities, such as a need for advanced materials science research, and wider availability of high performance computing.

Priorities for the Office of Science in FY 2017

As we enter the final year of this administration, I want to update you on recent developments and share our priorities for the Office of Science.

Dr. Cherry Murray was confirmed as Director of the Office of Science last December. She has a distinguished background as a leader in scientific research, having worked at Bell Laboratories and most recently as a professor of technology, public policy, and physics at Harvard University.

Research must be balanced against facility operations and construction. Over 31,000 scientists and students use Office of Science user facilities each year. The FY 2017 Budget for the Office of Science continues our tradition of successfully building and operating world-class facilities that enable researchers from across the country and globe to conduct groundbreaking research.

The FY 2017 Budget Request maintains a healthy balance between our research funding modalities. New methods of funding, like the Energy Frontier Research Centers (EFRCs), have been successful in fostering collaborative research by multidisciplinary teams to address complex scientific questions. Their success was built upon a long-term core of base funding in Basic Energy Sciences for individual principal investigators.

The FY 2017 Budget Request supports high performance computing, which is vital to every area of science. The Office of Science has a key role to play in the president's National Strategic Computing Initiative. Our goal is to produce an exascale supercomputing environment, by the mid-2020s, capable of meeting 21st century scientific challenges. This means close collaboration with industry in order to co-design software and hardware to ensure that new computational tools and applications can take advantage of DOE's exascale platform.

Finally, the FY 2017 Budget Request continues our support for basic research to advance clean energy. Fundamental research is the key to developing truly transformative technologies that could radically change the energy landscape. The Office of Science has a long and proud history of engaging the scientific community in workshops and other forums to identify key scientific opportunities for investment.

Overview of the Office of Science FY 2017 Budget Request

The Office of Science supports research probing the frontiers of science, in an attempt to answer the most fundamental disciplinary and interdisciplinary questions, from discovering nature's mysteries through the study of sub-atomic particles, atoms, molecules, and emergent phenomena that are the building blocks of the cosmos to the DNA, genetic codes, proteins, cells, biological systems and earth sciences that are the building blocks of life and the environment relevant to energy.

SC designs, builds, and operates the majority of large U.S. world-class scientific user facilities. Access to the facilities is competitively awarded and free of cost for researchers conducting non-proprietary work who intend to publish in scientific literature, and at cost for those who conduct proprietary research.

The Office of Science operates 28 state-of-the-art national scientific user facilities that put the U.S. at the forefront of science, technology and innovation. These include synchrotron and laser X-ray light sources, neutron scattering facilities, nanoscience centers, plasma fusion devices, high energy physics and nuclear physics accelerators and detectors, facilities for genomic and environmental science, and high performance computers. These facilities also provide a unique platform to advance high-priority national missions in partnership with other agencies.

In FY 2016, the enacted budget for the Office of Science has a healthy ratio of 42% support for direct research, 38% facility operations, and 14% construction and major items of equipment.

The Office of Science also provides the scientific foundations to enable the transition to a low-carbon, secure energy future with low-cost clean energy technologies. It advances a clean energy agenda through use-inspired fundamental research on energy production, conversion, storage, transmission, and use. It also advances our understanding of the earth and its climate.

The focus areas for this use-inspired fundamental research, which accounts for 32% of the non-construction budget in FY 2016, are determined in partnership with the applied energy and national security offices, and include 32 Energy Frontier Research Centers (EFRCs), two Energy Innovation Hubs, three Bioenergy Research Centers (BRCs), and Office of Science contributions to five of the Department's R&D crosscuts.

The FY 2017 Budget Request maintains this balance of about a third use-inspired research, and adds five new EFRCs, expands industry linkages of the BRCs, and supports an enhanced role for the Office of Science in the Department's crosscut programs, providing the scientific and analytical foundation to inform applied technology investments. The Request includes \$100M for new use-inspired research to support the President's Mission Innovation Initiative.

As the steward of ten of the DOE laboratories, SC provides direct funding support competitively to over 24,000 investigators at all of the 17 DOE labs and over 300 U.S. research institutions.

Over the last decade, the support of universities, determined competitively each year, has varied between 35% - 40% of the total direct research budget. In the FY 2017 Budget Request, support of academic research is proposed to increase over FY 2016 levels by nearly 10% with the authorization of \$100M of mandatory spending for competitively awarded university grants in an open call for proposals in all fields supported by the Office of Science. In addition, a third of the proposed FY 2017 line item construction budget, or another \$100M, will go to academia to maintain the optimal schedule and cost of the Facility for Rare Isotope Beams (FRIB) project at Michigan State University. Nearly three-quarters of the scientists who do research at SC user facilities are from academia. The value of user facility operations is the equivalent of well over an additional \$1B of support to university research.

The DOE Office of Science is an established leader of the U.S. scientific discovery and innovation enterprise. We fund over 43% of physical sciences research; making us the largest supporter of the physical sciences in the U.S.¹

DOE has supported the work of more than 100 Nobel Prize recipients over 70 years. In 2016, the Nobel Prize in physics was given to two teams of neutrino experimentalists from Canada and Japan, both of which included US researchers with strong DOE support. Just this past year, researchers at the DOE National Laboratories won 33 out of 100 R&D 100 Awards given by R&D Magazine.

Highlights of the Office of Science FY 2017 Budget Request by Program

Advanced Scientific Computing Research (ASCR) supports research to discover, develop and deploy computational and networking capabilities to analyze, model, simulate and predict complex phenomena important to the U.S.

The FY 2017 Budget Request for ASCR is \$663M is an increase of \$42.2M, or 6.8% over the FY 2016 Enacted level. The increase supports research on the linked challenges of exascale computing capability and data-intensive science and computational partnerships under the Scientific Discovery through Advanced Computing (SciDAC) program to support clean energy.

ASCR's support for the Exascale Computing Initiative will be transitioned to a formal SC Exascale Computing Project following DOE project management guidelines with the goal to design, research, and plan the procurement of a capable exascale machine by mid-2020s. The FY 2017 Budget Request includes \$154M in ASCR for the Office of Science coordinated with NNSA's budget of \$95M for ASCR's exascale project activities include only those required for

¹ National Science Board 2016 Science and technology Indicators

the delivery of exascale computers. Additional exascale funding for the development of exascale applications resides in SC program offices: \$26 million in Basic Energy Sciences and \$10 million in Biological and Environmental Research. The four focus areas of the project are hardware technology R&D, system software technology R&D, application development and system engineering for exascale systems.

With the creation of a new line item, funds are incorporated from existing applied mathematics, computer science, computational partnerships and research and evaluation prototypes subprograms of the ASCR budget. Funding in these areas relevant to exascale computing has been moved into the project.

The FY 2017 Budget Request also supports preparations at the two leadership computing facilities at Argonne (ANL) and Oak Ridge National Laboratory (ORNL) for 75-200 petaflop upgrades at each facility by 2018-2019. The National Energy Research Scientific Computation Center (NERSC) at Lawrence Berkeley National Laboratory will take delivery of the NERSC-8 supercomputer, expanding the capacity of the facility to 10-40 petaflops to address growing demand. ESnet is increased by \$7M to \$45M in FY 2017 to provide increases in bandwidth for the growing data requirements of SC facilities.

Basic Energy Sciences (BES) supports fundamental research to understand, predict and ultimately control matter and energy at the electronic, atomic, and molecular scales. This work will provide foundations for new energy technologies. The FY 2017 Budget Request for BES of \$1.937B is an increase of \$87.7 M or 4.7% over the FY 2016 Enacted level.

The FY 2017 Budget Request increases funding for core research and the EFRCs in key areas related to Departmental priorities, such as the Subsurface Technology and Engineering RD&D (\$41.3M), and the Advanced Materials crosscutting initiatives (\$17.6M). A new activity is initiated in Computational Chemical Sciences (\$14M) to advance U.S. leadership in computational chemistry codes in preparation for exascale computing and supports the Exascale Computing Initiative.

The Request continues support for two hubs: the Joint Center for Artificial Photosynthesis (led by LBNL and Cal Tech), and the Joint Center for Energy Storage Research led by Argonne National Laboratory (ANL). The FY 2017 Budget Request also provides for the optimal operations of five synchrotron light sources, five nanoscale research centers, and two neutron scattering centers. The Request continues to support construction of the Linac Coherent Light Source-II (LCLS-II), and it continues funding the Advanced Photon Source (APS) Upgrade Major Item of Equipment (MIE) at ANL.

Biological and Environmental Research (BER) supports fundamental research and scientific user facilities to achieve a predictive understanding of complex biological, climatic, and environmental systems for a secure and sustainable energy future. The FY 2017 Budget Request for BER of \$661.9M is an increase of \$52.9M or 8.7 percent above the FY 2016 Enacted level.

The FY 2017 Budget Request continues to support core research in Genomic Science and the three DOE Bioenergy Research Centers (BRCs), and it increases support for research to understand microbiome interactions in diverse environments (+\$10M). The Request also continues to support core research to understand climate-relevant atmospheric and ecosystem processes, and requests increased support (+\$12.5M) for the development of a layered energy-water data system and to establish regional-scale data, modeling, and analysis test beds to support analysis of dynamic energy-water systems. The Request supports the optimal operations of BER's three scientific user facilities: the DOE Joint Genome Institute managed by LBNL, the Environmental Molecular Sciences Laboratory at Pacific Northwest National Laboratory, and the Atmospheric Radiation Measurement Climate Research Facility.

Fusion Energy Sciences (FES) supports research to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation for fusion energy. The FY 2017 Budget Request for FES of \$398.2M decreases by \$39.8M or 9.1 percent from the FY 2016 Enacted level. The Request supports continued progress on the U.S. Contributions to ITER Project of \$125M and core research in burning plasma science. DOE is committed to following Congressional direction in the FY 2016 Consolidated Appropriations Act to produce a report and recommendation on future participation in ITER by May 2.

The FY 2017 Budget Request includes increased funding for the operation of the National Spherical Torus Experiment Upgrade (NSTX-U) at Princeton Plasmas Physics Laboratory to support 16 weeks of run time and to conduct high priority plasma-materials interaction research. DIII-D (located in San Diego) operations funding supports 560 hours of operation and the Request includes an increase to provide for targeted enhancements to the facility. Funding for research at both DIII-D and NSTX-U will support research in areas identified as priorities by the research community and for enhanced collaborations with MIT research staff. The Request supports targeted facility enhancements for DIII-D. FY2016 was the planned final year of funding for the MIT Alcator C-mod facility. The Request supports international collaborations on facilities such as the new W-7X stellarator in Germany, the EAST tokamak in China, and the KSTAR tokamak in Korea.

High Energy Physics (HEP) supports research to understand how the universe works at its most fundamental level by discovering the most elementary constituents of matter and energy, probing the interactions among them, and exploring the basic nature of space and time itself. The FY 2017 Budget Request for HEP of \$817.9M is an increase of \$22.9M or 2.9 percent above the FY 2016 Enacted level.

The Request continues to implement the recommendations of the 2014 Particle Physics Project Prioritization Panel (P5) Report issued by the High Energy Physics Advisory Panel. The FY 2017 Budget Request supports full operation of existing major HEP facilities and experiments, including optimal operations for the upgraded Neutrinos at the Main Injector (NuMI) beamline located at Fermi National Accelerator Laboratory (FNAL), part of the NOvA Experiment (detectors located in Minnesota). The construction of the Muon to Electron Conversion Experiment (Mu2e), also at FNAL, continues, consistent with the planned construction funding profile. MIEs for the Large Hadron Collider (LHC) at CERN in Switzerland continue, supporting upgrades the ATLAS (A Large Toroidal LHC Apparatus) and Compact Muon Solenoid detectors.

Consistent with the P5 Report recommendations, the FY 2017 Budget Request enhances support for technical design and construction associated with the Long Baseline Neutrino Facility (LBNF)/Deep Underground Neutrino Experiment (DUNE) project (\$45.0M) at FNAL, and continued construction of three MIEs for next generation dark-energy and dark-matter experiments (\$23.5M). LBNF/DUNE's underground detectors will be located in South Dakota.

The Request includes funding for one new MIE, the Facility for Advanced Accelerator Experimental Tests II (FACET-II, +\$5M) at LBNL and SLAC, and for research and conceptual design of the Proton Improvement Plan II (PIP-II) project (\$15.2M) at FNAL. Funding increases for the fabrication of the Large Synoptic Survey Telescope (a collaboration with the National Science Foundation) MIE according to the planned profile. Core research increases slightly to provide support for high priority efforts.

Nuclear Physics (NP) supports experimental and theoretical research to discover, explore, and understand all forms of nuclear matter. The FY 2017 Budget Request for NP of \$635.7M is an increase of \$18.6M or 3.0 percent relative to the FY 2016 Enacted level, and consistent with the recommendations of the Nuclear Science Advisory Committee 2015 Long Range Plan. The Request provides for modest increases in core research at universities and DOE national laboratories to support high priority research of the nuclear physics community, as well as the development of cutting edge approaches for producing isotopes critical to the Nation.

It also supports the continued construction of the Facility for Rare Isotope Beams (FRIB) at Michigan State University at \$100M, which will provide world-leading capabilities for nuclear structure and astrophysics research. The 12 GeV Upgrade for the Continuous Electron Beam Accelerator Facility at Thomas Jefferson Accelerator Laboratory will be completed in FY 2017, and the full 12 GeV scientific program initiated, enabling groundbreaking searches for exotic particles and new physics.

The FY 2017 Budget Request also provides for increased operations of the Relativistic Heavy Ion Collider at Brookhaven National Laboratory (+4 weeks, 24 weeks total in FY 2017) for explorations of spin physics and intriguing new phenomena observed in quark gluon plasma formation, and for operations of the Argonne Tandem Linac Accelerator System (ATLAS) utilizing newly completed instrumentation. Two new MIEs are initiated in FY 2017: the Gamma-Ray Energy Tracking Array detector led by LBNL (+\$0.5M) to exploit the world-leading science capabilities of FRIB, and the Stable Isotope Production Facility (+\$2.5M) at ORNL to establish a domestic capability for the production of a broad range of enriched stable isotopes for research and applications.

Science and Lab Infrastructure (SLI)

Ongoing construction projects that will provide new laboratory buildings, renovated facilities, and upgraded utilities are proceeding towards on-time completion within budget. While significant improvements to SC infrastructure have been made, it is important to maintain a strong level of investment and continue renewing the SC national laboratory complex. The FY 2017 Budget Request of \$130M is \$16.4M, or 14.4 percent, over the FY 2016 Enacted level and provides funding for three on-going and two new line-item construction projects.

The FY 2017 Budget Request continues funding for the Materials Design Laboratory project at Argonne National Laboratory, the Photon Science Laboratory Building project at SLAC National Accelerator Laboratory, and the Integrative Genomics Building project at Lawrence Berkeley National Laboratory. New funding is requested to start the Integrated Engineering Research Center at Fermi National Accelerator Laboratory and the Core Facility Revitalization project at Brookhaven National Laboratory.

In addition, the Request continues to focus on Secretary Moniz's priority of addressing basic needs in core general purpose infrastructure as identified through the enterprise-wide Laboratory Operations Board assessments to reduce deferred maintenance. General Plant project funding requested in FY 2017 will enhance and update HVAC systems and controls at LBNL, support electrical distribution upgrades at SLAC, upgrade cryogenics infrastructure at Thomas Jefferson National Accelerator Laboratory and will replace and upgrade electrical distribution systems at Ames Laboratory.

Conclusion

I appreciate the opportunity to discuss how the President's FY 2017 Budget Request advances the Department's mission in delivering fundamental scientific research and accelerating the development of clean energy technologies. The Department of Energy is focused on investing across the innovation chain to secure America's energy future and enhance American

competitiveness. The Fiscal Year 2017 Budget Request aims to continue and advance this pursuit.