Science
($K)

FY 2016 Enacted[a]	FY 2017 Annualized CR[b]	FY 2018 Request
5,347,000	5,336,835	4,472,516

Overview

The Office of Science's (SC) mission is to deliver scientific discoveries and major scientific tools to transform 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.

SC accomplishes its mission and advances national goals by supporting:

- *The frontiers of science*—exploring nature's mysteries from the study of fundamental subatomic particles, atoms, and molecules that are the building blocks of the materials of our universe and everything in it to the DNA, proteins, and cells that are the building blocks of life. Each of the programs in SC supports research probing the most fundamental disciplinary questions.

- *The 21st Century tools of science*—providing the nation's researchers with 27 state-of-the-art national scientific user facilities - the most advanced tools of modern science - propelling the U.S. to the forefront of science, technology development and deployment through innovation.

- *Science for energy and the environment*—paving the knowledge foundation to spur discoveries and innovations for advancing the Department's mission in energy and environment. SC supports a wide range of funding modalities from single principal investigators to large team-based activities to engage in fundamental research on energy production, conversion, storage, transmission, and use, and on our understanding of the earth systems.

SC is an established leader of the U.S. scientific discovery and innovation enterprise. Over the decades, SC investments and accomplishments in basic research and enabling research capabilities have provided the foundations for new technologies, businesses, and industries, making significant contributions to our nation's economy, national security, and quality of life. Select scientific accomplishments in FY 2016 enabled by the SC programs are described in the program budget narratives. Additional descriptions of recent science discoveries can be found at http://science.energy.gov/news/highlights.

Highlights and Major Changes in the FY 2018 Budget Request

The FY 2018 Budget Request for SC is $4,473 billion, a decrease of $874 million, or 16.2 percent, relative to the FY 2016 Enacted level, to implement the Administration's objectives for achieving overall reductions in civilian, discretionary spending. The FY 2018 Request supports a balanced research portfolio of basic scientific research probing some of the most fundamental questions in areas such as: high energy, nuclear, and plasma physics; materials and chemistry; biological and environmental systems; applied mathematics; next generation high-performance computing and simulation capabilities; and basic research for advancement in new energy technologies. The Request supports about 19,000 investigators at over 300 U.S. institutions and the Department of Energy (DOE) laboratories. In FY 2018, SC's suite of scientific user facilities will continue to provide unmatched tools and capabilities for over 27,000 researchers from universities, national laboratories, industry, and international partners. The Request will also support the construction of new user facilities and the R&D necessary for future facilities and facility upgrades to continue to provide world class research capabilities to U.S. researchers.

[a] The FY 2016 Enacted level includes SBIR and STTR and reflects updates through the end of the fiscal year.
[b] FY 2017 amounts shown reflect the P.L. 114-254 continuing resolution level annualized to a full year. These amounts are shown only at the congressional control level and above, below that level, a dash (-) is shown.

Highlights of the FY 2018 Budget Request by Program Office include:

- *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 DOE and the United States. The ASCR Budget Request of $722 million, is an increase of $101 million, or 16.3 percent, relative to the FY 2016 Enacted level. The increase supports activities to accelerate the Department's Exascale Computing Initiative (ECI) and intends to accelerate delivery of at least one exascale-capable system in 2021 —reasserting U.S. leadership in this critical area. These activities includes research and development to accelerate application and software stack development, vendor R&D partnerships, and site preparations. ASCR will also continue to focus research efforts on the linked challenges of exascale computing and data-intensive science, on computational partnerships under the Scientific Discovery through Advanced Computing (SciDAC) program, and on quantum information and machine learning to ensure continued U.S. leadership in computational science building toward exascale. Within the Office of Science Exascale Project (SC-ECP), the ASCR portion includes only the research activities required for the delivery of exascale-capable systems. Funding for the Leadership Computing Facilities is significantly increased to initiate site preparations and vendor partnerships that will allow them to deploy an exascale-capable system as rapidly as possible. The four areas of focus of SC-ECP are hardware technology R&D, system software technology R&D, application development, and system engineering for exascale systems. The FY 2018 Request supports the upgrade of the Oak Ridge Leadership Computing Facilities to 200 petaflops (pf) and early science operations of this powerful new capability. The Argonne Leadership Computing Facility will operate Mira (at 10pf) and Theta (at 8.5pf) for existing users, while turning focus to site preparations for deployment of exascale system of novel architecture. The National Energy Research Scientific Computing Center (NERSC) operates the NERSC-8 supercomputer and prepares for the delivery of NERSC-9 in 2020, and additional funds are requested to upgrade the Energy Sciences Network to address the rapidly growing volume of scientific data transmission.

- *Basic Energy Sciences (BES)* supports fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels to provide foundations for new energy technologies. The BES Budget Request of $1,554.5 million is a decrease of $294.5 million, or 15.9 percent from the FY 2016 Enacted level. The FY 2018 Request focuses resources toward early-stage fundamental research, on the operation and maintenance of a complementary suite of scientific user facilities, and in the highest priority facility upgrades. No funding is requested for the two BES-supported Energy Innovation Hubs, *Batteries and Energy Storage* and *Fuels from Sunlight*, or for the DOE Experimental Program to Stimulate Competitive Research. In the remaining core research activities, BES will place emphasis on basic science areas with the potential to transform the understanding and control of matter and energy including emphasis on emerging high priorities in quantum materials and chemistry, catalysis science, synthesis, instrumentation science, and materials and chemical research related to interdependent energy-water issues. The funding decrease will require BES to curtail the operation and maintenance of BES suite of facilities. The Stanford Synchrotron Radiation Lightsource will operate through the first quarter of the fiscal year, then will transition to a warm standby status. The Request contains no funding for two of the five nanoscience centers: the Center for Functional Nanomaterials at Brookhaven National Laboratory and the Center for Integrated Nanotechnologies at Sandia and Los Alamos National Laboratories. The remaining BES facilities will operate at 6–10% below the FY 2016 Enacted level. BES decreases funding for related accelerator and detector research. The Request will continue to support construction of the Linac Coherent Light Source-II, and will convert the Advanced Photon Source Upgrade project from a Major Item of Equipment to a line-item construction project and will provide support per the project plan.

- *Biological and Environmental Research (BER)* supports fundamental research and scientific user facilities to achieve a predictive understanding of complex biological, earth, and environmental systems for energy and infrastructure resilience and sustainability. The BER Budget Request of $349 million is a decrease of $260 million, or 42.7 percent, below the FY 2016 Enacted level. The FY 2018 Request implements Administration decisions to shift focus to more fundamental research, and to prioritize research focused on biological and earth and environmental systems. In the Earth and Environmental Systems Sciences subprogram (formerly named "Climate and Environmental Sciences"), the Request focuses on continuing to support development of the DOE high-resolution earth system model and for model diagnostics and intercomparisons, as well as ARM observations at two fixed sites. Targeted reductions occur in lower priority activities, including integrated assessments, climate feedbacks, anthropogenic aerosols and black carbon, and field activities in the tropics and northern peatlands focused on functional responses to climate variability and atmospheric stressors. The Biological Systems Science subprogram implements priority-shifts to the core research areas of Genomic Sciences, including biodesign and microbiome, and support for the recompeted Bioenergy Research

Centers. Mesoscale activities supported include new efforts to utilize quantum materials for advanced bioimaging capabilities. The Request supports reduced operations of BER's three scientific user facilities: the DOE Joint Genome Institute (JGI), the Environmental Molecular Sciences Laboratory (EMSL), and ARM.

- *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 FES FY 2018 Request of $309.9 million is a decrease of $128 million, or 29.2 percent, below the FY 2016 Enacted level. The FES Budget Request will support design activities and existing hardware fabrication contracts for the U.S. Contributions to ITER Project along with foundational research in burning plasma science. The Request provides increased support for the DIII-D program, including operations funding that will support 18 weeks of run time, and research in priority areas identified by the 2015 community workshop. NSTX-U operations funding will support continued facility repair and recovery actions to obtain reliable research operation, while NSTX research will address priorities identified by the 2015 community workshops. FES will increase funding for massively parallel scientific computing through the SciDAC partnership with ASCR to accelerate development of a whole-device modeling capability. The FY 2018 Request will also continue support for leveraged research opportunities by U.S. scientists on international superconducting tokamak and stellarator facilities with unique capabilities. FES will also provide support to emphasize opportunities for core discovery plasma science on intermediate-scale facilities.

- *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 HEP FY 2018 Request of $672.7 million is a decrease of $122.3 million, or 15.4 percent below the FY 2016 Enacted level. The Request will focus support on the highest priority elements identified in the 2014 High Energy Physics Advisory Panel (HEPAP) Particle Physics Project Prioritization Panel (P5) Report. The Request will enhance support for the Long-Baseline Neutrino Facility and Deep Underground Neutrino Experiment (LBNF/DUNE) early far-site construction, including site preparation and cavern excavation, and design efforts for the facility and detector. The Request will also provide funding for the start of Major Item of Equipment (MIE) funding for the High-Luminosity Large Hadron Collider (HL-LHC) Accelerator Upgrade Project (AUP) and supports the design efforts for the HL-LHC A Toroidal LHC Apparatus (ATLAS) and Compact Muon Solenoid (CMS) Detector Upgrade Projects. It will provide support for the Large Synoptic Survey Telescope camera (LSSTcam), Muon to Electron Conversion Experiment (Mu2e), and Large Underground Xenon (LUX)-ZonEd Proportional scintillation in LIquid Nobles gases (Zeplin) (LZ) projects consistent with the planned fabrication funding profiles. The Request will provide funding for one new MIE, the Facility for Advanced Accelerator Experimental Tests II (FACET-II), for the design and fabrication of the Super Cryogenic Dark Matter Search at Sudbury Neutrino Observatory Laboratory (SuperCDMS-SNOLAB) project, and for research and conceptual design of the Proton Improvement Plan II (PIP-II) construction project. HEP will rebaseline the Dark Energy Spectroscopic Instrument (DESI) project, which received CD-3 approval for start of fabrication so that it can be completed on a delayed timescale. The Request also will place a higher priority on supporting the research programs that are critical to executing the P5 Report recommendations. The Request also reduces funding for the Fermilab Accelerator Complex to operate and support the neutrino and muon experiments.

- *Nuclear Physics (NP)* supports experimental and theoretical research to discover, explore, and understand all forms of nuclear matter. The FY 2018 Budget Request of $502.7 million is a decrease of $114.4 million, or 18.5 percent, below the FY 2016 Enacted level. The FY 2018 Budget Request will continue support for the highest priority research and scientific user facilities to maintain U.S. leadership in some areas of nuclear science following an overall reduction in program scope in response to the funding decrease. Funding was completed for the 12 GeV Upgrade at the Continuous Electron Beam Accelerator Facility (CEBAF) in FY 2016, allowing NP to initiate the associated science program in FY 2018 to search for exotic particles and new physics. The FY 2018 Request will provide for modified operations of the Relativistic Heavy Ion Collider (RHIC) to confirm the origin of intriguing new phenomena observed in quark gluon plasma formation, and for operations of the Argonne Tandem Linac Accelerator System (ATLAS) to provide opportunities for research in nuclear structure and nuclear astrophysics. The Request will support the continued construction of the Facility for Rare Isotope Beams (FRIB) at a level below the performance baseline profile; FRIB will provide world-leading capabilities for nuclear structure and astrophysics. The Request will also continue to support the Gamma-Ray Energy Tracking Array (GRETA) detector, which will exploit the world-leading science capabilities of FRIB, and the Stable Isotope Production Facility (SIPF) within available resources. The Request supports core research at universities and DOE national laboratories and the development of cutting-edge approaches for producing isotopes critical to the Nation.

Basic and Applied R&D Coordination

Coordination between the Department's basic research and applied technology programs is a high priority within DOE and is facilitated through joint planning meetings, technical community workshops, annual contractor/awardee meetings, joint research solicitations, focused DOE program office working groups in targeted research areas, and collaborative program management of DOE's Small Business Innovation Research (SBIR) and Small Business Technology Transfer Research (STTR) programs. Co-funding of research activities and facilities at the DOE laboratories and partnership/collaboration encouraging funding mechanisms facilitate research integration within the basic and applied research communities. SC's R&D coordination also occurs at the interagency level. Specific collaborative activities are highlighted in the "Basic and Applied R&D Coordination" sections of each individual SC program budget justification narrative.

High-Risk, High-Reward Research[a]

SC incorporates high-risk, high-reward, basic research elements in all of its research portfolios; each SC research program considers a significant proportion of its supported research as high-risk, high-reward. Because advancing the frontiers of science also depends on the continued availability of state-of-the-art scientific facilities, SC constructs and operates national scientific facilities and instruments that comprise the world's most sophisticated suite of research capabilities. SC's basic research is integrated within program portfolios, projects, and individual awards; as such, it is not possible to quantitatively separate the funding contributions of particular experiments or theoretical studies that are high-risk, high-reward from other mission-driven research in a manner that is credible and auditable. SC incorporates high-risk, high-reward basic research elements in its research portfolios to drive innovation and challenge current thinking, using a variety of mechanisms to develop topics: Federal advisory committees, triennial Committees of Visitors, program and topical workshops, interagency working groups, National Academies' studies, and special SC program solicitations. Many of these topics are captured in formal reports, e.g., *Building for Discovery: Strategic Plan for U.S. Particle Physics in the Global* Context, by the High Energy Physics Advisory Panel (HEPAP-P5) (2014)[b]; *Neuromorphic Computing—From Materials to Systems Architecture Roundtable*, BES and ASCR workshop report (2015)[c]; *Report of the BESAC Subcommittee on Future X-ray Light Sources,* by the Basic Energy Sciences Advisory Committee (BESAC) (2013) [d]; *Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science*, by BESAC (2015)[e]; *Basic Research Needs Workshop on Quantum Materials for Energy Relevant Technology,* BES workshop report (2016)[f]; *Molecular Science Challenges*, BER workshop report (2014)[g]; *Building Virtual Ecosystems: Computational Challenges for Mechanistic Modeling of Terrestrial Environments*, BER workshop report (2014)[h]; *Isotope Research and Production Opportunities and Priorities*, by the Nuclear Science Advisory Committee (NSAC) (2015)[i]; and *Nuclear Physics Long Range Plan*, by the NSAC (2015) [j].

Scientific Workforce

SC and its predecessors have fostered the training of a skilled scientific workforce for more than 50 years. In addition to the undergraduate and graduate research opportunities provided through SC's Office of Workforce Development for Teachers and Scientists (WDTS), the six SC research program offices train undergraduates, graduate students, and postdoctoral researchers through sponsored research awards at universities and the DOE national laboratories. The research program offices also support targeted, undergraduate and graduate-level experimental training in areas associated with scientific user facilities and not readily available in university academic departments, such as particle and accelerator physics, neutron and x-ray scattering, nuclear chemistry, and nuclear physics. SC coordinates with other DOE offices and other agencies on best practices for training programs and program evaluation through internal DOE working groups and active participation in the National Science and Technology Council's (NSTC's) Committee on Science, Technology, Engineering, and Mathematics

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[a] In compliance with the reporting requirements in the America COMPETES Act of 2007 (P.L. 110-69, section 1008)
[b] http://science.energy.gov/~/media/hep/hepap/pdf/May%202014/FINAL_P5_Report_Interactive_060214.pdf
[c] https://science.energy.gov/~/media/bes/pdf/reports/2016/NCFMtSA_rpt.pdf
[d] http://science.energy.gov/~/media/bes/besac/pdf/Reports/Future_Light_Sources_report_BESAC_approved_72513.pdf
[e] http://science.energy.gov/~/media/bes/besac/pdf/Reports/CFME_rpt_print.pdf
[f] https://science.energy.gov/~/media/bes/pdf/reports/2016/BRNQM_rpt_Final_12-09-2016.pdf
[g] http://genomicscience.energy.gov/biosystemsdesign/index.shtml
[h] http://science.energy.gov/~/media/ber/pdf/workshop%20reports/VirtualEcosystems.pdf
[i] http://science.energy.gov/~/media/np/nsac/pdf/docs/2015/2015_NSACI_Report_to_NSAC_Final.pdf
[j] Working title, to be released in Fall 2015, link TBD

Education (CoSTEM). SC also participates in the American Association for the Advancement of Science's (AAAS) Science & Technology Policy Fellowships program and the Presidential Management Fellows (PMF) Program to bring highly qualified scientists and professionals to DOE headquarters for a maximum term of two years.

Cybersecurity

DOE is engaged in two categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities and improving cybersecurity in the electric power subsector and the oil and natural gas subsector. The cybersecurity crosscut supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts such as the Joint Cybersecurity Coordination Center (JC3) for incident response and the implementation of Department-wide Identity, Credentials, and Access Management (ICAM).

FY 2016 Enacted Level

In the tables throughout this Budget Request, FY 2016 funding is reflected at the Enacted level at the congressional control points. Below the congressional control points, funding reflects the execution of the budget, including reallocations at the subprogram level.