Science
($K)

FY 2015 Enacted	FY 2015 Current[a]	FY 2016 Enacted	FY 2017 Request
5,067,738	5,132,813	5,347,000	5,672,069

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*—discovering 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 the 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*—advancing a clean energy agenda through fundamental research on energy production, conversion, storage, transmission, and use by advancing our understanding of the earth and its climate. Targeted investments include three DOE Bioenergy Research Centers (BRCs), the Energy Frontier Research Centers (EFRCs), two Energy Innovation Hubs, and atmospheric process and climate modeling research.

SC is an established leader of the U.S. scientific discovery and innovation enterprise. Over the decades, SC investments and accomplishments in basic research have provided the foundations for new technologies, businesses, and industries, making significant contributions to our Nation's economy and quality of life. Select scientific accomplishments in FY 2015 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 2017 Budget Request

The FY 2017 Budget Request for SC is $5.572 billion, an increase of $222 million or 4.1 percent, relative to the FY 2016 Enacted level. The FY 2017 Request supports a balanced research portfolio invested in discovery science research probing the most fundamental questions: in high energy, nuclear, and plasma physics; materials and chemistry; biological systems; the complex interactions between earth system components; mathematics; crosscutting high-performance computing and simulation; and basic research that produces advances in clean energy. The Request supports over 24,000 investigators at over 300 U.S. institutions and the DOE laboratories. SC user facilities continue to provide unmatched tools and capabilities for more than 31,000 researchers from universities, national laboratories, industry, and international partners. The FY 2017 Request supports the construction of new user facilities, and the operation, maintenance, and enhancement of the existing network of user facilities, which provide world class research capabilities in the United States. The FY 2017 Request also invests significantly in targeted research and development (R&D), such as accelerator R&D, necessary for future facilities and facility upgrades to deliver desired capabilities and maximize scientific potential.

In addition to the FY 2017 Request, an authorization proposal for $100 million of mandatory funding for University Grants (Mandatory) will be transmitted to Congress, for a total FY 2017 Budget of $5.672 billion. SC will make the funds available through a competitive, merit-based review of proposals solicited from and provided by the university community. The

[a] Includes funding for Small Business Innovation Research (SBIR) and Small Business Technology Transfer Research (STTR) transferred to SC by other Department of Energy components.

solicitation will be designed to leverage past accomplishments and accelerate ongoing activities, as well as open new paths for future SC basic research endeavors in the mission areas of Advanced Scientific Computing Research, Basic Energy Sciences, Biological and Environmental Research, Fusion Energy Sciences, High Energy Physics and Nuclear Physics.

Highlights of the FY 2017 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 United States. The ASCR Budget Request of $663.2 million is an increase of $42.2 million, or 6.8 percent, relative to the FY 2016 Enacted level. The increase supports research on the linked challenges of capable exascale and data-intensive science, and computational partnerships under the Scientific Discovery through Advanced Computing (SciDAC) program to support clean energy. In FY 2017, the ASCR portion of the SC component of the Department's Exascale Computing Initiative (ECI) is contained in a new line item, the Office of Science Exascale Computing Project (SC-ECP), which includes only the activities required for the delivery of exascale computers. 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. With the creation of the new line item, funds are incorporated within SC-ECP research activities from existing applied mathematics, computer science, computational partnerships, and research and evaluation prototypes subprograms of the ASCR budget. The FY 2017 Request supports preparations at the two Leadership Computing Facilities for 75–200 petaflop upgrades at each facility in the 2018–2019 timeframe. The National Energy Research Scientific Computing Center (NERSC) will take delivery of the NERSC-8 supercomputer, which will expand the capacity of the facility to 10–40 petaflops to address growing demand.

- *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 $1,936.7 million is an increase of $87.7 million or 4.7 percent from the FY 2016 Enacted level. The FY 2017 Request includes increases for core research and the Energy Frontier Research Centers (EFRCs) in key areas related to Departmental priorities, such as the Subsurface Technology and Engineering RD&D and the Advanced Materials crosscutting initiatives. A new activity is initiated in Computational Chemical Sciences to advance U.S. leadership in computational chemistry codes in preparation for exascale computing and supports the ECI. The Request continues to support the Fuels from Sunlight and the Batteries and Energy Storage DOE Energy Innovation Hubs. The FY 2017 Request also provides for the 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) request.

- *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 BER Budget Request of $661.9million is an increase of $52.9 million or 8.7 percent above the FY 2016 Enacted level. The FY 2017 Request continues to support for core research in Genomic Science and the three DOE Bioenergy Research Centers (BRC), and it increases support for research to understand microbiome interactions in diverse environments. The Request also continues to support core research to understand climate-relevant atmospheric and ecosystem processes, and requests increased support for field research and modeling to understand the dynamic physical, biogeochemical, microbial, and plant processes interactions involved in the energy-water nexus. The Request supports the operations of BER's three scientific user facilities: the DOE Joint Genome Institute (JGI), the Environmental Molecular Sciences Laboratory (EMSL), and the Atmospheric Radiation Measurement Climate Research Facility (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 2017 Request of $398.18 million decreases by $39.8 million or 9.1 percent from the FY 2016 Enacted level. The FES Budget Request supports continued progress on the U.S. Contributions to ITER Project and core research in burning plasma science. It requests increased funding for the operation of the National Spherical Torus Experiment Upgrade (NSTX-U) to support 16 weeks of run time and to conduct high priority plasma-materials interaction research. DIII-D operations funding supports 560 hours of operation and the Request includes an increase to provide for targeted enhancements to the facility. Increased 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.

- *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 2017 Request of $817.9 million increases by $22.9 million or 2.9 percent above the FY 2016 Enacted level. The Request continues to implement the recommendations of the 2014 High Energy Physics Advisory Panel (HEPAP) Particle Physics Project Prioritization Panel (P5) Report. The FY 2017 Request supports full operation of existing major HEP facilities and experiments, including optimal operations for the upgraded Neutrinos at the Main Injector (NuMI) beamline of NuMI Off-axis ν_e Appearance (NOvA) Experiment, construction of the Muon to Electron Conversion Experiment (Mu2e), consistent with the planned construction funding profile, and the MIEs for the Large Hadron Collider (LHC) upgrades the ATLAS (A Large Toroidal LHC Apparatus) and Compact Muon Solenoid (CMS) detectors. Consistent with the P5 Report recommendations, the FY 2017 Request enhances support for technical design and construction associated with the Long Baseline Neutrino Facility (LBNF)/Deep Underground Neutrino Experiment (DUNE) project, and continued construction of three MIEs for next-generation dark-energy and dark-matter experiments. The Request includes funding for one new MIE, the Facility for Advanced Accelerator Experimental Tests II (FACET-II), and for research and conceptual design of the Proton Improvement Plan II (PIP-II) construction project. Funding increases for the fabrication of the Large Synoptic Survey Telescope 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 of $635.7 million increases $18.6 million or 3.0 percent relative to the FY 2016 Enacted level. 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), which will provide world-leading capabilities for nuclear structure and astrophysics research. The 12 GeV Upgrade for the Continuous Electron Beam Accelerator Facility (CEBAF) 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 Request also provides for increased operations of the Relativistic Heavy Ion Collider (RHIC) 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 (GRETA) detector to exploit the world-leading science capabilities of FRIB, and the Stable Isotope Production Facility (SIPF) to establish a domestic capability for the production of a broad range of enriched stable isotopes for research and applications.

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 "tech teams" and 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. 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]

The Office of Science 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,

[a] In compliance with the reporting requirements in the America COMPETES Act of 2007 (P.L. 110-69, section 1008).

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) [a]; *Top Ten Exascale Research Challenges*, by the Advanced Scientific Computing Advisory Committee (ASCAC) (2014) [b]; *Report of the BESAC Subcommittee on Future X-ray Light Sources,* by the Basic Energy Sciences Advisory Committee (BESAC) (2013) [c]; *Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science*, by BESAC (2015)[d]; *Synergistic Challenges in Data-Intensive Science and Exascale*, ASCR workshop report (2012) [e]; *Molecular Science Challenges*, BER workshop report (2014)[f]; *Building Virtual Ecosystems: Computational Challenges for Mechanistic Modeling of Terrestrial Environments*, BER workshop report (2014)[g]; *Isotope Research and Production Opportunities and Priorities*, by the Nuclear Science Advisory Committee (NSAC) (2015)[h];and *Nuclear Physics Long Range Plan*, by the NSAC (2015) [i].

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, graduate-level experimental training in areas associated with scientific user facilities, such as particle and accelerator physics, neutron and x-ray scattering, 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 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.

Crosscutting Initiatives

The FY 2017 Budget Request for SC includes investments that serve as the first step in implementing the President's commitment to double Federal funding for clean energy research over the next five years. Through the government-wide Mission Innovation initiative, SC and DOE will join other Federal entities in commitment to accelerate the pace of innovation and the research and development of affordable clean energy technologies to ensure a secure and clean energy future for the United States. The FY 2017 Budget Request for SC's ASCR, BES, BER, and FES programs will support a new generation of scientists and engineers conducting fundamental research aimed at addressing complex scientific questions and accelerating the transformation of that research into clean energy technology solutions. Specific proposed activities in this area are discussed in greater detail in the respective program's budgets.

The Department is organized into three Under Secretariats—Science and Energy, Nuclear Security, and Management and Performance—which recognize the complex interrelationship between the DOE Program Offices. The Budget Request continues crosscutting programs coordinated across the Department and seek to tap DOE's full capability to effectively and efficiently address the United States' energy, environmental, and national security challenges. These crosscutting initiatives are discussed further within the Programs in which the crosscuts are funded. SC participates in the following crosscuts:

[a] http://science.energy.gov/~/media/hep/hepap/pdf/May%202014/FINAL_P5_Report_Interactive_060214.pdf
[b] http://science.energy.gov/~/media/ascr/ascac/pdf/meetings/20140210/Top10reportFEB14.pdf
[c] http://science.energy.gov/~/media/bes/besac/pdf/Reports/Future_Light_Sources_report_BESAC_approved_72513.pdf
[d] http://science.energy.gov/~/media/bes/besac/pdf/Reports/CFME_rpt_print.pdf
[e] http://science.energy.gov/~/media/ascr/ascac/pdf/reports/2013/ASCAC_Data_Intensive_Computing_report_final.pdf
[f] http://genomicscience.energy.gov/biosystemsdesign/index.shtml
[g] http://science.energy.gov/~/media/ber/pdf/workshop%20reports/VirtualEcosystems.pdf
[h] http://science.energy.gov/~/media/np/nsac/pdf/docs/2015/2015_NSACI_Report_to_NSAC_Final.pdf
[i] Working title, to be released in Fall 2015, link TBD

Advanced Materials (Adv Mat): Affordable, reliable, and high-performance materials are critical for clean energy applications and for global manufacturing competitiveness in the 21st century. The new Advanced Materials crosscut, identified as a priority in both the 2015 Quadrennial Technology Review and Quadrennial Energy Review, will employ advanced synthesis, modeling, and characterization to accelerate and reduce the cost of materials qualification in a wide variety of clean energy applications, from discovery through deployment. While materials RD&D underpins much of DOE's historic and current portfolio across both basic science and applied offices, this newly formed crosscut focuses on a subset of materials R&D that will involve close coordination among the participating offices in forming a cohesive network with the following capabilities: (1) materials design and synthesis, (2) functional (applied) design, (3) process scale-up, (4) qualification, and (5) digital data and informatics.

Exascale Computing Initiative (ECI): Exascale systems are needed to support areas of research that are critical to national security objectives as well as applied research advances in areas such as earth-systems models, combustion systems, and nuclear reactor design that are not within the capacities of today's systems. Exascale systems' computational power is needed for increasing capable data-analytic and data-intense applications across the entire Federal complex. Exascale is a component of long-term collaboration between the Office of Science's Advanced Scientific Computing Research program and the National Nuclear Security Administration's Advanced Simulation and Computing Campaign (ASC) program.

Subsurface Technology and Engineering RD&D (Subsurface): Over 80 percent of our total energy supply comes from the subsurface, and this importance is magnified by the ability to also use the subsurface to store and sequester fluids and waste products. The subsurface crosscut, Subsurface, will address identified grand challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals and Risk Assessment Tools to ensure enhanced energy security, material impact on climate change via CO_2 sequestration, and significantly mitigated environmental impacts from energy-related activities and operations.

Energy-Water Nexus (EWN): There is increasing urgency to address the energy-water nexus in an integrated way due to changing precipitation and temperature patterns, accelerated drawdown of critical water supplies, population growth and regional migration trends, and the introduction of new technologies that could shift water and energy demands. The energy-water nexus crosscut is an integrated set of cross-program collaborations designed to accelerate the Nation's transition to more resilient energy and coupled energy-water systems. The crosscut supports: (1) an advanced, integrated data, modeling, and analysis platform to improve understanding and inform decision-making for a broad range of users and at multiple scales; (2) investments in targeted technology research opportunities within the system of water-energy flows that offer the greatest potential for positive impact; and (3) policy analysis and stakeholder engagement designed to build from and strengthen the two preceding areas while motivating more rapid community involvement and response.

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 Credential and Access Management (ICAM).

FY 2017 Crosscuts ($K)

	Adv Mat	ECI	Subsurface	EWN	Cyber security	Total
Advanced Scientific Computing Research	0	154,000	0	0	0	154,000
Basic Energy Sciences	17,600[a]	26,000	41,300	0	0	84,900
Biological and Environmental Research	0	10,000	0	24,300	0	34,300
Safeguards and Security	0	0	0	0	27,197[b]	27,197
Total, Crosscuts	17,600	190,000	41,300	24,300	27,197	300,397

[a] The $17,600K supports the Department's Advanced Materials Crosscut. An additional $11,500K in BES for Quantum Materials is also included in SC's total investment, as described in the advanced materials crosscut narrative.

[b] The $27,197K supports the Department's Cybersecurity Crosscut. An additional $6,039K for CyberOne in the Safeguards and Security program is also included in SC's total investment to support cybersecurity. CyberOne is funded through the Working Capital Fund (WCF).