Science

($K)

FY 2014 Enacted	FY 2014 Current	FY 2015 Enacted	FY 2016 Request
5,066,372	5,131,038	5,067,738	5,339,794

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. The 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 energy.

The SC accomplishes its mission and advances national goals by supporting:

- *The frontiers of science*—discovering nature's mysteries from the study of subatomic particles, atoms, and molecules that are the building blocks of the materials of our everyday world to the DNA, proteins, and cells that are the building blocks of entire biological systems; each of the programs in the SC supports research to probe the most fundamental questions of its disciplines.
- *The 21st Century tools of science*—providing the Nation's researchers with 26 state-of-the-art national scientific user facilities, the most advanced tools of modern science, enabling the U.S. to remain at the forefront of science, technology, and innovation.
- *Science for energy and the environment*—advancing a clean energy agenda through fundamental research on energy production, conversion, storage, transmission, and use and through advancing our understanding of the earth and its climate; targeted investments include the three DOE Bioenergy Research Centers (BRCs), the Energy Frontier Research Centers (EFRCs), two Energy Innovation Hubs, and atmospheric process and climate modeling research.

The SC has long been a leader of U.S. scientific discovery and innovation. 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 2014 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/stories-of-discovery-and-innovation/.

Highlights and Major Changes in the FY 2016 Budget Request

The FY 2016 request for the SC is $5.340 billion, an increase of $272 million or 5.4 percent, relative to the FY 2015 enacted level. The FY 2016 request supports a balanced research portfolio that invests in discovery science—research that probes some of the most fundamental questions in high energy, nuclear, and plasma physics; materials and chemistry; biological systems and earth system components; and mathematics—as well as basic research that underpins advances in clean energy. The request supports about 22,000 investigators at over 300 U.S. academic institutions and at all of the DOE laboratories. The SC user facilities continue to offer capabilities unmatched anywhere in the world; nearly 31,000 researchers from universities, national laboratories, industry, and international partners are expected to use these facilities in FY 2016. The FY 2016 request supports the construction of new user facilities necessary to provide world class research capabilities in the United States and 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.

- *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 DOE. ASCR grows $80.0 million, or 14.8 percent, relative to the FY 2015 enacted level. The increase provides support for research that focuses on the linked challenges of capable exascale and data-intensive science, and computational partnerships under the Scientific Discovery through Advanced Computing (SciDAC) program. The request provides for significantly expanded investments in Research and Engineering Prototypes (REP) to develop critical technologies and system integration for exascale, including initiation of exascale node and system architecture design efforts. REP initiated partnerships with key vendors accelerates the R&D of critical technologies to advance the Department's exascale goals and reduce the economic and manufacturing barriers to their commercial production. The FY 2016 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) 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 in order to provide the foundations for new energy technologies. BES increases $116 million or 6.7 percent from the FY 2015 enacted level. The requests continues support for on-going core research at approximately the FY 2015 enacted level, including a small increase for the Energy Frontier Research Centers (EFRC) to support areas underrepresented in the current EFRC portfolio, and it continues support for the Batteries and Energy Storage Energy Innovation Hub. A renewal decision for the Fuels from Sunlight Energy Innovation Hub will be made in 2015. The Computational Materials Sciences activity is increased. The FY 2016 request provides for operations of five synchrotron light sources, five nanoscale research centers, and two neutron scattering centers. Funding to transition the Lujan Neutron Scattering Center to NNSA is also continued. No funds are requested in FY 2016 for National Synchrotron Light Source (NSLS) because the newly constructed National Synchrotron Light Source-II (NSLS II) is in operations. The request also provides for increases in construction for the Linac Coherent Light Source-II (LCLS-II), and it continues funding the Advanced Photon Source (APS) Upgrade and the NSLS-II Experimental Tools (NEXT) major items of equipment 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. BER increases by $20.4 million or 3.4 percent above the FY 2015 enacted level. The FY 2016 request continues support for core research in Genomic Science and the three DOE Bioenergy Research Centers (BRC), while funding for Radiological Sciences and Structural Biology Infrastructure is decreased as activities are completed. Increased support is requested in FY 2016 for research to understand the interdependencies of water, energy, and climate change. Operations are supported for BER's three scientific user facilities, the Joint Genome Institute (JGI), the Environmental Molecular Sciences Laboratory (EMSL), and the Atmospheric Radiation Measurement (ARM) 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 FES FY 2016 request decreases by $47.5 million or 10.2 percent from the FY 2015 enacted level. Funding at the FY 2015 level is requested for key U.S. Contributions to ITER project, including important critical path items. Funding for the operations of the National Spherical Torus Experiment (NSTX), which completed a major upgrade in FY 2014, is increased to support 16 weeks of run time and to begin fabrication of two important facility enhancements. DIII-D research and operations are maintained at the FY 2015 request levels. The FY 2016 request supports five weeks of research operations of the Alcator C-Mod facility in its final year of operations.
- *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. HEP increases by $22.0 million or 2.9 percent above the FY 2015 enacted level. The request supports the planned construction funding profile for the Muon to Electron Conversion Experiment (Mu2e), and the MIEs for the Large Hadron Collider (LHC) upgrades to two detectors – the ATLAS (A Large Toroidal LHC Apparatus) and Compact Muon Solenoid (CMS) detectors. Optimal operations for the upgraded Neutrinos at the Main Injector (NuMI) beamline of NuMI Off-axis ν_e Appearance (NOvA) Experiment are provided. The FY 2016 request increases to support R&D and project engineering and design associated with the Long Baseline Neutrino Facility (LBNF), and initiation of the fabrication of three new MIEs for next–generation dark–energy and dark–matter experiments, consistent with the High Energy Physics Advisory Panel (HEPAP) (P5) report recommendations. Funding increases for the fabrication of the Large Synoptic Survey Telescope MIE according to the planned profile. Core research is decreased slightly to provide support for high priority efforts.
- *Nuclear Physics (NP)* supports research to discover, explore, and understand all forms of nuclear matter, supporting experimental and theoretical research to create, detect, and describe the widely varied forms of nuclear matter that exist in the universe, including those no longer found naturally. NP increases $29.1 million or 4.9 percent relative to the FY 2015 enacted level. Construction of the Facility for Rare Isotope Beams (FRIB) continues, consistent with the performance baseline profile approved in August 2013. Funding for the 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF) Upgrade decreases as accelerator commissioning is completed in FY 2015. The FY 2016 request also

provides for operation of the Relativistic Heavy Ion Collider (RHIC) for 22 weeks and for optimal operations at the Argonne Tandem Linac Accelerator System. Core research increases in FY 2016 to support high-priority research areas.

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 funding mechanisms that encourage partnerships also 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 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]; *Top Ten Exascale Research Challenges*, by the Advanced Scientific Computing Advisory Committee (ASCAC) (2014) [c]; *Report of the BESAC Subcommittee on Future X-ray Light Sources,* by the Basic Energy Sciences Advisory Committee (BESAC) (2013) [d]; Synergistic *Challenges in Data-Intensive Science and Exascale*, ASCR workshop report (2012) [e]; *Biosystems Design*, BER workshop report (2012) [f]; and *Nuclear Physics: Exploring the Heart of the Matter*, by the National Research Council (2012) [g].

Scientific Workforce

The SC and its predecessors have more than a 50-year history in the training of a skilled scientific workforce. In addition to the undergraduate and graduate research internship programs supported through the SC's Office of Workforce Development for Teachers and Scientists (WDTS), the six SC research programs support the training of undergraduates, graduate students, and postdoctoral researchers through ongoing 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. The SC coordinates with other DOE offices and other agencies on best practices for training programs and program evaluation through active participation in the National Science and Technology Council's (NSTC's) Committee on Science, Technology, Engineering, and Mathematics Education (CoSTEM). The 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 to DOE headquarters for 1–2 years.

Crosscuts

The FY 2016 Budget request continues crosscutting programs which coordinate across the Department to address our energy, environmental and national security challenges. These crosscutting initiatives, summarized below, are discussed in greater detail in the supporting programs' narratives.

Exascale Computing: 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 climate models, combustion systems, and nuclear reactor design that are not within the capacities of today's systems. Exascale systems' computational power are needed for

[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] http://science.energy.gov/~/media/ascr/ascac/pdf/meetings/20140210/Top10reportFEB14.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/ascr/ascac/pdf/reports/2013/ASCAC_Data_Intensive_Computing_report_final.pdf
[f] http://genomicscience.energy.gov/biosystemsdesign/index.shtml
[g] http://www.nap.edu/catalog.php?record_id=13438

increasing capable data-analytic and data-intense applications across the entire Federal complex. Exascale is a component of long-term collaboration between the SC's Advanced Scientific Computing Research (ASCR) program and the National Nuclear Security Administration's (NNSA) Advanced Simulation and Computing Campaign (ASC) program.

Subsurface Engineering: 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, SubTER, will address identified challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to ensure enhanced energy security, material impact on climate change via CO2 sequestration, and significantly mitigated environmental impacts from energy-related activities and operations.

Energy-Water: 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.

Cyber Security: DOE is engaged in three categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities; bolstering the U.S. Government's capabilities to address cyber threats; 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 for incident response and the implementation of Department-wide Identity Credential and Access Management.

FY 2016 Crosscuts ($K)

	Exascale Computing	Subsurface Engineering	Energy-Water	Cyber Security	Total
Advanced Scientific Computing Research	177,894	0	0	0	177,894
Basic Energy Sciences	12,000	5,000	0	0	17,000
Biological and Environmental Research	18,730	0	11,800	0	30,530
Safeguards and Security	0	0	0	33,156	33,156
Total, Crosscuts	208,624	5,000	11,800	33,156	258,580

Science
Funding by Congressional Control ($K)

	FY 2014 Enacted	FY 2014 Current	FY 2015 Enacted	FY 2016 Request	FY 2016 vs. FY 2015
Advanced Scientific Computing Research	**478,093**	**463,472**	**541,000**	**620,994**	**+79,994**
Basic Energy Sciences					
Research	1,609,929	1,560,702	1,594,500	1,649,000	+54,500
Construction					
13-SC-10 Linac Coherent Light Source-II, SLAC	75,700	75,700	138,700	200,300	+61,600
07-SC-06 National Synchrotron Light Source (NSLS) II, BNL	26,300	26,300	0	0	0
Total, Construction	**102,000**	**102,000**	**138,700**	**200,300**	**+61,600**
Total, Basic Energy Sciences	**1,711,929**	**1,662,702**	**1,733,200**	**1,849,300**	**+116,100**
Biological and Environmental Research	**609,696**	**593,610**	**592,000**	**612,400**	**+20,400**
Fusion Energy Sciences					
Research	305,177	296,355	317,500	270,000	-47,500
Construction					
14-SC-60 ITER	199,500	199,500	150,000	150,000	0
Total, Fusion Energy Sciences	**504,677**	**495,855**	**467,500**	**420,000**	**-47,500**
High Energy Physics					
Research	745,521	723,920	729,000	731,900	+2,900
Construction					
11-SC-40 Long Baseline Neutrino Facility, FNAL	16,000	16,000	12,000	16,000	+4,000
11-SC-41 Muon to Electron Conversion Experiment, FNAL	35,000	35,000	25,000	40,100	+15,100
Total, Construction	**51,000**	**51,000**	**37,000**	**56,100**	**+19,100**
Total, High Energy Physics	**796,521**	**774,920**	**766,000**	**788,000**	**+22,000**

	FY 2014 Enacted	FY 2014 Current	FY 2015 Enacted	FY 2016 Request	FY 2016 vs. FY 2015
Nuclear Physics					
Operation and Maintenance	488,638	474,302	489,000	517,100	+28,100
Construction					
14-SC-50 Facility for Rare Isotope Beams, Michigan State University	55,000	55,000	90,000	100,000	+10,000
06-SC-01 12 GeV CEBAF Upgrade, TJNAF	25,500	25,500	16,500	7,500	-9,000
Total, Construction	**80,500**	**80,500**	**106,500**	**107,500**	**+1,000**
Total, Nuclear Physics	**569,138**	**554,802**	**595,500**	**624,600**	**+29,100**
Workforce Development for Teachers and Scientists	**26,500**	**26,500**	**19,500**	**20,500**	**+1,000**
Science Laboratories Infrastructure					
Infrastructure Support					
Payment in Lieu of Taxes	1,385	1,385	1,713	1,713	0
Facilities and Infrastructure	900	900	6,100	30,977	+24,877
Oak Ridge Landlord	5,951	5,951	5,777	0	-5,777
Oak Ridge Nuclear Operations	0	0	0	12,000	+12,000
Total, Infrastructure Support	8,236	8,236	13,590	44,690	+31,100
Construction					
15-SC-75 Infrastructure and Operational Improvements at PPPL	0	0	25,000	0	-25,000
15-SC-76 Materials Design Laboratory at ANL	0	0	7,000	23,910	+16,910
15-SC-77 Photon Science Laboratory Building at SLAC	0	0	10,000	25,000	+15,000
15-SC-78 Integrative Genomics Building at LBNL	0	0	12,090	20,000	+7,910
13-SC-70 Utilities Upgrade, FNAL	34,900	34,900	0	0	0
13-SC-71 Utility Infrastructure Modernization, TJNAF	29,200	29,200	0	0	0
12-SC-70 Science and User Support Building, SLAC	25,482	25,482	11,920	0	-11,920
Total, Construction	**89,582**	**89,582**	**66,010**	**68,910**	**+2,900**
Total, Science Laboratories Infrastructure	**97,818**	**97,818**	**79,600**	**113,600**	**+34,000**
Safeguards and Security	**87,000**	**87,000**	**93,000**	**103,000**	**+10,000**
Program Direction	**185,000**	**185,000**	**183,700**	**187,400**	**+3,700**

	FY 2014 Enacted	FY 2014 Current	FY 2015 Enacted	FY 2016 Request	FY 2016 vs. FY 2015
Small Business Innovation/Technology Transfer Research (SC portion)	**0**	**128,539**	**0**	**0**	**0**
Subtotal, Science	**5,066,372**	**5,070,218**	**5,071,000**	**5,339,794**	**+268,794**
Small Business Innovation/Technology Transfer Research (DOE transfer)	**0**	**64,666**	**0**	**0**	**0**
Use of prior year balances (SBIR)	**0**	**-3,846**[a]	**0**	**0**	**0**
Use of prior year balances (Rescission)	**0**	**0**	**-3,262**	**0**	**+3,262**
Total, Science Appropriation	**5,066,372**	**5,131,038**	**5,067,738**	**5,339,794**	**+272,056**
Federal FTEs	**956**	**929**	**940**	**945**	**+5**

SBIR/STTR:

- FY 2014 Current: SBIR: $112,472,000 (includes unobligated prior-year funds of $3,277,000 from BER and $569,000 from ASCR) was reprogrammed within SC and $57,066,000 was transferred from other DOE programs; STTR: $16,067,000 was reprogrammed within SC and $7,600,000 was transferred from other DOE programs.
- FY 2015 projected: SBIR: $116,876,000 and STTR: $16,119,000 (SC only).
- FY 2016 Request: SBIR: $124,644,000; STTR: $18,696,000 (SC Only).

[a] Reflects the use of prior-year unobligated balances ($3,846,000) in FY 2014 for SBIR.